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Founding Chair: Prof. Dr. Ibrahim Dincer
Conference Chair: Prof. Dr. Zafer Utlu

11th GLOBAL CONFERENCE on GLOBAL WARMING

14 - 16.06.2023

HALİÇ UNIVERSITY
İSTANBUL / TÜRKİYE

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PROCEEDINGS

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11th Global Conference on

GLOBAL WARMING

14-16 June 2023
Halic University
Istanbul, Turkey

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FOREWORDS

MESSAGE FROM THE CHAIRMAN

Global Conference on Global Warming (GCGW) is a multi–disciplinary international conference on all aspects of global warming including its evidence, causes, impacts and potential solutions. This conference aims to provide a forum for the exchange of technical information, dissemination of high-quality research results, presentation of new policy and scientific developments and promoting future priorities for a more sustainable development and energy security. It covers a broad range of topics on atmospheric changes, climate change impacts, climate change modeling and simulations, energy and environment policies, energy resources and conversion technologies, renewables, emission reduction and abatement, waste management, ecosystem and biodiversity, sustainable development, etc.

GCGW has been organized successfully as a leading congress in the area since 2008, and GCGW-2023 is the 11th one of this conference series. The previous conferences were held in various parts of the world, namely four times in Istanbul, one time in Lisbon, Beijing, Athens, Doha, Zagreb, and Sharjah successfully. The scientific part of the GCGW-2023 includes plenary sessions in which keynote speakers present as well as parallel sessions in which invited papers and general papers are presented in oral form. There are also poster presentation sessions. During the conference, awards best paper and best poster awards will be given to acknowledge the high quality of work of the participants. The social part of the GCGW-2023 includes a welcoming reception and a gala dinner.

All the papers submitted to the conference have gone through a quick review process to increase the quality of these papers. Accepted papers have been published in the GCGW-2023 proceedings. After the conference ends, high-quality papers will be considered, in extended form, for publication in the special issues of the specific reputable international journals. The roadmap for World's global warming strategies was discussed with nine distinguished panellists and the moderator. 132 attendees have attended this event from 15 different countries. The GCGW-2023 has been a successful conference, and the output of this conference will definitely be another milestone in World's global warming activities.

Prof. Dr. Ibrahim DINCER
GCGW 2023 Founding Chair

FOREWORDS

MESSAGE FROM THE PRESIDENT

Global warming refers to the long-term increase in Earth's average surface temperature due to human activities, primarily the emission of greenhouse gases into the atmosphere. The most significant greenhouse gas is carbon dioxide (CO2), which is released through the burning of fossil fuels such as coal, oil, and natural gas. Other greenhouse gases include methane, nitrous oxide, and certain industrial chemicals. The effects of global warming are wide-ranging and pose significant challenges to the environment, human societies, and ecosystems.

The 11th Global Conference on Global Warming (GCGW-2023) was held successfully in İstanbul, the cultural capital of Turkey from 14th to 16th June 2023, hosted by OntarioTech University, and Haliç University in collaboration with the World Society of Sustainable Energy Technologies.

The 11th Global Conference on Global Warming (GCGW-2023) is a multi – disciplinary international conference on all aspects of global warming including its causes, impacts and potential solutions. The conference aimed to provide a forum for exchanging technical information, disseminating high-quality research results, presenting new policy and scientific developments, and promoting future priorities for more sustainable development and energy security. Participants from all disciplines related to global warming (e.g. ecology, education, engineering, natural sciences, social sciences, economics, management, physical sciences, information technology, etc) are welcome to contribute to this unique event which is held at the Haliç University this year.

GCGW-2023 had featured 8 keynote speakers, 5 invited speakers, 32 parallel sessions and 2 poster sessions. The 'Workshop for Partnership and Networking on Global Warming Technologies' was also organized within GCGW-2023 to bring the leading academicians, researchers, scientists, and students together to lead a new effective network and collaboration between the universities, industrial partners, and government. In this workshop, speakers from research groups working on global warming and sustainable energy technologies introduced their group, and presented their past and current research projects, collaborations, infrastructures, and future research strategies. A panel discussion session was also organized online on the last day of the conference. The roadmap for Turkey's global warming strategies was discussed with eight distinguished panelists and the moderator. 152 attendees have attended this event from 28 different countries. The GCGW-2023 has been a successful conference, and the output of this conference will definitely be another milestone in global warming activities.

As the Association President, I would like to register my sincere appreciation to the Organizing Committee Members, Executive Organizing Committee Members, and the Honorary Chair Prof. İbrahim Dincer. In addition, I would like to acknowledge the assistance, support and coordination of our sponsors. Last but not least, I warmly thank the congress keynote speakers, authors, session chairs, and all attendees, whose contributions and efforts made this conference a great success.

Prof. Dr. Zafer UTLU
GCGW 2023 President

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SCIENTIFIC PROGRAM

Time	Day 1 - Wednesday 14th June 2023			
08:00-10:00	**Registeration** Main Conference Hall (registeration will be open from 9:00 -18:00 wednesday 14th June)			
10:00-10:10	Opening Remarks : Professor Zafer Utlu			
10:10-10:25	Short Remarks : Professor Ibrahim Dincer			
10:25-10:40	Music Recital Main Conference Hall			
10:40-10:45	Group Photo Main Conference Hall			
10:45	Tea Break Main Conference Hall			
11:00-11:40	Keynote Speaker: Prof. Dr. Seeram Ramakrishna Title: **Role of Circular Economy in Net Zero Transition**			
11:40-12:20	Keynote Speaker: Prof. Dr. Mihri Ozkan Title: **Carbon capture and emission reduction via electric vehicles help to tackle climate change**			
12:20-12:35	Sponsors' speeches - RePG Energy			
12:35	Buffet Lunch			
13:30-14:10	Keynote Speaker: Prof Dr. Cengiz S. Özkan Title: **Role of Energy Storage in Electrification of Economy and Sustainability**			
14:30	**Session 1**	**Session 2**	**Session 3**	**Session 4**
	Renewable Energies and Sustainable Chair: Nader JAVANI	Global Warming and Environment Chair: Moslem Sharifishourabi	Digitalization/Policies, Management and Economics Chair: Hafiz Muhammad Rizwan	Analysis Chair: Aliaksandr Pauliuchenka
	#7 "A comprehensive review of the impact of feedstock chosen in the pyrolisis precess on the emmissions of gas turbine engines" **#11 "Wind and solar-based energy system with hydrogen and battery storages and heat pump for sustainable communities"** **#27 "Feasability and comparison of using an integrated solar-base system for a sample residental building in different cities of Russia"** **#36 "Technical assessment of chp system integrated with carbon capture and utilization technology"** **#58 "Experimental investigations to reduce CO2 emission in a single cylinder CI engine using waste plastic oil blend combined with lemon peel oil"** *Topkapı*	**#6 "Temperature change of a vehicle battery uring the driving cycle"** **#33 "Environmental Impact Assessment of a New Multigenerational System"** **#59 "Green future transport"** **#63 "Energy efficiency evaluation and forecasting of the sussex ports to adress climate change concerns: a data-driven decision model "** **#93 "Assessing the impact of climate change on soil moisture and** *Boğaziçi*	**#14 "Secapsoft software for decision making based on data analytics and carbon reduction"** **#26 "Confidence-Base Regression with Energy Based Models in Deep Learning"** **#110 "The effect of generative AI on the digitization of yhe energy sector"** **#45 "Economic growth and sustainability: debating the pros and cons of degrowth and green growth"** **#89 "Using artificial intelligence algorithms for solar energy prediction"** *Taksim*	**#10 "Gravitional Water Vortex Heat Exchanger as a Waste " heat recovery Unit"** **#17 "Dynamic thermal moeling of a greenhouse"** **#22 "Controller design that provides lighting automation for energy efficiency in buildings"** **#44 "Exergy analysis of different fuel blends powere compression ignition engine- a review"** **#118 "Hydrogen production from geothermal energy"** *Haliç*
15:45	**Tea Break** *Venue*			
	Session 5	**Session 6**	**Session 7**	**Session 8**
16:00-17:30	Renewable Energies and Sustainable Chair: Nurdan Yildirim	Global Warming and Environment Chair: Ebru Hancioglu	Digitalization/Policies, Management and Economics Chair: Nilsen Sunter Eroglu	Analysis Chair: Mehmet Ziya Söğüt
	#29 "Optimization and development of a water- energy-carbon nexus model: a techno-economic analysis" **#55 "Techno-economic and environmental analysis of the integration of solar tracked or fixed-tilt photovoltaic power plants to open coal"** **#46 "Plastic recycling in a R&D office: recycling of plastic waste as granules and fibre"** *Topkapı*	**#112 "A study on global warming effect of Gas Turbine Power Generation Process"** **#43 "Assessment of environmental protection costs within the framework of global warming"** **#40 "Ecospace program as the transition of civilization to the natural path of technocratic development"** **#23 "Ust biosphere technologies for solving global environmental problems"** *Boğaziçi*	**#92 Optimization of carbon trading and renewable energy management by using blockchain technology and artificial intelligence"** **# 98 "Confidence-Based Regression with Energy- Based Models in Deep Learning"** **# 104 "The geostrategic and economic impact of Türkiye's hydrogen energy vision on Europe"** **#129 "Holistic chain management of environment, matter, energy and processes with artificial intelligence for sustainable tourism industry"** *Taksim*	**#48 "Transformation of a touristic facility to cogeneration system and thermoeconomic analysis"** **#64 "Energy, Exergy and Emission Performance Prediction of the Hydrogen-Fueled Scimitar Engine with Machine Learning Methods"** **#67 "Machine learning methods for the prediction of CO2 emissions in spark-ignition engines"** **#68 "Sustainability: technological development, growth and environmental pollution"** *Haliç*
17:30	**Close**			

Time				
10.40	Venue: Small Conference Hall			
10.40	COMFORT BREAK			
10.45-12.30	Session 9 **Renewable Energies and Sustainable** Chair: Sahver Omeraki Cekirdekci	Session 10 **Global Warming and Environment** Chair: Ali Ayati	Session 11 **Renewable Energies and Sustainable** Chair: Nurdan Yildirim	Session 12 **Analysis** Chair: Mahdi Deymi-Dashtebayaz
	#60 "Effects of green finance on renewable energy generation in Turkey" #66 "Reduction of CO2 emissions and combustion stability in lean limits by optimizing the engine spark timing for hydrogen induction in gasoline" #75 "Sustainable formic acid production from CO2: a life cycle assessment analysis" #71 "Investigation of hydrogen production potential based on an ocean thermal energy conversion plant; thermodynamic performance" *Topkapı*	#108 "Mof-doped mxene for CO2 adsorption" #39 "An environmental impact comparison of thermochemical cycles and steam methane reforming for hydrogen production processes " #123 "Investigating the impact of green certificate campus. implementation on greenmetric in university campuses" #56 "The use of enhanced carbon nanotubes (CNT AND CNT/PVA) obtained from composite packaging wastes as carbon dioxide adsorbent" #74 "Investigation of Life Cycle Assessment for Rural Wastewater Treatment Plants" *Boğaziçi*	#50 "Characterization of carbon nanotube enhanced composite phase change material derived from waste ldpe" #115 "System design for green power generation with piezoelectric materials" #97 "Surface plasmon resonance-mediated optical tunability and photocatalytic activity in Ag- DECORATED Cd0.5Zn0.5S Photocatalysts #101 "Performance evaluation of geothermal assisted VAC system with LiBr-H2O for residential cooling" #105 "Thermal storage units as a peak shaving product for energy and building sector integration" *Taksim*	#85 "Determination of electricity, heating-cooling and hydrogen production performance by using externally fired gas turbine flue gas in turbine- bleeding regeneration SRC, ORC, Li-Br/H20 absorption chiller and electrolysis unit" #86 "Thermo-economic analysis of green hydrogen production using diesel engine at different loads of exhaust waste heat in SRC and ORC-IHE with zeotropic and low GWP fluids integrated with thermoelectric generators" #87"Investigation of exergetic and environmental performance of freezing food considering cryogenic cooling" #52 "Net zero energy building in the United Arab Emirates: Life cycle assessment of global warming potential" *Haliç*
12.30-13.30	Buffet Lunch			
13.30	Session 13 **Renewable Energies and Sustainable** Chair: B. Koray Tuncalp	Session 14 **Global Warming and Environment** Chair: Meltem Vatan	Session 15 **Renewable Energies and Sustainable** Chair: Neslihan Colak Gunes	Session 16 **Analysis** Chair: Ozum Calli
	#77 "Remote sensing technologies for renewable energy management" #79 "Butyrate generation during the fermentation of bio-hydrogen as a green chemical" #82 "Development of phase change material micro-capsules and composites using a green method" #57 "A lesson proposal for using the circular economy in design education" *Topkapı*	# 25 "The effect of the construction industry on global warming and solution suggestions" #34 "Minimization of greenhouse gas emissions from groundwater treatment using biochar derived by solar pyrolysis in compliance with EU green deal" #53 "Environmental comparison of different coal-fired technologies used by thermal power plants via life cycle assessment" #102 "Environmental impact investigation of using hydrogen sulfide and waste-based hydrogen in blending with black sea natural gas" *Boğaziçi*	#72 "Performance analysis of a biomass-based Brayton and supercritical- CO2 integrated power plant" #70 "Environmental Effects of Pretreatment Processes Applied to Cotton Fabrics" #119 "Evaluating the impact of solar energy systems on exergy efficiency and carbon footprint in extra virgin organic olive oil production" #18 "A life cycle assessment study for sustainable denim fabric production" *Taksim*	#94 "Determinants of the countries' performances regarding climate change" #96 "Assessment of environmental impact of irreversibility in a cooling section of dry-type cement production plant" #69 "Retrofit scenarios for overheating problem of a studio-type housing in the mediterranean climate" #114 "A Comparative Study for Electrical Energy Forecasting Using Random Forest and Decision Tree Methods" *Haliç*
	Poster session: #4 "Numerical investigation of hybrid thermal photovoltaic system performance for ship propulsion in Arabian Gulf" #28 "Navigating toward sustainability: impact of using marine pilots in ports sustainability" #31 "Energy efficiency and solar energy impelimantation opportunities for dairy farms #78 "Comparison of traditional and innovative thermal insulation materials in terms of energy efficiency" #84 "Preparation of microcapsules containing phase change materials for passive cooling in computers #109 "Simulation-based study of natural gas to hydrocarbon liquids (gtl) process using fischer-tropsch synthesis: a case study of neem field in western Sudan" #111 "Photocatalytic reduction of carbon dioxide into methanol over copper based metal organic framework" #116 "Solar radiation and energy efficiency: analyzing the impact on cooling and heating in different climatic regions" # 127 "The effects of global warming and climate change on human health"			
14.45	*Tea Break*			
15.00	Session 17 **Renewable Energies and Sustainable** Chair: Ahmet Durmayaz	Session 18 **Global Warming and Environment** Chair: Eralp ÖZİL Paris Agreement, COP 27, IPCC Synthesis Report, UN 2030 sustainability platform, and local governments in Turkey	Session 19 **Renewable Energies and Sustainable** Chair: Yeliz Konuklu	Session 20 **Renewable Energies and Sustainable** Chair: Melik Ziya Yakut
	#24 "Recycling perovskite materials for sustainable solar technologies: Recovery of high cost fto substrates" #88 "Investigation of O2 ratios on structural and optical properties of ito films for high-efficiency silicon heterojunction solar cells" # 100 "A study on green hydrogen production potential in Canada" *Topkapı*	#124 "A case study of carbon footprint measurement in university campus" #61 "Calculation of the footprint of a local government in Turkey: The case of Seydikemer district" #62 "Estimation of the cost of converting all road transportation vehicles in Turkey to net zero emitting electrical vehicles by 2035 #65 "Eco friendly production options in sanitary ware industry: Carbon footprint and sustainability approach" *Boğaziçi*	# 83 "Humic acid based phase change material microcapsules for thermal energy storage" #54 "A Study of Hydrogen Production Potential via Iron-Chlorine (Fe-Cl) and Magnesium Chloride (Mg- Cl) of the A Fusion Reactor " # 18 "Life cycle assessment of different energy sources for municipal gasification system" #51 "Graphene nanosheet synthesis from waste plastics via pyrolysis" *Taksim*	#120 "Enhanced exergetic performance of a geothermal-based organic rankine cycle through employing partially evaporated working fluid" #121 "Evaluation of inverter types used in solar energy systems with multi-criteria decision making (MCDM) #122 "Evaluation of solar based green hydrogen production technologies with multi-criteria decision making (MCDM)" #38 "Reduction of energy costs from groundwater treatment using biochar application in terms of water-energy nexus: Development of energy cost indicator" *Haliç*
16.45	*Tea Break*			
17.00-17.30	Keynote Speaker: Prof. Dr. Birol Kilkis Title: Micro Fuel Cells for Combined Heat and Power in the Quest of Decarbonization versus Complete Electrification in EU Countries Venue: Small Conference Hall			
	Leaving by buses for the gala dinner			
18.30	Gala Dinner & Awards Ceremony			
22.00	Close			

Time	Day 3- Friday 16th June 2023			
09:30	Keynote Speaker: Prof. Dr. Sandro NIZETIC Title: The role of Photovoltaic Technologies in Energy Transition			
10.10	Keynote Speaker: Prof. Dr. Abdul-Ghani OLABI Title: Digital Twin & Artificial Intelligent for Renewable Energy & Energy Storage Systems Venue: Small Conference Hall			
10.40	COMFORT BREAK			
	Session 21	Session 22	Session 23	Session 24
10.50	**Renewable Energies and Sustainable** Chair: Salahaddin Bendak	**Global Warming and Environment** Chair: Meltem Vatan	**Renewable Energies and Sustainable** Chair: Mohammed Alfatih Salah Hamza Hamid	**Renewable Energies and Sustainable** Chair: Secil Pelin Aka
	#21 "Sustainability relevance in micro-volume housing" #73 "Water footprints in denim production" #32 "Performance of 3d electrodes fabricated from TIB2/Graphene/Carbon nanofiber composites in hydrogen evolution reaction" #38 "Reduction of energy costs from groundwater treatment using biochar application in terms of water- #9 "Examining the impact of global climate change on women in energy nexus: Development of energy cost indicator" *Topkapı*	#12 "Analyzing fast fashion retailers' efforts to reduce carbon footprint: The case of h&m and lc waikiki" #47 "Planning ports in changing climate - sea level rise and floating ports" #8 "Evaluation of environmental impacts of hydrogen production " #9 "Examining the impact of global climate change on women in terms of health inequity" *Boğaziçi*	#5 "A comparative study of alternative fuels for reducing marine emissions: Environmental, technical, and economic assessment" #90 "From sunlight to clean energy: harnessing plasmonic Ni nanoparticles and MoS2 for sustainable hydrogen generation in CdXZn1-XS" # 80 "The effects of calsium carbonate on hydrogen technologies: Biomass, water, and fossil fuel" and butyrate production" #1 "Parabolic trough solar collector assisted hydrogen production" *Taksim*	#128 "Forecasting wind power generation using machine learning algorithms" #81 "Sustainable Thermal Desalination and Hydrogen Production: An Analysis of a Renewable- Based Energy System from a Thermodynamics Perspective" #95 "Development and analysis of a multi-rotor wind turbine and solar energy-based integrated system for rural electrification" #103 "Performance assessment of a solar and biomass-based energy system having metal hydride-based thermal compressors" *Haliç*
12.00	*Tea Break*			
	Session 25	Session 26	Session 27	Session 28
12.15	**Renewable Energies and Sustainable** Chair: Nader JAVANI	**Global Warming and Environment** Chair: Mohammed Alfatih Salah Hamza Hamid	**Global Warming and Environment** Chair: Adnan Midilli	**Analysis** Chair: Alireza SOURI
	#42 "Exergoenvironmental assessment of a high- temperature based geothermal system: A case study" #99 "A geothermal energy-based thermochemical cycle integrated with a cement factory for carbon capture for methane production" #13 "Investigation of the effects of global warming in the Meriç basin with the innovative Şen test" #136 "Experimental investigation and analysis of domestic cooktop burners with different natural gas- hydrogen mixtures" *Topkapı*	#91 "Investigation of the effect of solar radiation on optimum insulation thickness" #106 "Metal organic frameworks loaded membrane for microbial fuel cell application" #113 "A study on global warming effect of Combined Cycle Power Generation Process" #107 "Education on Metaverse Platforms Effects on CO2 Footprint Reduction: Istanbul School of Metaverse Case" Boğaziçi *Boğaziçi*	#132 "The role of hydrogen in reducing global warming effects" #117 "Use of the fallout radionuclides technique for soil erosion assessment in northwest Morocco and southwest Türkiye: Comparative study" #49 "General planetary transport system is the tool of non-rocket space industrialization to prevent planetary ecological-resources" #131 "In the quest of decarbonization; combined heat and power versus heat pumps in electrification strategies" Taksim *Taksim*	#126 "TURKEY'S changing roles in the geopolitics of energy transport: A discursive approach" #130 "Thermodynamic analysis of geothermal power plant assisted organic Rankine cycle with ANN approach" #35 "Machine learning-based classification approach for improving renewable energy management in IoT-based smart grids" #41 "Optimal Design and Performance Evaluation of an Off-Grid PV System: A Case Study in Bebel, Iraq" *Haliç*
13.15	**Closing Ceremony & Announcement & Buffet Lunch** *Venue: Topkapı*			

ORAL PROCEEDINGS

PARABOLIC TROUGH SOLAR COLLECTOR ASSISTED HYDROGEN PRODUCTION

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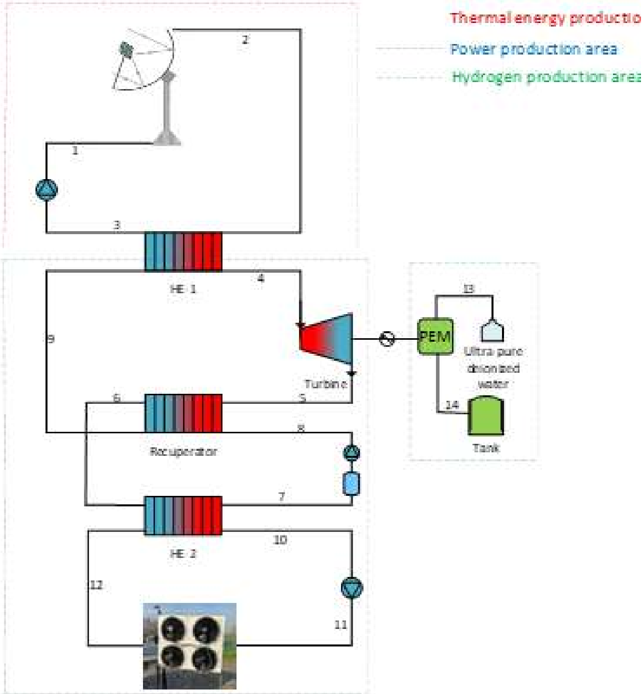
ABSTRACT
The authors discuss the solar-assisted hydrogen production system in this study. A parabolic trough collector is used to benefit from solar energy. The thermal energy obtained from the collector is converted into electrical energy in a uniquely designed organic Rankine cycle (ORC). The generated electrical energy is transferred to the proton exchange membrane (PEM) electrolyzer for hydrogen production. In this way, solar energy-assisted hydrogen production is realized. The presented work is considered holistic. As a result of the study, the energy efficiency of the S-1 system is calculated as 0.33%.

Keywords: Hydrogen production, Solar energy, Parabolic solar collector, ORC

1. INTRODUCTION
There are three main causes of global warming. These; human effects, volcanic activities and solar radiation. While volcanic activities and solar radiation are unavoidable parameters, the increase in emissions caused by human effects can be reduced or prevented [1, 2]. For this reason, reducing the emission values caused by human effects provides environmental and economic benefits. The great majority of emissions due to human effects come from the use of fossil fuels. For this reason, alternative solar energy systems to fossil fuels are widely used. Solar energy is divided into two groups as direct electricity generation systems and indirect electricity generation systems. Indirect power generation systems can also be divided into focused and non-focused. Among the focused systems, parabolic trough collectors are systems with medium and high temperature density. The resulting high temperature is converted into electrical energy using ORC [3].

Hydrogen energy comes to the fore in countries' energy policies on decarbonization. In terms of heating value, hydrogen is much higher than many energy sources such as fossil and coal. In addition, hydrogen energy is expressed as environmentally friendly energy when evaluated from an environmental point of view [4]. There are different methods of producing hydrogen. In this study, hydrogen production by the water electrolysis method is discussed.

2. MATERIAL AND METHODS
In this study, solar energy assisted hydrogen production system is discussed. Parabolic trough solar collector is used to benefit from solar energy. The working fluid from the collector is transferred to the ORC system for electricity generation. Heat transfer oil is used as the working fluid in the collector. In the ORC system, R1234yf is preferred as the working fluid. The study was examined according to two different scenarios. According to Scenario-1 (S-1), all of the electrical energy obtained in the ORC system is spent for hydrogen production. According to Scenario-2 (S-2), a part of the generated electrical energy is spent for hydrogen production. According to these two different scenarios, the efficiency of the system and the obtained thermodynamic values are presented comparatively. The flow chart of the investigated parabolic-based hydrogen production system is presented in Figure 1.



The design and analysis parameters of the whole system are given in Table 1. The energy and exergy balance equations applied to the waste heat-ORC based hydrogen production system are given below [5, 6];

$$\sum \dot{m}_{in} = \sum \dot{m}_{out} \quad (1)$$

$$\dot{Q}_{in} + \dot{W}_{in} + \sum(\dot{m}_{in}h_{in}) = \dot{Q}_{out} + \dot{W}_{out} + \sum(\dot{m}_{out}h_{out}) \quad (2)$$

$$\dot{Q}_U = A_c F_R[I\varepsilon\rho - U_L(T_{in} - T_{amb})] \quad (3)$$

$$\dot{Q}_{solar} = IA\varepsilon\rho \quad (4)$$

$$\eta_{col} = \frac{\dot{Q}_U}{\dot{Q}_{solar}} \quad (5)$$

Equipment	Value
Turbine input temperature	170 °C
Turbine input pressure	45.7 bar
Turbine output temperature	85 °C
Turbine output pressure	7.3 bar
Pump input temperature	57.3 °C
Pump input pressure	7.21 bar
PTC input temperature	32.5 °C
PTC output temperature	180.2 °C
PTC output pressure	4.2 bar
Flow rate in PTC	0.18 kg/s
Flow rate in ORC	0.052 kg/s
Isentropic efficiency of turbine	%67
Electricity efficiency of turbine	%90
Mechanical efficiency of turbine	%85
Heat exchanger effectiveness	%94
Pump efficiency	%82

3. RESULTS AND DISCUSSION

The scenario-1 and scenario-2 modules evaluation of the solar energy-based hydrogen production has discussed in this section. The experiments have carried out for different parameters considered under different collector output temperature and mass flow rate conditions. Furthermore, this section presents the energy efficiency of the scenario-1 and scenario-2 analysis results of the investigated solar based hydrogen production system. In addition, parametric analyses are presented to investigate the mass flow rate and collector output temperature conditions, which are effective on the whole system's performance.

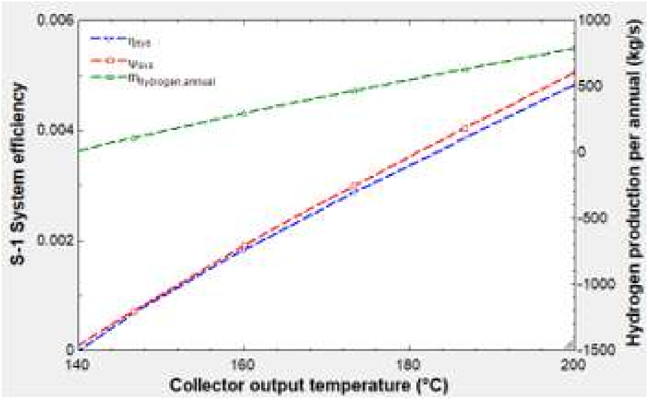


Fig. 2. S-1 system efficiency and hydrogen production amount depending on collector output temperature

4. CONCLUSIONS

In this study, a solar-assisted electricity and hydrogen generation system using parabolic troughs was experimentally investigated. The feasibility of green hydrogen production has been demonstrated in terms of thermodynamics. As a result of the study, the energy efficiency of the collector, ORC energy efficiency, PEMe energy efficiency and the energy efficiency of the whole system were calculated as 5.4%, 6%, 2.7% and 0.3%, respectively.

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TWO-OBJECTIVE OPTIMIZATION OF INTEGRATED ETSC-BASED ORC FOR POWER AND HYDROGEN GENERATION

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ABSTRACT

In this study, a modified solar-Organic Rankine Cycle (ORC) assisted hydrogen production system for two different scenarios was experimentally investigated. In the study, evacuated tube solar collector (ETSC), ORC system, Proton exchanger membrane electrolyzer (PEMe) unit are discussed with a holistic perspective. The presented work includes energy analysis of solar-ORC assisted hydrogen production. According to scenario 1 (S-1), only the case of hydrogen production from the installed system is considered. According to Scenario 2 (S-2), the coexistence of electrical energy and hydrogen production from the installed system is examined. As a result of the study, the energy efficiency in S-1 and S-2 operating modes was calculated as 5.53% and 9.28%, respectively.

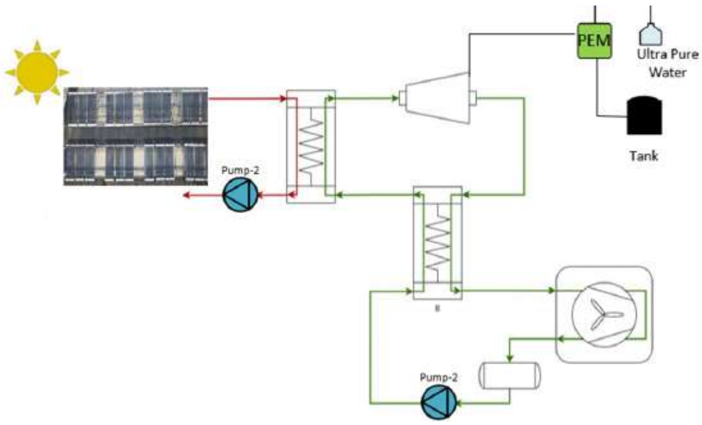
Keywords: Solar-ORC, Hydrogen production, Energy and exergy analysis, Solar energy, Hydrogen energy

1. INTRODUCTION

Although global energy consumption differs according to the level of development of countries, it generally increases by 1.6% annually [1]. Existing fossil resources are insufficient to meet this increase in energy consumption. In addition, considering the environmental effects of fossil resources, countries using fossil resources will be far from the targets promised in their climate agreements. Renewable energy sources, which are used instead of fossil sources, are an important solution to producing clean energy [2]. The use of renewable energy sources and hydrogen energy will reduce the use of fossil fuels. Depending on this decrease, negative environmental impacts due to fossil fuels will decrease. Considering recent studies, the use of renewable energy sources in hydrogen production is becoming increasingly common. In particular, solar-assisted hydrogen production has an important place in green hydrogen production. There are two basic methods to benefit from solar energy. These are PV systems with direct electricity generation and thermal systems with indirect electricity generation. Solar collectors are used to producing indirect electricity. Electrical energy is produced by using thermal energy Rankine/Organic Rankine Cycle and Kalina Cycle obtained from solar collectors [3, 4]. There are two basic requirements for hydrogen production. These are water and electricity. Electricity is provided from solar energy. When examining the studies in the literature, Wang et al. They presented a performance analysis of a hydrogen production system integrated into a hybrid energy system. Parabolic trough collector is preferred for solar energy generation, gas-steam turbine combined cycle and ORC are preferred for electricity generation. In addition, PEM was used for hydrogen production. In addition, 40% KNO-60% $NaNO_3$ molten salt was used as the working fluid. As a result, 102 MW of electricity was produced from the proposed system and the total electricity efficiency of the system was calculated as 44.2%. In addition, daily hydrogen production was measured as 172.4 kg. The main purpose of this study is to experimentally calculate the energy efficiency of electricity and hydrogen production in a roof application where hydrogen production is made according to two different working models.

2. EXPERIMENTAL STUDY

In this study, a thermodynamic analysis of a power generation system designed for two different operating scenarios is presented. In the study, which is based on solar-assisted electricity and hydrogen production, an evacuated tube U-type solar collector was used for thermal energy production. A total of 24 collectors were used in the roof-type solar energy system. There are 17 evacuated tubes in each collector. Each collector has equal dimensions of 1800 mm in length and 1200 mm in width. In addition, the surface area of each panel is 1.92 m2. The measurements made in the study were carried out in Turkey during the summer months. Water is preferred as the working fluid in the solar collector. The water in the collector is circulated at a flow rate of 1.53 kg/s. It is designed the collector integrated organic Rankine cycle (ORC) for electrical power generation. The ORC system uses the thermal energy obtained from the collectors as a heat source. The ORC system is a modular electricity generation system with an installed power of 5 kW. The ORC system is designed with on-grid grid connection turbine frequency control. A brazed heat exchanger is used as the evaporator. It was installed condenser as cooling system. A recuperate is used as an interconnector to increase efficiency in the ORC system. In this way, the working fluid at the turbine exit is subjected to a pre-cooling process before entering the condenser. Mixed gas was used as the working fluid in the ORC system. According to S-1, all of the electrical energy obtained from the turbine is transferred to the PEMe unit for hydrogen production. The main purpose of S-1 is to focus on the entire process of hydrogen production. According to S-2, the whole process focuses on the simultaneous production of both electricity and hydrogen. Although the amount of hydrogen obtained in S-2 is less than in S-1, the total useful work is more due to electricity generation. The flow chart of the study presented in Figure 1 is shown.



3. THERMODYNAMIC ANALYSIS

The presented solar-ORC based hydrogen generation system consists of three main parts. These are ETHPSC, ORC and PEMe. The first laws of thermodynamics are applied to each component in these three parts with a holistic approach. Engineering equation solver (EES) software is used for thermodynamic analysis and graphs are obtained depending on the results of this analysis. The design parameters of the whole system are given in Table 1. The thermodynamic analysis parameters of the whole system are given in Table 2. The hydrogen production parameters are given in Table 3. The energy and exergy balance equations applied to the solar-ORC based hydrogen production system are given below [6-9];

$$\sum \dot{m}_{in} = \sum \dot{m}_{out}$$

$$\dot{Q}_{in} + \dot{W}_{in} + \sum(\dot{m}_{in} h_{in}) = \dot{Q}_{out} + \dot{W}_{out} + \sum(\dot{m}_{out} h_{out})$$

Table 1. Design parameters

Parameter	Value
Solar radiation	750 W/m2 (constant case)
Collector number	24 pieces
Tube number	408 pieces
Dimensions of each collector	1.92 m2
Outer diameter of the glass	47 mm
Inner diameter of the glass	38 mm
Absorptivity coefficient of the glass	0.92
Emissivity coefficient of the glass	0.07
Working fluid (Collector)	Water
Working fluid (ORC)	Mixed fluid

Table 2. Analysis parameters

Parameter	Value
Collector output temperature	93.2 °C
Collector input temperature	84.6 °C
Collector output pressure	3.10 bar
Turbine input temperature	90.6 °C
Turbine input pressure	26.68 bar
Turbine output temperature	43.8 °C
Turbine output pressure	8.13 bar

Cooling input temperature	30.8 °C
Cooling output temperature	36.3 °C
Turbine electrical efficiency	0.90
Turbine mechanical efficiency	0.85
Heat exchanger effectiveness	0.93

Table 3. Hydrogen production parameters

Parameter	Value
Reaction	$H_2O \rightarrow 2H^+ + \frac{1}{2O_2} + 2e^-$
Output flow rate (in 150 W)	300 - 320 ml/min
Output pressure	0.02 – 0.4 MPa
Min. input power	150 W
Power voltage	AC 220 50-60 Hz
Purity of Hydrogen	%99.999
Electrolyser working temperature	25 °C
PEMe efficiency	%60-%85
Conductivity of water	0.045-0.056 µS

ETHPSC is used in the presented solar-ORC system and the useful solar thermal energy and exergy values can be calculated as follows [10-12];

$$\dot{Q}_U = A_c F_R [I\varepsilon\rho - U_L(T_{in} - T_{amb})]$$

$$\dot{Q}_{solar} = IA\varepsilon\rho$$

$$\eta_{col} = \frac{Q_U}{Q_{solar}}$$

3. RESULTS

The results of the presented study and the S-1 and S-2 evaluation of the solar-assisted hydrogen production have been discussed in this section. The experiments have been carried out for different parameters considered under different solar radiations and collector output temperature conditions. Furthermore, this section presents the energy efficiency of the S-1 and S-2 analysis results of the investigated solar-based hydrogen production system. In addition, parametric analyses are presented to investigate the solar radiations and collector output temperature conditions, which are effective on the whole system's performance. In Figure 2, energy production and consumption values are shown depending on the collector outlet temperature. If the collector outlet temperature changes between 80°C-150°C, the change in the amount of energy obtained from the turbine and ORC system is shown. In addition, the change in the energy consumption value of the pump in the ORC system at similar outlet temperatures is shown. Depending on the increase in the collector outlet temperature, the amount of energy produced from the turbine and the ORC system also increases. However, the energy consumption of the pump also increases with a similar trend. In the parametric study, it is seen that the theoretical work to be obtained from the turbine will increase, but the net work will decrease depending on the increase in the collector outlet temperature. The decrease in net work output is due to the increase in pump consumption. The cooling system needs to be improved to prevent this increase in pump and decrease in net production. Adding an additional cooling system to the existing system will also increase theoretical net work output.

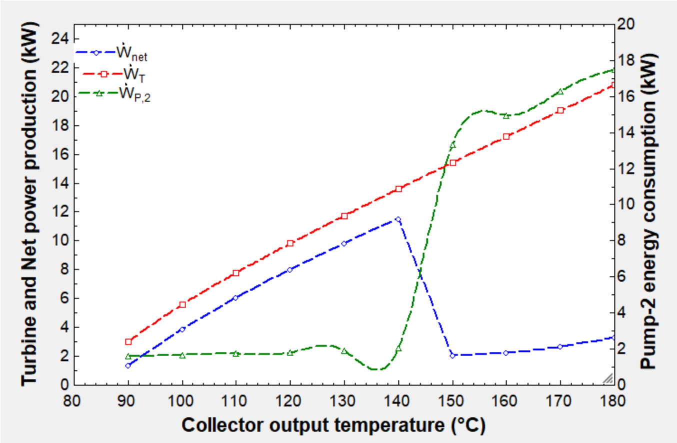


Figure 2. Energy production and consumption depending on the collector outlet temperature

4. CONCLUSIONS

In this study, the experimental analysis of the modified ORC system integrated hydrogen generation system for the roof type application ETSC is presented. The thermodynamic analysis of the system designed for two different operating scenarios according to the real operating conditions is discussed. The important results obtained in the study are presented below;

- The energy efficiency of ETSC is calculated as 59.05%.
- The energy efficiency of the ORC system was calculated as 4.32%.
- The energy efficiency of the turbine was measured as 3.8 kW.
- According to the S-1 and S-2 scenarios, the energy efficiency of the entire system was calculated as 5.53% and 9.28%, respectively.

In the presented project, the circulation of liquid fluids is very difficult due to the selection of the U-type ETSC collector system and the high number of collectors. The main problem of this study is that the energy consumed in the pump is close to the energy produced from the turbine in order to ensure the circulation of the working fluid in the collector. In order to avoid this problem, circulation is provided at low pump consumption by changing the connections between the collectors in the ETSC system.

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OPTIMIZATION OF CARBON TRADING AND RENEWABLE ENERGY MANAGEMENT BY USING BLOCKCHAIN TECHNOLOGY AND ARTIFICIAL INTELLIGENCE.

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ABSTRACT
This article showcases the idea of using blockchain technology and artificial intelligence for efficient carbon trading and renewable energy management optimization. On the one hand, the concept of carbon trading was adopted around the world to resist carbon emissions but it has its own challenges like lack of transparency and regulations. On the other hand, renewable energy sources are gaining power thus data accuracy and control are needed. It is assumed that through advanced digital technologies like blockchain and artificial intelligence, carbon emissions and smart energy management can be further improved.
Keywords: Carbon trading, Renewable energy, Blockchain technology, Artificial intelligence

1. INTRODUCTION
Due to climate change and environmental degradation, concern over carbon emissions and the ways of controlling and reducing them has rapidly increased. Carbon trading and renewable energy sources are examples of a global approach to reducing pollution. However, achieving reliable management of carbon and economic assets requires better and more efficient organization. It is assumed that the application of blockchain technology with the help of artificial intelligence in the future can develop a new automatic system.

As a response to high carbon emissions worldwide, at the end of last century in Kyoto, Japan was introduced the "Kyoto Protocol", which demonstrated the carbon trading mechanism based on the cap-and-trade principle as a new solution to the global warming question. A cap is the limited amount of greenhouse gasses (GHGs) that can be emitted. Under the carbon trade mechanism companies that emit less than the limit, are free to trade their allowances to companies that exceed the permitted emission level. Generally, carbon trading has proven to be a successful strategy against emissions. Policies, financial institutions, and support mechanisms have been established (Zhang et al., 2021). The trade volume of carbon dioxide in carbon markets increased by half in the year 2021 (Statista 2022). Nevertheless, operational management systems have their limitations. One of the biggest challenges facing carbon trading is an establishment of a decentralized system for the governments and energy companies, where in registries the data and transactions will be stored and monitored ("The Palgrave Handbook of International Energy Economics," 2022), the number of greenhouse gasses emitted, allowances being offset and being traded. This requires a high level of accuracy and reliability in managing data.

Carbon trading is not the only worldwide system that can benefit in reducing GHG. The huge amount of CO2 emissions still are produced by fossil fuels. Another significant area of research and development has been the usage of sunlight and air as a source of Renewable Energy. As a result, it will be necessary to increase the performance of alternative energy sources in order to meet the world's future energy needs. Smart energy management can be achieved by addressing the limitations associated with the design, efficiency, performance prediction, and weather estimation of the area where the formation is located. Monitoring and scheduling the use of on-site energy resources and loads, maintaining bidirectional communication between, facilitating energy trading between the electric grid and other sites, and storing, processing, and informing stakeholders of pertinent data should all be goals of energy management (Jha et al., 2017).

2. BLOCKCHAIN TECHNOLOGY
Blockchain technology has the capability to increase the effectiveness of the carbon trading process. Blockchain is a distributed ledger system, the core technology of Bitcoin, that was founded by Satoshi Nakamoto in 2008. Blockchain eliminates or significantly lowers fees, decentralizes control, and allows the use of smart contracts to turn code into money. Technology itself presents "blocks" inside the "chain" where all the data is connected with a previous and the next one. Providing secure and transparent transactions, blockchain creates an immutable record of all transactions in a shared digital ledger, which is verified and encrypted. Blockchain can ensure that all information related is tamper-proof, secure, and decentralized. Inside the system, no organization can manipulate or compromise the data, because of the way chains or hashes are codependent. In addition, blockchain technology could enable the tracking of carbon offset data such as

renewable energy certificates or carbon credits, making the process more reliable and easier to verify (OECD, 2019). The smart contracts of blockchain-enabled carbon trading platforms can automate the process of rewarding companies for their clean energy efforts. Blockchain can also encourage greater participation in carbon trading. With traditional carbon trading systems, only large companies can afford to participate in the market. With the aid of blockchain-enabled platforms, the industry can enable small and medium-sized enterprises to participate in carbon trading, thereby increasing the association of participants. (Pan et al., 2019) This will help further reduce greenhouse gas emissions and encourage more companies to invest in clean energy. In addition, blockchain-based carbon trading systems can help eliminate carbon leakage, which is the negative impact of carbon trading when emissions move from regulated to unregulated markets. By implementing a global and standardized carbon trading platform, blockchain can reduce these environmental loopholes.

3. APPLICATION OF ARTIFICIAL INTELLIGENCE FOR CARBON TRADING

Artificial Intelligence (Al) is a software technology, a complicated operation of AI similar to the human brain, and provides the most suitable option from a variety of possible (Li et al., 2022). AI covers methods, forecasting, data analysis, neural networks, learning, and problem-solving topics (Loureiro et al., 2021).
Artificial Intelligence (Al) creates a new business model and approach to a trading system and energy sources regulation. The suggestion is that AI can play a critical role in optimizing and calculating carbon trading by improving the accuracy of carbon emissions data. Data mining also refines the information, allowing artificial intelligence to be trained iteratively with more accurate data (Li et al., 2022). The accuracy of carbon emissions data is essential to ensure that carbon credits are properly distributed and that the carbon market operates effectively. Al-based systems can help define these issues by using data analytics to provide more accurate and reliable GHG data. Al can also play a role in predicting carbon emissions, allowing market participants to make more informed decisions. Artificial Intelligence Predictive analytics can help companies and traders determine future demand for carbon credits, leading to more accurate pricing in the carbon market. Al can also assist in identifying trends and trading patterns that will improve investment choices and increase profits in the carbon market. Figure 2 presents expectations of how blockchain and AI could be applied in the carbon trading market.

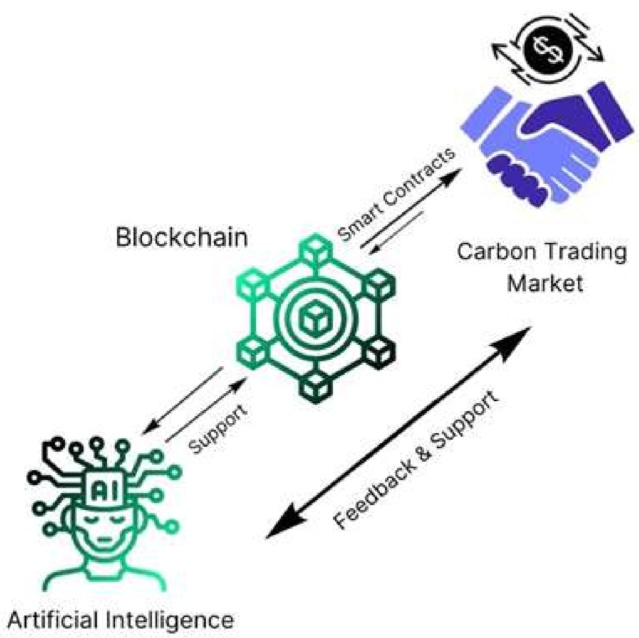

Figure 2. Application of Blockchain and Artificial Intelligence for Carbon Trading.

3.1. Application of Artificial Intelligence Renewable Energy

Artificial intelligence (AI) has been used to achieve sustainability in the energy sector, including generation, supply, and demand management design and control. AI has advanced significantly in recent years, and various AI-based techniques have been developed and implemented in various applications. All forms of renewable energy, such as wind, solar, geothermal, hydro, ocean, bioenergy, hydrogen, and hybrid energy, can be managed using AI models (Li et al., 2022).

The ability of Artificial Intelligence techniques to deal with nonlinear and complex data structures has led to their widespread application in the resolution of renewable energy-related problems. Issues with forecasting solar and wind energy, controlling the frequency of the power system, and evaluating transient stability can all be successfully resolved by AI (Zhang et al., 2022). Deep learning has significant advantages in solving complex problems like frequency analysis and control of power systems because of its powerful data analysis, prediction, and classification capabilities. Frequency is the key to maintaining the stability and safety of power systems, and frequency problems in modern power systems are becoming increasingly challenging (Zhang et al., 2022).
For the integration of renewable energy and Artificial Intelligence in energy smart systems (ESS), researchers have developed a variety of algorithms and techniques for optimization modeling, state estimations, and behavioral expressions.
A hybrid ESS control strategy is crucial for increasing resource utilization and energy efficiency. Commonly used techniques include dynamic programming, variable control, adaptive neuro-fuzzy inference systems control, and predictive control. The monitoring technique is typically complex, and it must operate continuously because sources are intermittent and must accomplish multiple goals (Abdalla et al., 2021).

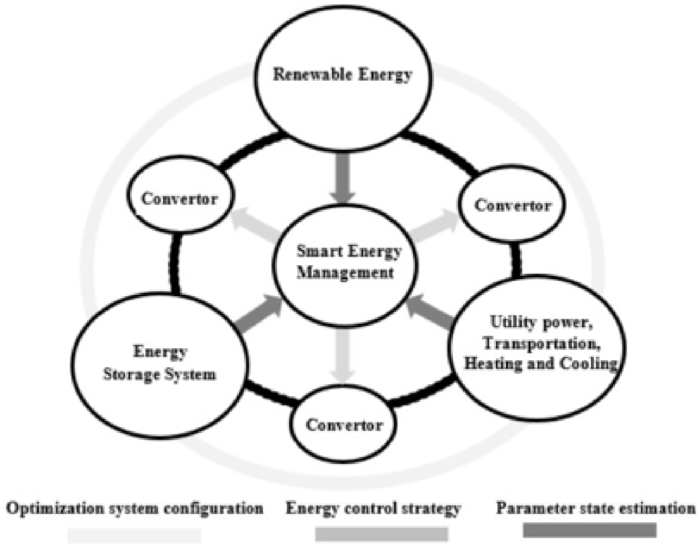

Figure 3. Application of Artificial Intelligence inside the smart energy management system
(Abdalla et al., 2021)

4. CONCLUSIONS

Both Blockchain Technology and Artificial Intelligence are popular and discussable topics now, with high expectations for the future. Hopefully, this idea will continue its development and bring us new models and achievements in the carbon trading system as in renewable energy management.

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NUMERICAL INVESTIGATION OF HYBRID THERMAL PHOTOVOLTAIC SYSTEM PERFORMANCE FOR SHIP PROPULSION IN ARABIAN GULF

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ABSTRACT

The global energy market is transferring from using fossil fuel to utilizing renewable energy systems on the way to reduce the harmful effects of the emissions and improve the overall efficiency in several applications. Implementation of renewable energy systems plays a significant role in controlling the greenhouse gases and non-greenhouse gases (GHG & NGHG) impact on the environment. Reducing the emissions from the maritime sector is a main goal of International Maritime Organization (IMO) using different types of regulations and control techniques. Present study investigates the possibility of implementing a hybrid solar thermal, photovoltaic system (PV/T) on a marine passenger ship to generate electrical power and meeting the heating purposes as well. The governing equations were solved numerically using a mathematical model developed in Matlab program. This was achieved by an iterative solution to reach the optimum solution. The optimal working conditions were selected based on Kuwait City ambient conditions on specific dates in summer and winter. Further, the system demonstrated its ability to provide stable electric source using the sized batteries and inverters that were sized based on the results from the Matlab. Finally, the results showed the possibility of improving the ship energy efficiency by utilising a hybrid solar thermal, photovoltaic system using different working fluids and increase the solar panel area as well.

Keywords: Renewable energy, Hybrid thermal photovoltaic, Greenhouse gas emissions, ship energy efficiency.

1. INTRODUCTION

Energy is one of the major factors for the human survival on earth. There have been many factors influencing the energy production over the past few decades. Renewable and sustainable energy systems need more investigations to provide sustainable development in terms of economic and technological growth [1]. Studies on energy conversion systems mainly focus on design, modeling and operation conditions of energy systems from different aspects [2]. Solar energy has been known as one of the most important renewable energy sources. With regard to energy management strategies for solar-diesel hybrid systems on land, several researchers have conducted extensive studies on the design [3], modeling, control and simulation [4], experimental performance [5], optimal management of hybrid power systems, optimum size of hybrid power systems [6], advanced controller design [7], and optimal operation of hybrid energy systems [8]. However, few studies have concentrated on strategies for energy management in solar-diesel hybrid ships. Liu et al. [9] investigated a solar-diesel hybrid ship consisting of solar energy, a storage battery, and a super capacitor. By establishing a mathematical model of the ship's movement, the characteristics of the solar power output were studied, and a method for suppressing its fluctuation using a dual-energy storage system was developed. Moreover, Guo et al. [10] proposed a load-flow calculation method for solar energy, a diesel generator, and battery hybrid ships, and also carried out a numerical simulation. Their results provided a theoretical basis for improving the stable and flexible output of PV systems.

3.2 - Photovoltaic Array size calculations

The photovoltaic module selection depends on the requirements for dimensions, efficiency, cost, and weight. For instance, the cost of the photovoltaic module depends on the efficiency and the material that has been used to produce the PV panel. The primary requirement is to find the area of the PV panel that is required to be purchased or designed. The equation for calculating the area of the solar panel is given as:

$$\mathbf{PV_{area}} = \frac{\mathbf{E_L}}{\mathbf{G_{av}} \times \boldsymbol{\eta}_{\mathbf{PV}} \times \boldsymbol{\eta}_{\mathbf{out}} \times \mathbf{TCF}} \qquad \textbf{(1)}$$

Where,

$\mathbf{G_{av}}$ The average solar energy input per day kWh/m²/day

$\mathbf{E_L}$ The average energy (load) demand per day

kWh/day

$\boldsymbol{\eta_{PV}}$ Solar PV module efficiency at standard test conditions y

$\boldsymbol{\eta_{out}}$ Battery and inverter efficiency

TCF Temperature correction factor

To calculate the temperature correction factor for the PV module, equation (2) is given [6]:
To calculate the temperature correction factor for the PV module, equation (2) is given [6]:

$$\boldsymbol{TCF_{PV} = [1 - (T_{PV} - 25) \times (-0.5\%)]} \qquad \textbf{(2)}$$

Where,

$\mathbf{T_{Pv}}$ Photovoltaic panel surface temperature

The relationship between the photovoltaic area and the energy demand is considered an important aspect. The temperature of the photovoltaic is 70.1°C based on previous experimental trials. Further, the relationship between the electrical energy demand and the photovoltaic area with varying efficiency from 10-18%, where the surface of the proposed system is kept at temperature 55°C.
The selected photovoltaic panel specification is shown in Table 2, where the specifications are shown at standard test conditions and the rest of the information.

Term	**Specification**
Model	SXp154L
Cells per module	36
Maximum power	154 Wp
Maximum power voltage	18.3 V
Maximum power current	8.5 A
Open circuit Voltage	23 V
Short circuit current	9.1 A
Panel efficiency	18%
Panel dimensions	1523x683x2 mm
Panel weight	2.4 kg

The proposed photovoltaic system calculates will be based on a module temperature of 55°C as previously stated and thus the temperature.

correction factor can be calculated from equation 2 as follows:

$$TCF_{PV} = [1 - (55 - 25) \times (-0.5\%)]$$

$$TCF_{PV} = 0.85 \qquad (4)$$

From equation 1, the area of the photovoltaic modules required can be calculated as follows:

$$\mathbf{PV_{area}} = \frac{\mathbf{40}}{\mathbf{8 \times 0.18 \times 0.765 \times 0.85}} \qquad (5)$$

$$\mathbf{PV_{area} = 43\ m^2} \qquad (6)$$

The sample of the general arrangement of the proposed system is shown in Fig. 1, where the length of the front area is utilised for the solar panels. The dimensions of the vessel are 49.4 by 12.2 meter and a 2.5-meter height.

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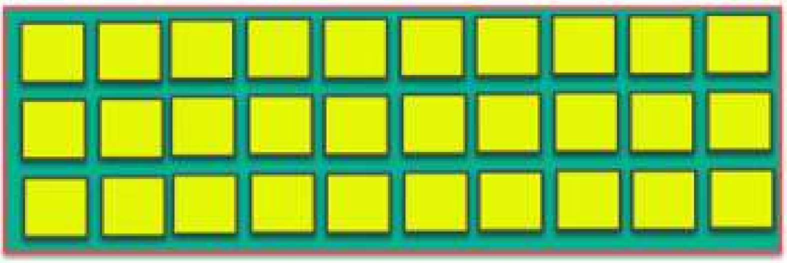


Figure 1 Schematic diagram of the front area utilised for solar energy harvesting

The number of hybrid panels that will be installed in the front area can be calculated as follows:

$$\mathbf{Number\ of\ modules} = \frac{\mathbf{Total\ area\ required}}{\boldsymbol{Area\ of\ the\ module}} \qquad (7)$$

$$\mathbf{Number\ of\ modules} = \frac{\mathbf{43}}{\mathbf{1.04}} = \mathbf{41.33} \approx \mathbf{42}\ \boldsymbol{module} \qquad (8)$$

These modules will be used to power a generator and supply energy to the ship for the demand load of 40 kW and save daily fuel consumption of 20% of the energy supplied.

.2.3 – Battery sizing

The storage capacity of the lead acid or dry batteries can be calculated using the following equation.

$$\mathbf{Storage\ capacity} = \frac{\mathbf{N_C \times E_L}}{\mathbf{DOD \times \eta_{out}}} \qquad \mathbf{(9)}$$

N_C The largest number of continuous cloudy days

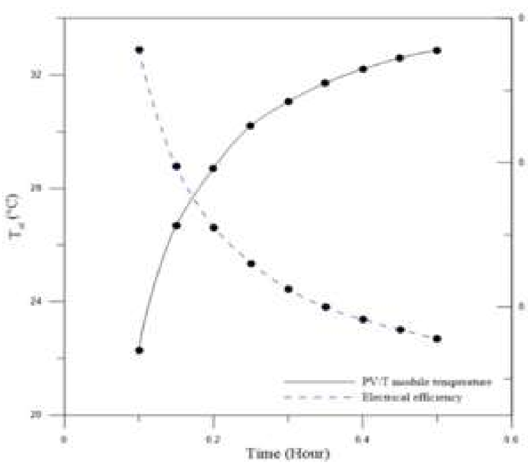
The maximum permissible depth of discharge for the battery

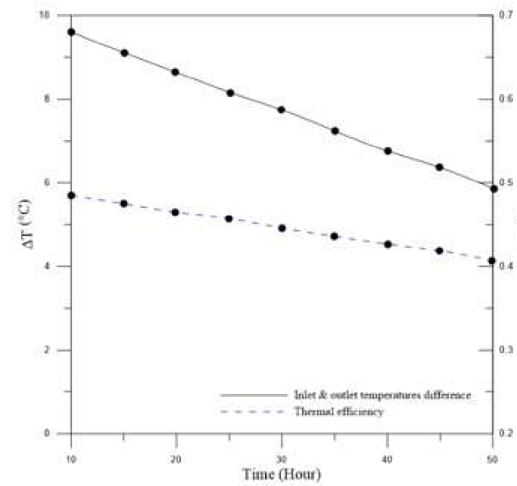
4. RESULTS AND DISCUSSIONS

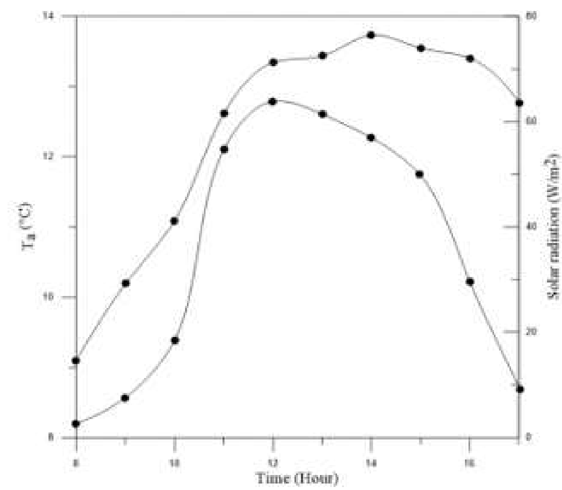
There have been several studies, which investigated the hybrid PV/T system with comparison to the standalone PV system. The thermal-photovoltaic system was modelled using an in-home MATLAB code to analyze and balance the basic heat transfer equations. The data of solar radiation are based on Kuwait city and were used for respective ambient temperature. The PV module main influential parameters such as glass cover temperature, module temperature, absorber plate temperature were computed using the developed model. Figure 12 shows the variation of the solar radiation along with the ambient temperature for a specific day in winter season under the climatic conditions of Kuwait. It can be observed from the figure that the ambient temperature varies between 7 and 12°C whereas the solar radiation varies between 0 and 72 W/m. The hourly variation of the photovoltaic module temperature (TPV) against the temperature dependent electrical efficiency at a mass flow rate of 0.1 kg/s is shown in Figure 15. In addition, the temporal variations of solar radiation and ambient temperature, the TPV rises in forenoon and falls after around 3 pm due to the reduction in solar radiation and ambient temperature.

Figure 14 Variation of solar radiation as a function of ambient temperature in winter

Figure 15 Variation of module temperature and electrical efficiency







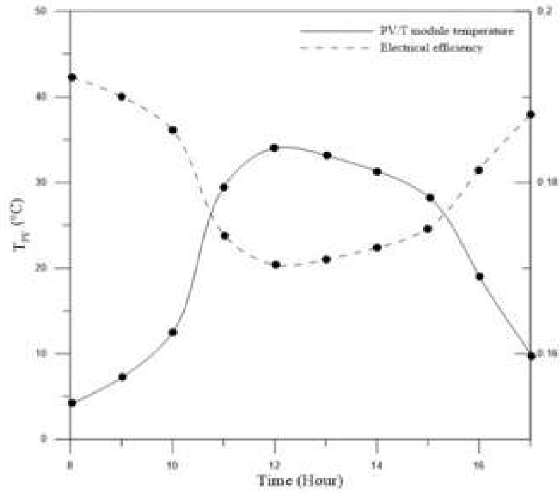


Figure 16 Variation of outlet temperature and electrical efficiency

Figure 17 Variation of temperature different and thermal efficiency

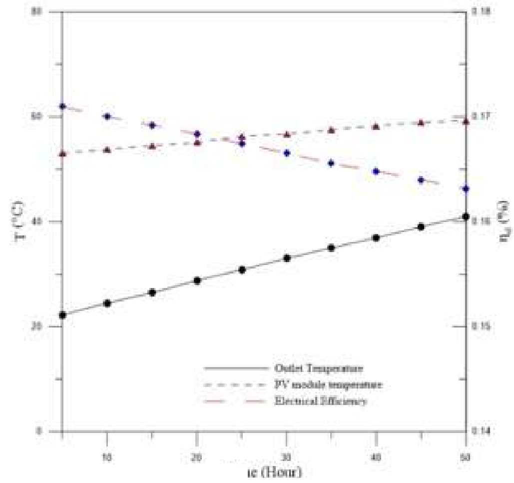


Figure 18 Variation of Photovoltaic temperature, [thermal or electrical] efficiency and outlet temperature with time

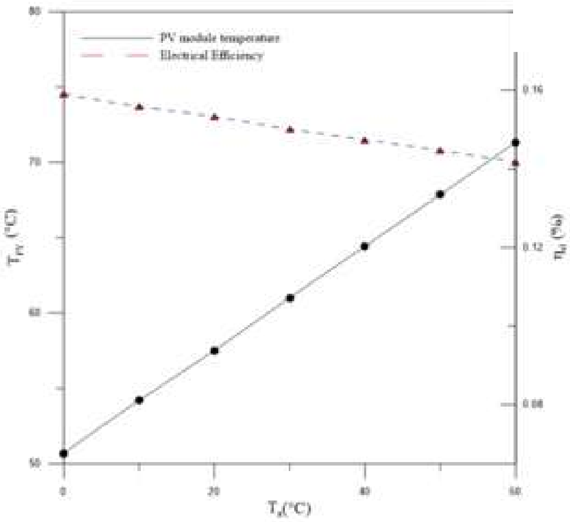


Figure 19 Variation of Photovoltaic temperature and [thermal or electrical] efficiency along with ambient temperature

5. Conclusions

The results showed that when the average temperature of the working fluid was equal to the ambient temperature, the thermal efficiency increased by 3.6% and the electrical efficiency increased by 5.8%. It implies that the mathematical model of the PV/T collector is basic accurate based on previous studies. Moreover, at low inlet temperature of the working fluid results a very high overall energy efficiency of the PV/T collector.

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A COMPARATIVE STUDY OF ALTERNATIVE FUELS FOR REDUCING MARINE EMISSIONS: ENVIRONMENTAL, TECHNICAL, AND ECONOMIC ASSESSMENT.

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ABSTRACT
The study evaluates the environmental and economic benefits of both natural-dual fuel engines and methanol-dual fuel engines, using a container ship as a case study. Results show that the use of natural gas in a dual fuel engine significantly reduces NOx, SOX, CO2, PM, and CO emissions by 83%, 95%, 19.4%, 95%, and 32.6%, respectively, with a percentage of 95% NG and 5% MDO. On the other hand, using methanol as a dual fuel with a 95% Methanol percentage also reduces emissions, but to a lesser extent.
Keywords: IMO regulations, Natural gas, Greenhouse gas emissions, ship energy efficiency

1. INTRODUCTION
One solution for addressing the depletion of fossil fuels is to explore alternative marine fuels (Elkafas et al., 2019). These alternative fuels can be categorized into two groups: liquid fuels, which include methanol, ethanol, and biodiesel, and gaseous fuels, which include propane, natural gas, and hydrogen (IMO 2018). Based on research, natural gas, and methanol are the most promising alternative marine fuels (Sadek and Elgohary 2020). Natural gas is effective in reducing emissions, including nitrogen oxide, and is available in compressed or liquid form. Methanol is also effective in reducing emissions and meeting the IMO 2020 requirements (Jayaraman et al., 2019).

These studies, however, primarily focused on the environmental effects as a determinant of whether alternative fuel is acceptable for use in the maritime sector, without considering technical evaluation, attaining IMO specifications, or economic impact such as cost-effectiveness (Kesieme et al., 2019). The objective of this study is to evaluate the environmental and economic benefits of using alternative marine fuels, specifically natural gas, and methanol, considering the A13-class container ship as a case study.

2. Methodology
2.1 - Environmental Analysis
Firstly, the total emission for ships during one travel per ton can be calculated by using Eq. (1). The ship emission (EM) depends on the main engine power (Pw) in kW, the operation trip time (T) in h, the load factor (Lf) to take the consideration of maneuvering and standby during the trip, and fuel pollution factor (Pf) in g/kWh; (i) is the type of emission, (f) is the type of fuel (Ammar 2019; Ammar and Seddiek 2020).

$$EM_{trip,i,f} = \sum\left[t\left(P_w . L_f . P_{f,i}\right)\right] \quad (1)$$

The Energy Efficiency Design Index (EEDI) is used to assess energy efficiency and CO2 pollution during ship operation (Elkafas et al. 2021). EEDI calculates energy efficiency for ships with gross tonnages over 400 metric tons using a complex formula based on emission, speed, and capacity, which can be evaluated by using Eq. (2-5).

$$EEDI_{require} = \left(1 - \frac{X}{100}\right) * \frac{z}{DWT^y} \quad (2)$$

$$EEDI_{attained} = \frac{(ME(s) + AE(s) - innovative\ technology)}{Transport\ work} \quad (3)$$

$$ME(s) = \left\{\sum_{i=1}^{nME} P_{ME(i)} . C_{FME(i)} . SFC_{ME(i)}\right\} \quad (4)$$

$$innovative = \left\{\sum_{i=1}^{neff} f_{eff(i)} . P_{eff(i)} . C_{FME} . SFC_{ME}\right\} \quad (5)$$

Finally, the denominator (transport work) can be calculated by using Eq. (6), which fi,f1,fw, and fc are the correction factor for specific ship types.

$$Transport\ work = f_i . f_1 . f_w . f_c . V_{ref} . Capacity \qquad (6)$$

Both of specific fuel consumption (SFC) and conversion factor (CF) are related on fuel types, and for dual fuel engine, the term of SFC*CF can be evaluated by Eq. (7):

$$SFC_{DF} * CF_{Df} = SFC_{PF} * CF_{Pf} + SFC_{Gas} * CF_{Gas} \qquad (7)$$

Table (1) describe for EEDI Parameters

DWT	Dead Weight Tonnage
ME, AE	Main Engine, Auxiliary engine
$P_{ME(i)}$	Power output from main and auxiliary engine
SFC	Specific fuel consumption for engines
C_{FAE}	The fuel conversation factor from engines
MCR_M	The maximum continuous rating
$P_{PTI(x)}$	The shaft motor mechanical power
P_{eff}	Power saving Because of innovative electrical

2.2 - Economic analysis

The economic analysis for using methanol or natural gas was evaluated by calculating the reduction of ship emissions annual cost-effectiveness ECE, as shown in Eq. (8):

$$EAC_{CE} = \frac{ACC+AMC}{RE} \qquad (8)$$

3. Case study: container ship

In this study, an A13-class container ship was selected to study the environmental and economic impacts assessment process from using alternative fuels instead of diesel fuel. The container vessel AL RIFFA was built in 2017 with 13500 containers and sailing under Malta flag (Al Riffa 2022). The relation between the specific fuel consumption and MCR can be used to calculate SFC (El Gohary and Abdou 2011). For 85%MCR, SFC is 169.1 (g/kWh). For low-speed diesel engines, the emission factors are 17 g/kWh, 0.36 g/kWh, 688.79 g/kWh, 0.19 g/kWh, 1.4 g/kWh, and 0.6 g/kWh for NOx, SOx, CO2, PM, CO, and HC, respectively. Both NOx and SOx emissions are incompatible with current IMO limitation as IMO 2016 regulation reduced NOx emissions to less than 3.4 g/kWh.

4. Results and discussion

To begin, the pollution factor such as PNOX, Psox, PCO2, PPM, Pco, and PHC for marine diesel oil, natural gas and methanol was calculated, For MDO (0.1% S), the pollution factors at slow speed diesel engine were 688.79 g/kWh, 0.36 g/kWh, 17 g/kWh, 0.19 g/kWh, 1.4 g/kWh, and 0.6 g/kWh for CO2, SOx, NOx, PM, CO, and HC, respectively, while for NG, the emission factors were 548.2 g/kWh, 2.16 g/kWh, 0.92 g/kWh, and 1.4 g/kWh and for methanol fuel were 275 g/kWh, 2.47 g/kWh, 0.54 g/kWh, and 0.9205 g/kWh, respectively. We are now investigating the impact of dual fuel injection on pollution factors. Fig. 1 shows the effect of using methanol and natural gas on SOx, PM, CO and HC emissions.

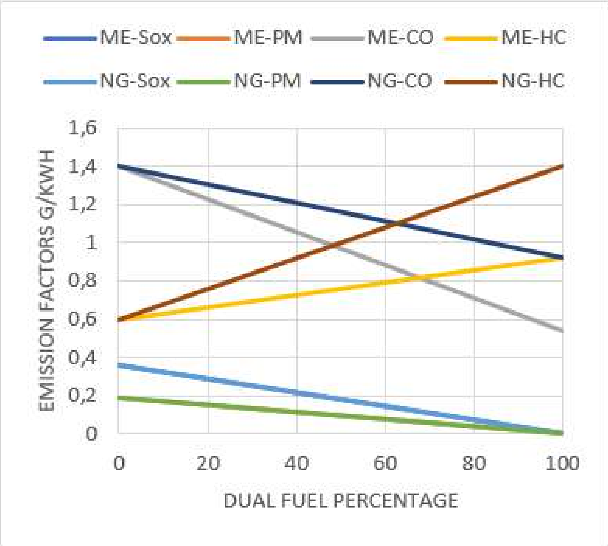


Fig. 1 the PM, SOX, CO, and HC emission factor reduction for NG and ME

According to IMO 2016 limitations, the NOx emission rate is based on engine speed and equals 3.5549 g/kWh. Fig. 2 describes the reduction effect of using methanol and natural gas compared with diesel fuel. The NOx emission reduced to 2.6153 g/kWh and 2.3084 g/kWh, respectively. According to Fig. 2, using natural gas dual fuel with ratio above 90% NG or Methanol with ratio above 93% ME will be compliant with the new IMO requirements

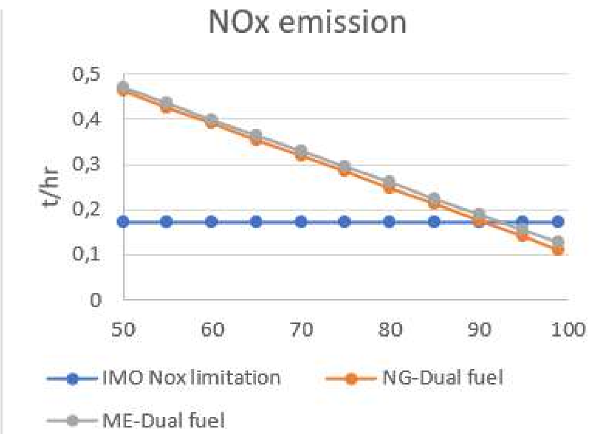
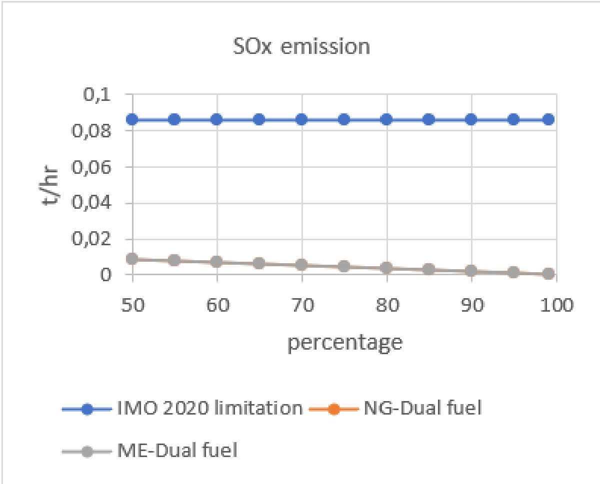


Fig. 2 Rates of NOx emission at various pilot fuel percentages

For SOx emissions, IMO 2020 imposed new requirements for fuel oil used on board ships should not exceed 0.5% sulfur that equals 0.0857 ton/hr. As shown in Fig. 3, there was a similarity for using dual fuel by natural gas or methanol that complied with IMO limitations for each dual fuel percentage



4.1. Energy efficiency assessment

The required EEDI for the Al-Riffa ship, which was built in 2012, is 15.971 gCO2/ton-nm at the DWT 145528 ton. According to IMO, this value should be reduced to 20% at phase 2 and equal 12.777 gCO2/ton-nm. Another value is the attained EEDI, and then compare this value with required EEDI in phase 2. Based on IMO regulations, the service speed (23 kn) can be used as a reference velocity and 70% DWT is considered as a ship capacity. The actual EEDI is 14.83 gCO2/ton-NM; this value reduced from required EEDI with ratio 7.14%, which is lower than the required EEDI, but will be incompatible with phase 2 from 2020 to 2025, as shown in Fig. 4.

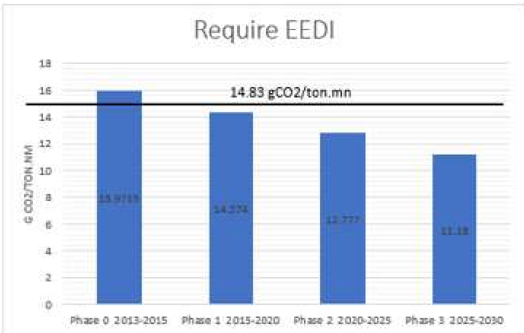


Fig. 4 The required EEDI for the Al-Riffa ship

It is now necessary to calculate the total emission per trip and the annual emission for each emission factor. For this, a dual fuel engine with 90% natural gas and 93% methanol was used to evaluate the emission factor, as shown in Table 2.

Table 2 the emission factor during, operation, maneuvering, and standby by using dual fuel.

	type of emission	during operation (kg/hr.)	during maneuvering (kg/hr.)	during standby (kg/hr.)
90%NG	NOx	197.019	46.3575	11.5894
	SOx	1.9464	0.45789	0.11449
	CO_2	30399.5	7152.83	1788.21
	PM	1.02727	0.24171	0.06043
	CO	52.3367	12.3145	3.07863
93% ME	NOx	188.536	44.3615	11.0904
	SOx	1.36248	0.32058	0.08015
	CO_2	16434.4	3866.92	966.731
	PM	0.7191	0.169197	0.04229
	CO	32.451	7.6355	1.90888

Table 3 Environmental analysis of the Al Riffa container ship.

Emission	Fuel type	Emission ton /year	Reduction ton/year	% Of reduction / year
NOx	Diesel	8392.897		
	NG	1799.042	6593.855	78.56
	ME	1721.581	6671.317	79.49
SOx	Diesel	177.732		
	NG	17.773	159.959	90.00
	ME	12.441	165.291	93.00
CO_2	Diesel	340055.52		
	NG	277587.17	62468.33	18.37
	ME	150067.62	189987.9	55.87
PM	Diesel	93.803		
	NG	9.380	84.423	90.00
	ME	6.566	87.237	93.00
CO	Diesel	691.180		
	NG	477.901	213.278	30.86
	ME	296.319	394.861	57.13

4.2. Economic assessment

The calculations are based on diesel, natural gas, and methanol fuel costs of 1320.8 $/m3, 684.2 $/m3, and 528.34 $/m3, in addition to 8.0 $/m3 for the bunkering prices. Fig. 5 depicts the yearly fuel savings resulting from the conversion of diesel engines to natural gas dual-fuel engine and methanol dual-fuel engine.

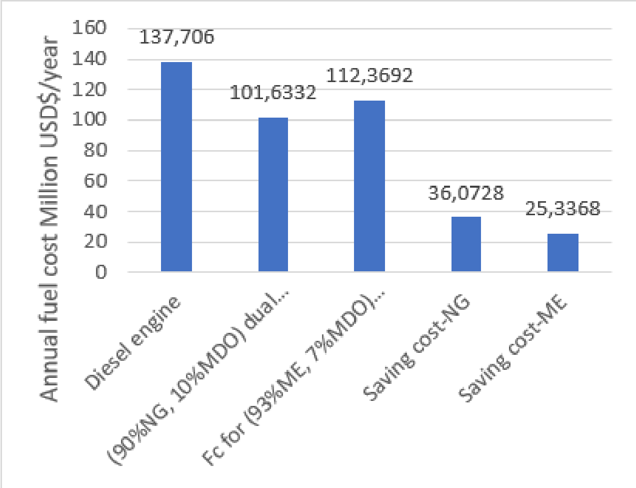


Fig. 5 the annual fuel saving cost for dual fuel engine

For conversion cost from the main engine to a dual fuel engine, it is expected to be 10.72 million dollars with 285 $/kW conversation rate. For operation and maintenance costs, according to data collected, the total operation and maintenance cost is 714749 $/years. Fig. 6, shows the annual cost-effectiveness of the proposed dual-fuel engine in reducing ship emissions for the container ship

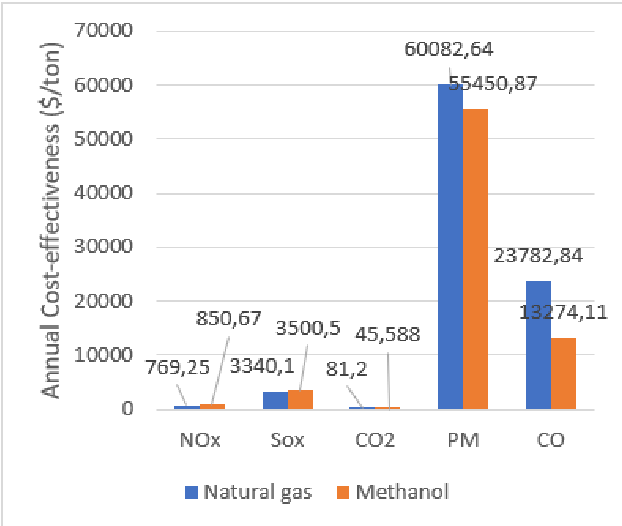


Fig. 6 The annual cost-effectiveness of the proposed dual-fuel engine

5. Conclusions

From an environmental standpoint, the analysis results show that using natural dual fuel engines with ration (90%NG and 10%MDO) reduces NOx, SOx, CO2, PM, CO emissions by 78.56%, 90%, 18.37%, 90%, and 30.83%, respectively. On the other hand, the emissions saved percentage by using 93% methanol as a dual fuel is 79.49%, 93%, 55.87%, 93%, and 57.13%, respectively. Moreover, converting a conventional diesel engine to a dual fuel engine powered by natural gas or methanol as an alternative fuel will comply with IMO 2016 and 2020 emission requirements for NOx and SOx with marine diesel oil percentages less than 10%.

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TEMPERATURE CHANGE OF A VEHICLE BATTERY DURING THE DRIVING CYCLE

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ABSTRACT
Since electric vehicle usage is increased, battery thermal management systems has become a very important topic. In this study, a lithium-ion battery with a capacity of 30.5 Ah is modeled as a lumped system and a cold plate is designed to remove the heat from the battery. %50-50 water-ethylene glycol (WEG) is used as the heat transfer medium. Cold plate inlet temperature is set to 20°C for WEG and a cooling cycle is integrated into the system to provide the set temperature of the WEG. The initial temperature of the battery is set to 30°C. To calculate the heat generation of the battery, İstanbul driving cycle is used to calculate the needed power for the electric motor. The system is modeled in Matlab Simulink and iterative solutions are done in Matlab. Results show that the battery bottom surface temperature is kept at 21.57°C and cold plate outlet temperature for WEG is kept at 21.1°C and the power consumption of the compressor used for the cooling cycle is decreased from 425.82 W to 20.46 W during the process.
Keywords: Battery thermal management system, Cooling, Cold Plate, Driving Cycle, Li-Ion Battery

1.INTRODUCTION
The depletion of fossil fuels and their environmental impact have forced the transportation industry to run the vehicles with electric motors. Nowadays, lithium-ion batteries are the best choice for use in electric vehicles to store energy due to their lighter weight, higher energy density, lower self-discharge rates, higher specific power, higher recyclability, and longer cycle life compared to lead-acid and nickel-based batteries (Celen et al., 2021). Pure electric vehicles and hybrid electric vehicles have been vigorously developed by many countries as a response to global energy shortage and environmental pollution. Lithium-ion batteries are the main power source of pure electric vehicles and hybrid electric vehicles due to their high specific energy, long cycle life, low self-discharge, and no memory effect (Wang et al., 2022). So seriously has the exponential environmental degradation affected the communities' attitude that they believe utilizing eco-friendly vehicles is one of the most effective key steps towards eliminating greenhouse gases. Moreover, the increasing energy demand has led to imposing stricter emission laws, and in this regard, sustainable and promising renewable energy sources could be the answer. Another possible approach to reduce fossil fuel dependence, which has recently attracted much attention, is the utilization of rechargeable batteries. To develop this technique, it is necessary to apply an efficient stack of battery packs. Lead-acid, lithium-ion, and Ni-MH are some kinds of rechargeable batteries. Among them, a remarkable recognition was acquired by lithium-ion batteries as an efficient energy storage unit due to faster-charging capabilities, high specific energy densities, longer charge-discharge life cycles, and high specific power. Moreover, what makes this kind of battery just unique of its kind is its lower discharge rates when they are not in service (Salimi et al., 2022). Regulating the batteries in a safe operating temperature range of 25°C to 40°°C during charging and discharging cycles in automobiles is necessary to reduce non-uniform temperature distribution, as it leads to an electrical imbalance amongst the cells and thereby lowers the performance of module or pack (Monika et al., 2021).

2.MATERIAL AND METHODS
The system, which can be seen in Fig.1(a), consists of a compressor, an expansion valve, an evaporator, a condenser, a pump, a cold plate, and a battery pack. In the cooling cycle, R410a is used as the refrigerant, and on the liquid side WEG is used for heat transfer fluid, and battery discharge is modeled using İstanbul driving cycle (Dinc et al., 2012). Briefly, during the discharging process, the battery starts generating some amount of heat and this causes the temperature rise for the battery. To prevent the temperature rise, WEG flows through the pipes inside the cold plate and removes the heat from the battery. To decrease the temperature of the WEG to the set temperature, the cooling cycle starts to run and remove the heat from the system.

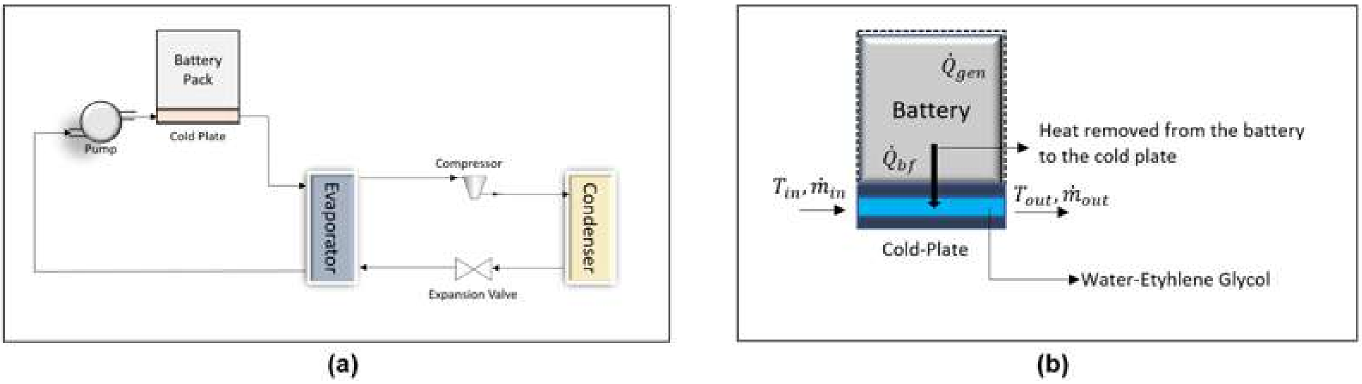

Fig.1. Definition of the system: a) Schematic view and b) heat transfer mechanism

2.1.Electric Model of the Battery

In this study, the equivalent circuit model is used for modeling the battery using the manufacturer's experimental datasheet. While Fig.2(a) shows that the change of the impedance of the battery module cells at different temperatures is important, Fig.2(b) shows that the change of the open circuit voltage (OCV) of the battery module at different temperatures can be neglected.

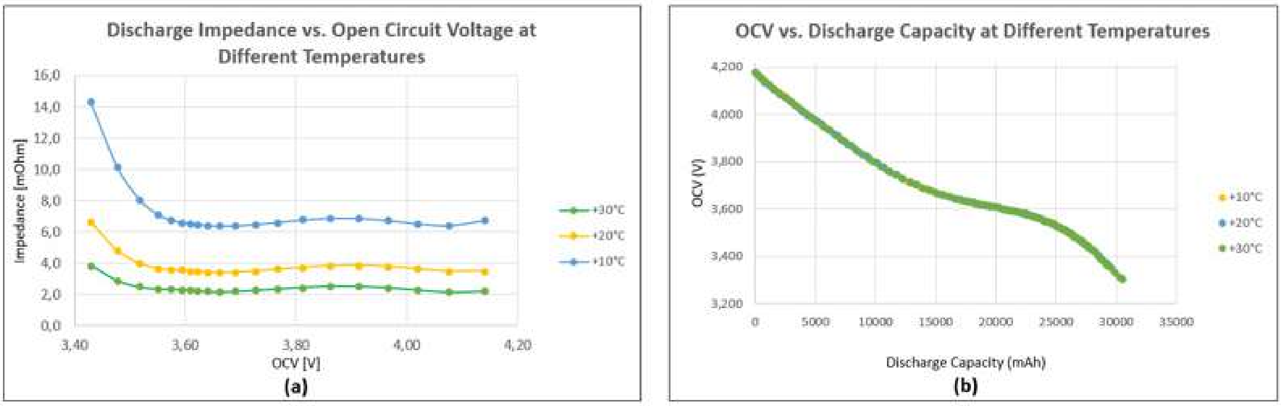

Fig.2. Datasheet of battery cell. a) Discharge impedance against OCV at different temperatures. b) OCV against discharge capacity at different temperatures. (Farasis, P29F 14S2P Configuration Battery Datasheet)

According to the datasheet provided by Farasis, the electric model is created in Matlab Simulink and connected to the İstanbul driving cycle and as an assumption, car mass is taken 500 kg.

2.2.Thermal Model of the Battery-Cold Plate System

For simulating the change in the temperature of the battery pack, the thermal resistance network model is created to estimate the heat transfer rate from the battery to the WEG flowing through the cold plate. Fig.1(b) shows that the heat transfer mechanism of the battery pack and cold plate couple and the equations can be given as follows:

For the battery pack,

$$\dot{Q}_{gen} - \dot{Q}_{bc} = m_b c_b \frac{dT_b}{dt} \tag{1}$$

For the cold plate,

$$\dot{m}_{in} c_{weg} (T_{in} - T_{out}) + \dot{Q}_{bc} = \rho_{weg} V_{weg} \frac{dT_{weg}}{dt} \tag{2}$$

Where $\dot{Q}_{gen}$ is heat generation calculated using the İstanbul driving cycle and electric model [W], $\dot{Q}_{bc}$ is the heat removed from the battery [W], T_{weg} is the temperature of the WEG in the control volume inside the cold plate [°C], T_b is the temperature of battery pack [°C], T_{in} and T_{out} are the inlet and outlet temperatures of WEG respectively [°C], m_b, c_b, c_{weg}, ρ_{weg}, V_{weg} and $\dot{m}_{in}$ are the mass of battery pack [kg], the specific heat of the battery pack [J/kg·K], the specific heat of WEG [J/kg·K], the density of WEG [kg/m^3], the volume of WEG inside of the cold plate [m^3], the mass flow rate of WEG [kg/s] respectively. The removed heat from the battery can be written as follows:

$$\dot{Q}_{bc} = \frac{T_b - \left(\frac{T_{in} + T_{out}}{2}\right)}{R_{ov}} \tag{3}$$

$$R_{overall} = \frac{t}{k_{cp}A} + \frac{ln\left(\frac{D_o}{D_i}\right)}{2\pi k_{cp}L} + \frac{1}{h_{weg}A_i} \tag{4}$$

$$h_{weg} = \frac{Nu \cdot k_{weg}}{D} \tag{5}$$

Where t is the thickness of the cold plate [m], R_{ov} is the overall thermal resistance [°C/W], k_{cp} [W/m·K] is the thermal conductivity of the cold plate, h_{weg} [W/m^2·K] is the heat transfer coefficient of WEG, L is the total length of the pipe inside the cold plate [m], D is the hydraulic diameter of the pipe [m], Nu is the Nusselt number, A_i is the pipe inner surface area [m^2], A is the battery pack bottom surface area [m^2], D_o and D_i are the outer and inner diameters of pipe [m]. Nusselt number depends on the flow characteristics of the WEG which is expressed in the equations given below (Incropera, 2011):

Turbulent flow (Re > 3000),

$$Nu = \frac{(f/8)(Re - 1000)Pr}{1 + 12.7(f/8)^{1/2}(Pr^{2/3} - 1)} \tag{6}$$

$$Re = \frac{4\dot{m}}{\pi D \mu} \tag{7}$$

$$f = (0.790\ln(Re) - 1.64)^{-2} \tag{8}$$

Where f is friction factor, Re is Reynolds number, Pr is Prandtl number, μ is dynamic viscosity [Pa·s]. If the flow is laminar (Re ≤ 3000) Nu is equal to 3.66.

3. RESULTS AND DISCUSSION

The heat generation rate of the battery (shown in Fig.3 (a)) is calculated in Simulink according to the İstanbul Driving Cycle using the equivalent resistance model. At the beginning of the simulation, the power request of the vehicle is high due to inertia. The results show that the constant inlet temperature of WEG provides effective cooling for the battery bottom surface. During the process, if the battery bottom surface temperature decreases (Fig.3 (b)) temperature difference between the surface and WEG decreases as well (Fig.3 (c)). This situation will cause the net heat transfer rate to decrease. Thus, the power consumption of the compressor will decrease (as shown in Fig.3 (d)).

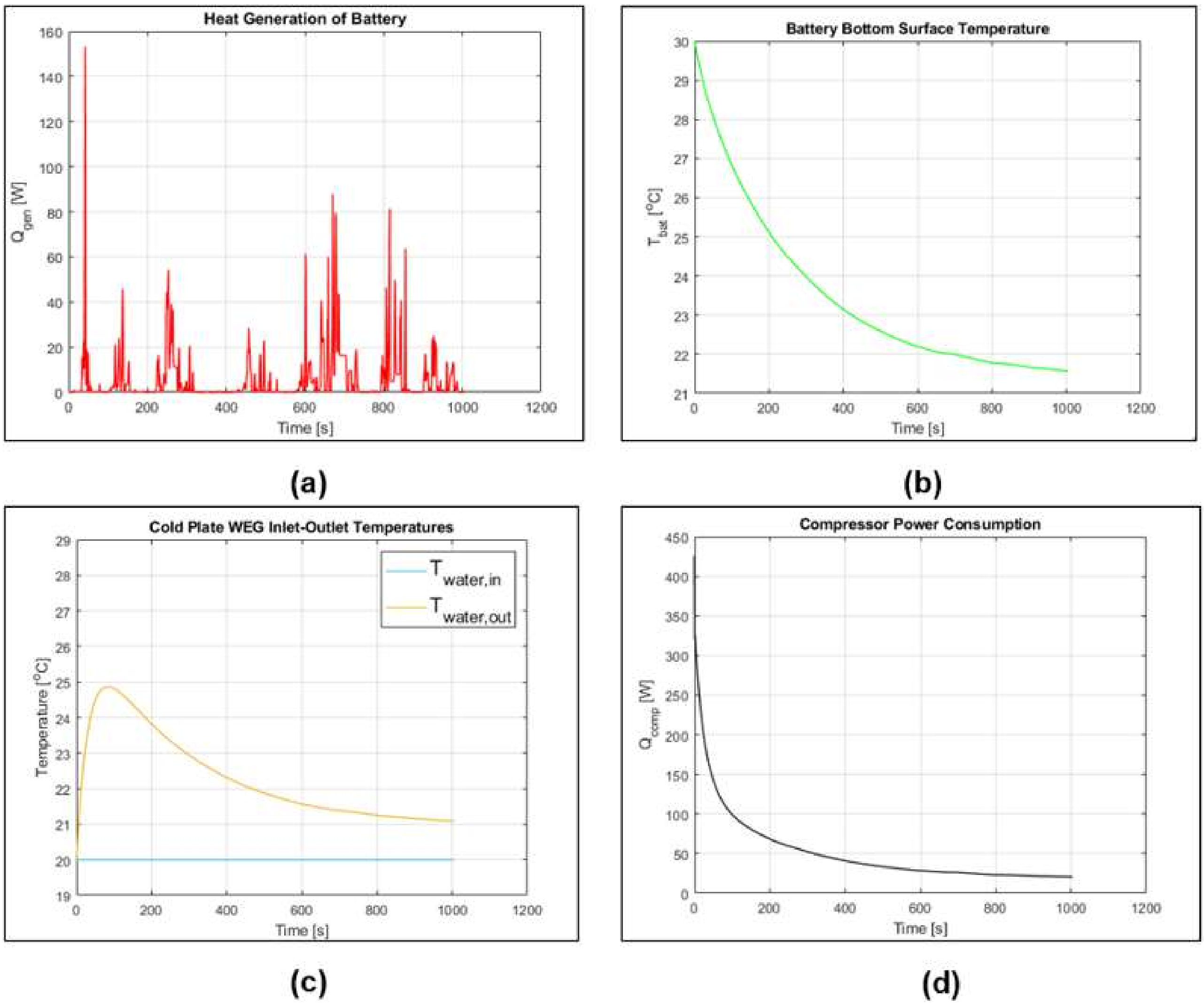

Fig.3. a) Heat generation of battery, b) battery bottom surface temperature change, c) constant WEG inlet temperature and WEG outlet temperature change in time, and d) power consumption of the compressor.

4. CONCLUSIONS

This study reveals that 20°C constant temperature inlet of WEG provides an efficient cooling performance with the designed cold plate geometry. The flow characteristic is calculated as laminar for the mass flow rate of 0.05 kg/s and hydraulic diameter of cold plate tube of 0.025 m corresponding Re number is 436.6 (less than 3000). For turbulent flow, the cold plate design can be changed or the velocity of WEG can be increased. This change will cause heat removed from the battery and the power consumption of the pump and the compressor to increase. For the cooling cycle, evaporator and condenser heat transfer coefficients and surface areas are determined based on the maximum heat load removed from the battery with 8°C of evaporation and 48°C condensation reference temperatures using the LMTD (Logarithmic Mean Temperature Difference) method. Calculated UA values for the evaporator and condenser are 67.88 W/K and 77.35 W/K respectively. The simulation is completed using these UA values for the cooling cycle side.

Acknowledgement

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Greek Letters

	density, kg/m3
μ	dynamic viscosity, Pa·s

Subscripts

weg	water ethylene glycol
i	inner
o	outer
cp	cold plate
b	battery
in	inlet
out	outlet
ov	overall
gen	generation
bc	heat transfer rate from the battery to cold plate

Superscripts

*reference condition

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A COMPREHENSIVE REVIEW OF THE IMPACT OF FEEDSTOCK CHOSEN IN THE PYROLYSIS PROCESS ON THE EMISSIONS OF GAS TURBINE ENGINES

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ABSTRACT
The limited petroleum resources and depletion over time cause substantial fluctuations in the prices of petroleum-derived fuels. Therefore, the pursuit of renewable and sustainable aviation fuels as alternatives to jet fuels tends to accelerate. The production of sustainable aviation fuel (SAF) from wastes by the pyrolysis process is an attractive research issue as it is easy to apply and has low cost. The use of biofuel produced by the pyrolysis process in commercial aviation is currently in process and it seems possible to be used in commercial aviation in the future. Thus, the effect of bio-oil produced by the pyrolysis process on the emission characteristics of aviation gas turbine engines should be well analyzed. In this study, the effect of the feedstock chosen in the pyrolysis process on the characteristics of the pyrolysis oil (PO) and the effect of the PO on the emission characteristics of aviation gas turbine engines are examined in detail. Regardless of the feedstock, PO has some common unfavorable properties such as high viscosity, density, water, and residue content. In addition, wood-derived POs have a significantly lower calorific value than base fuels (Kerosene, JP-4, and Diesel). However, the unfavorable properties of POs derived from wood can be improved by distillation or upgrading processes. The review results show that compared to the base fuel when PO produced from woody feedstock is used in gas turbine engines, carbon monoxide (CO), unburned hydrocarbon (HC), smoke, and particulate matter (PM) emissions tend to increase, while nitrogen oxides (NOx) emissions are similar. In the case use of plastic-derived PO in gas turbine engines, NOx emissions tend to increase, while CO and HC emissions tend to be similar to base fuel. By means of the co-pyrolysis of different feedstocks, emissions can be similar to or lower than the base fuel.
Keywords: Sustainable aviation fuels, Pyrolysis oil, Waste to energy, Aviation gas turbines

1. INTRODUCTION
The aviation industry is constantly growing because aircraft are the fastest and safest means of transportation and cargo. Due to the growing aviation industry, the increasing number of aircraft also increases the need for necessary jet fuels. Jet fuels are mainly produced from fossil-derived resources. However, since fossil fuel resources are limited, they will be depleted in the future. In addition, carbon dioxides (CO2) emissions from the burning of fossil fuels cause greenhouse gas and cause global warming. For this reason, the investigation trend for SAFs is increasing continuously (Kazemi et al., 2019 and Arter et al., 2022).
Today, SAFs produced in specific ways are allowed to be blended with conventional jet fuels in limited proportions. ASTM D7566 certified SAF are hydroprocessed esters and fatty acids (HEFA), catalytic hydrothermolysis jet (CHJ), hydrocarbon-hydroprocessed esters and fatty acids synthetic paraffinic kerosene (HC-HEFA-SPK), synthetic iso-paraffins (SIP), Fischer-Tropsch synthetic paraffinic kerosene (FT-SPK), Fischer-Tropsch synthetic paraffinic kerosene with aromatics (FT-SPK/A), and alcohol-to-jet (ATJ). In addition, the ASTM D1655 specification allows the co-processing of oils, fats, greases, and FT-crude hydrocarbons with fossil jet fuels in the refinery process, provided that it is limited to 5% (Gunerhan et al., 2023). However, the production capacity of the current SAF is far from meeting the fuel needs of the aircraft. For this reason, the search for new SAFs production pathways continues. The pyrolysis process, which is under development to meet ASTM standards (Csonka et al., 2022), stands out among other SAF as it is both simpler and more economical (Anex et al., 2010). The pyrolysis process, which is under development to meet ASTM standards (Csonka et al., 2022), stands out among other SAF because it is both easy to implement and less costly (Anex et al., 2010).

2. PRODUCTION OF PYROLYSIS OIL FROM BIOMASS
In the pyrolysis process, any organic material (biomass) is decomposed into pyrolysis oil (PO), char, and syngas products by thermal degradation in the absence of oxygen/air (Fig. 1). The pyrolysis process can be divided into slow and fast pyrolysis. Since the purpose of the pyrolysis process is to increase the yield of PO that can be used as fuel, the fast pyrolysis process is preferred in bio-oil production because of its high liquid yield. Particle size (~1 mm), temperature range (~500 °C), heating rate (>200 °C/min), and steam residence

time (<4 s) and cooling of steam are important parameters to increase bio-oil yield in the pyrolysis process (Tsai et al., 2007). In addition, the feedstock source and the use of the catalyst are other parameters that affect the yield and quality of bio-oil (Lee et al., 2019). Crude PO is not suitable for direct use in gas turbine engines due to its high freezing point, water content, acidity, corrosiveness, density, and viscosity compared to jet fuels. However, it is possible to eliminate the disadvantages of the crude PO with upgrading processes such as aqueous phase reforming, esterification, and catalytic cracking (Pawar et al., 2020).

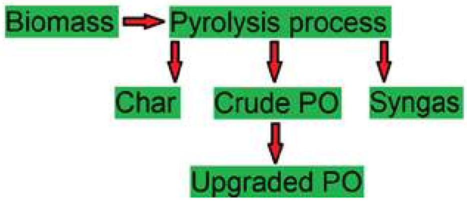

Fig. 1. Stages of the pyrolysis process (Adapted from Pawar et al., 2020).

3. RESULTS AND DISCUSSION

The number of studies investigating the effect of PO produced from biomass on the emissions of aviation gas turbine engines is limited. However, due to the increasing necessity for SAF, the number of studies is expected to increase gradually.

Kasper et al. (1983) ran a J69-T-29 gas turbine combustion assembly with the PO produced from agricultural and forest products/waste. Compared to JP-4, PO's smoke number, CO, and HC emissions increased more than a few times, while no significant difference was observed in NOx emissions. With the air/fuel ratio increase, a decrease trend was observed in HC and CO emissions, while no change was observed in NOx emissions. It was emphasized that reducing CO and HC emissions indicates good fuel atomization. Seljak et al. (2014) ran a micro gas turbine (MGT) engine with distilled tyre pyrolysis oil (TPO) and the emission results of TPO were compared to diesel fuel. While CO and HC emissions of TPO were close to or less than diesel fuel, NOx emissions increased by over 44% because of the fuel-bonded nitrogen (FBN) in the TPO. Also, the soot formation of TPO was much higher compared to diesel. Rizzo et al. (2014) ran the APU-derived Garrett AiResearch GTP 30–67 gas turbine engine with TPO and the emission results of TPO were compared to diesel fuel. The use of TPO increased NOx emissions by 103%, while CO and HC emissions were similar to diesel fuel. The fact that the CO and HC emissions did not increase showed that the combustion was well performed, while the reason for the high NOx emission was attributed to the FBN in the TPO content. Beran et al. (2020) ran an OPRA OP16 gas turbine with wood-based PO and the results were compared to diesel fuel. PO's NOx emissions were similar to diesel fuel, while CO emissions were twice higher than diesel fuel. The high CO emission was attributed to the very small combustion chamber. Seljak et al. (2016a) ran a MGT engine with distilled TPO and investigated the effects of the regenerative and the simple cycles on emissions. However, it was determined that the cycles did not have a significant effect on NOx, CO, and HC emissions. Seljak et al. (2016b) ran a MGT engine with distilled TPO. TPO's CO emissions were similar to diesel fuel while NOx emissions were significantly increased compared to diesel fuel. It was emphasized that since TPO's CO emissions are comparable to diesel, no additional processes are required to increase combustion efficiency. Because the high primary air temperature caused high local temperatures in the combustion chamber, resulting in a decrease in CO emissions while increasing NOx emissions. As the primary air temperature increased, the NOx emission of all tested fuels increased. In addition, the FBN of TPO caused NOx emissions to increase even more. Buffi et al. (2018) ran an APU-derived small-scale gas turbine engine with a pine wood PO/ethanol blend fuel. Compared to pure ethanol and diesel, CO and NOx emissions increased significantly as the volume of PO in the blended fuel increased. It was emphasized that the more viscous PO causes the formation of larger droplets and an increase in CO emissions. As the engine load increased, CO emissions decreased significantly, while the opposite trend was valid for NOx emissions because of the FBN in the PO. Broumand et al. (2020) produced PO from wood residues and run the MGT engine with 100% PO and blended (90% PO/10% ethanol) fuels. Adding ethanol to PO slightly reduced CO, NOx, and PM emissions while increasing HC emissions compared to 100% PO. It was stated that ethanol added to PO reduced the droplet diameter and that the small droplet diameter was an effective parameter to reduce gaseous emissions. Therefore, an effective atomization technique both increases combustion efficiency and reduces gas emissions. Suchocki et al. (2021) ran a miniature gas turbine engine with a blended fuels of TPO and kerosene. As the TPO volume in the blended fuel increased, NOx emission index increased significantly at all engine speeds, while sulphur oxides (SO2) emission index decreased. In addition, while there was no obvious trend below 70 000 rpm for CO emissions, CO emissions increased as the engine speed increased. At full engine load, the NOx emission index of 50% TPO/50% kerosene blended fuel increased from 0.15 to 0.24 g/kg while the CO emission index increased from 70 to 90 g/kg compared to 100% Jet A. At full engine load, the SO2 emission index was negligible for all fuel blends. The authors stated that increasing CO emission indicates the presence of incomplete combustion and lower quenching reactions in the primary zone. Moreover, the FBN in the TPO caused an increasing in NOx emissions. Anderson et al. (2021) produced PO from plastic waste and ran a MGT engine with multiwall carbon nanotubes doped blended fuel (Jet A 70% fuel, 20% PO, and 10% ethanol). The NOx, CO, and CO2 emissions were reduced by 42%, 47%, and 35%, respectively, when using PO blended fuel compared to Jet A. The lower calorific value of the blended fuel and higher combustion rate were shown as the main reasons for the reduction in NOx emissions. It was emphasized that CO emissions vary depending on the air/fuel ratio and the exhaust temperature. The reduction of CO2 emission was attributed to the doping of ethanol and nanoparticles to the blended fuel. Broumand et al. (2021a) ran a C30 MGT engine with PO (produced from wood residue)/ethanol blend fuels. While the NOx emissions of the PO/ethanol blend fuel were comparable to that of diesel fuel, the CO, HC, and PM emissions increased significantly as the PO volume in the blended fuel increased. The authors emphasized that the preponderant parameter in NOx emission is FBN, while the CO and HC emissions depend on air-to-liquid mass flow ratio and/or droplet diameter. Broumand et al. (2021b) produced bio-oil from wood residues and sewage sludge by the pyrolysis process and the produced fuels were tested in the C30 MGT engine. Sewage sludge PO was upgraded with the thermo-catalytic reforming process and tested pure (100%), while wood-derived PO was blended with ethanol and tested as a blended fuel. The CO and HC emissions of the wood-derived PO/ethanol blended fuel were much higher compared to the upgraded sewage sludge PO, while the NOx emissions were much lower. It was emphasized that the higher carbon content and lower oxygen and water content of sewage sludge PO compared to the wood-derived PO facilitates ignition and combustion, resulting in reduced CO and HC emissions, while the high nitrogen content of sewage sludge PO caused an increase in NOx emissions. The CO and HC emissions of wood-derived PO/ethanol blend fuel was very high compared to diesel fuel, while NOx emissions were comparable. The CO and NOx emissions of the upgraded sewage sludge PO were very high compared to diesel fuel, while the HC emissions were comparable. Suchocki et al. (2022) ran a MGT (GTM-140) engine with waste plastic PO/Jet A blended fuels. The POs were produced from polystyrene (PS) and polypropylene (PP) and were named PSO and PPO. As the PSO volume in the blended fuel increased, the NOx emission index increased significantly because of the FBN. The PPO's NOx emission index was similar to PSO's, but the increase in the NOx emission index was lower. A similar trend to NOx emissions was observed for CO emissions of the PSO and PPO fuels, but the CO emission index was lower than for NOx. As the volume of PSO in the blended fuels increased, the CO emission index also increased slightly, but this trend was not clear for PPO blended fuels. The high oxygen content of PPO (5.5%) compared to other fuels can have contributed to the lower CO emissions.

The CO, CO2, HC, NOx, SOx, and PM emissions released into the atmosphere from gas turbine engines have negative effects on the environment and human health. Therefore, low-emission biofuels come to the fore in the search for SAF. In the studies in the literature, the CO, HC, and NOx emissions of bio-oils produced by the pyrolysis process have been examined in detail. The CO and HC emissions generally follow each other. The presence of CO and HC emissions indicates incomplete combustion. For this reason, CO and HC emissions can be reduced by increasing combustion efficiency. By increasing the volume of the primary zone or residence time, mixing the fuel and air in the primary zone well, reducing the liner wall-cooling air in the primary zone, and improving the fuel atomization increase the combustion efficiency and reduce the CO and UH emissions (Lefebvre et al., 2010). The NOx is another important type of emission. The NOx emissions can be produced by thermal NO, nitrous oxide mechanism, prompt NO, and FBN mechanisms. The researchers stated that the nitrogen in the POs caused the high NOx emission. Therefore, NOx emissions can be also reduced if the nitrogen content of POs is reduced during the pyrolysis process or post-process.

In the research in the literature, bio-oil produced via the pyrolysis process is used in aviation gas turbine engines as pure or blended with the base fuel in various proportions. The emission characteristics of the PO produced vary depending on the selected feedstocks. High viscosity, density, water, and nitrogen content of POs can adversely affect the combustion process and cause an increase in CO, HC, and NOx emissions. To overcome this unfavorable situation, co-pyrolysis of different feedstocks and the distillation or upgrading processes can be applied after the pyrolysis process. For example, while CO and HC emissions of TPO are comparable to base fuel, NOx emissions are higher. On the other hand, POs produced from agricultural products/wastes, exhibit the opposite emission trend of TPO compared to base fuel. Since both fuel types have desirable and undesirable properties, the blending of TPO and wood-PO in ideal proportions can provide an improvement in terms of emissions. In addition, the emission characteristics can be improved by improving the undesirable properties of POs through distillation and upgrading processes.

4. CONCLUSIONS

In this literature survey, the emission characteristics of aviation gas turbine engines run with different pyrolysis oils (PO) were examined. The POs can be produced different feedstocks such as waste tyres, waste plastics, agricultural or woody residues, etc. Depending on the chosen feedstock, the properties of the PO differ. For this reason, the emission characteristics of PO produced from different feedstock also differ from each other. The principal findings of the research were summarized as follows:

•The CO and HC emissions of tyre pyrolysis oil (TPO) were comparable to base fuel, while NOx emissions were significantly higher.

•While the NOx emission of the PO produced from agricultural products was comparable to the base fuel, the CO and HC emissions increased significantly.

•The emission results of waste plastic POs differ from each other. The inadequacy of research on the use of plastic PO in aviation gas turbine engines does not allow for a comprehensive inference. It is recommended to conduct more comprehensive and numerous studies on the use of plastic POs in aviation gas turbine engines.

•The CO and NOx emissions of sewage sludge PO increased significantly compared to the base fuel, while the HC emission was comparable.

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EVALUATION OF ENVIRONMENTAL IMPACTS OF HYDROGEN PRODUCTION TECHNOLOGIES: BIOMASS, WATER, AND FOSSIL FUEL

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ABSTRACT
Global advancement has been comprehensively dependent on the overutilization of natural sources dated from the Industrial Revolution. Anthropogenic activities have contributed to increasing levels of greenhouse gases (GHGs) in the environment, driving global climate change, through the massive utilization of fossil fuels and reforestation. The most critical challenge of the earth is achieving carbon neutrality by 2050 in response to the deteriorating worldwide climate change. Therefore, restructuring the existing industrial processes and developing novel processes to reduce GHG emissions and promote the capture of atmospheric CO2 is thus crucial and a tremendous issue. Since the existing energy requirement and growing urbanization have resulted in damages to the environment, there is a deep need in developing a feasible and sustainable energy solution. Hydrogen (H2) has emerged as a promising and renewable option as it has significant benefits over conventional non-renewable fuels, particularly regarding a sustainable environmental viewpoint. In this regard, the present study deals with the environmental impact assessment of various H2 production technologies from fossil fuel, water, and biomass. The environmental impact assessment study reveals that biological H2 production processes are one of the most promising options for H2 production in an environmentally friendly and cost-effective manner. This study is the starting point for selecting sustainable technological breakthroughs to reduce climate change considering environmental impact parameters.

Keywords: Green hydrogen, Environmental sustainability, Renewable, Non-renewable, Global warming potential.

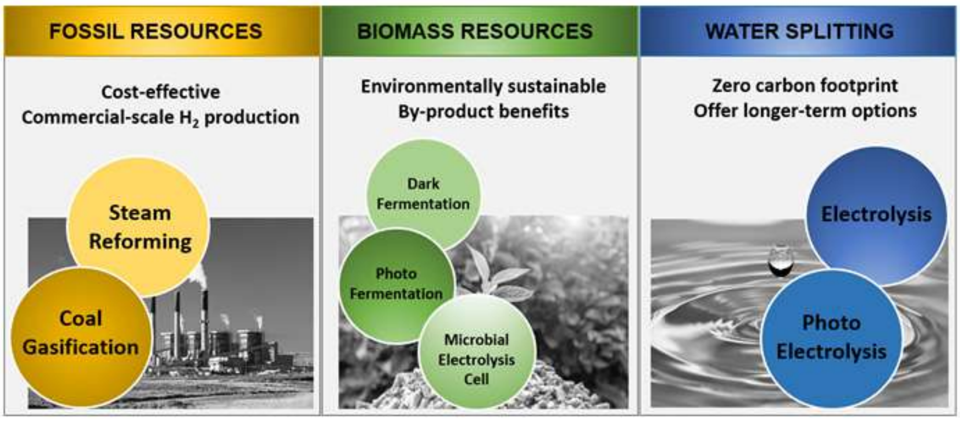
1. INTRODUCTION
The most prominent energy source is fossil fuels, and as urbanization and industrialization are increasing, so does its need for energy. It is projected that the world's energy demand will increase by 48% within the following 20 years as a result of the rapid increase in population [1]. Currently, 80% of the world's energy demands are provided by fossil fuels [2]. However, one of the most significant environmental problems associated with using fossil fuels is the release of greenhouse gases (GHGs), which contribute to global warming and concerns about climate change. Namely, producing energy from carbon-containing fossil fuel resources damages the environment [3]. Various types of renewable energy resources may be utilized to prevent the problems of environmental sustainability and energy requirement. Recently, H2 has gained significant interest as the best alternative among cleaner fuels, with its benefits over conventional fuels. However, most commercial H2 production processes include gasification, steam reforming, and pyrolysis, utilizing fossil fuels as feedstock. Therefore, traditional H2 production technologies are not adequately sustainable since they heavily depend on fossil fuels that cause carbon emissions. On the other hand, H2 production from water using electrolysis and biomass (algae, agricultural residues, organic food wastes, and energy crops) using biological processes has attracted attention as sustainable and environmentally friendly technologies. Moreover, when compared to the fossil fuel-based and water-based H2 production methods, the H2 production from biological processes such as dark fermentation (DF), photo-fermentation (PF), microbial electrolysis cells (MECs), and integration of these processes is much cleaner methods thanks to the simultaneous production of energy and the minimization of waste by using various biomass residues as a substrate.

In the literature, several research focus on various aspects of H2 production processes and their resources. The researchers [4] investigated the clean and sustainable H2 production technologies with wastewater treatment. A comparison of H2 production methods was performed considering environmental, economic, reliability, social, and technical parameters. They reported that among the investigated processes, the H2 production from wastewater using the MECs process is the most environmentally friendly method with the lowest global warming potential (GWP) of 0.17 kg CO2 eq./kg H2. In another study, the life cycle assessment of conventional and novel H2 production technologies was performed to understand the environmental impacts of technologies and identify their sustainability potentials. Several studies have investigated the environmental impacts of H2 production technologies based on the various feedstock.

However, most of these studies widely considered GWP and acidification potential (AP) as environmental impact parameters. However, H2 production processes seriously impact various parameters such as mineral resources, water uses, human health, and land use. Hence, these factors should be considered to obtain a holistic result in determining the sustainability potentials of the H2 production processes.
This paper aims to present a comprehensive environmental impact comparison of H2 production processes that are utilized different resources as substrates. In this regard, seven H2 production technologies are compared, considering their environmental impacts, including AP, freshwater ecotoxicity (FE), fossil resource scarcity (FRS), freshwater eutrophication potential (FEP), particulate matter formation (PMF), GWP, land use (LU), ozone depletion (OD), ionizing radiation (IR), water consumption potential (WCP), water scarcity footprint (WSF). Overall, this study presents insight into the industrial applicability of H2 production processes from various resources by evaluating environmental sustainability.

2. ANALYSIS METHODOLOGY

Fossil fuel sources are most commonly utilized resources to produce H2 among the potential H2 production technologies. However, the shift to the H2 economy demands that H2 be created from abundant, clean, and renewable sources to create a sustainable energy system. Therefore, in this paper, six primary methods are considered to produce H2: gasification and steam reforming of fossil resources, electrolysis of water, and DF, PF, and MEC of biomass. Recently, there has been an increase in interest in producing H2 from biomass resources as a considerable amount biomass waste is produced by various industrial and agricultural operations. Moreover, H2 production from biomass using particularly biological processes has currently gained significant interest in overcoming the drawbacks of conventional H2 production technologies. Overall, the environmental assessment of biological and thermochemical H2 production processes were determined. Overview of the H2 production technologies from various resources considered for this study are presented in Fig. 1.



2.1. Environmental Impact Assessment

This section compares the environmental impacts of 1 kg of H2 produced from different processes. The H2 production processes are compared regarding AP, FE, FRS, FEP, PMF, GWP, LU, OD, IR, WCP, and WSF. AP (kg SO2 eq.) and GWP (kg CO2 eq.) measure the amount of polluting acid deposited into water resources, soil, and organisms and CO2 released into the atmosphere, respectively. IR (kBq Co-60 eq.) and OD (kg CFC-11 eq.) present the impact of radiation on materials and the amount of ozone destroyed by emission, respectively. FE (kg 1,4-DCB eq.) measures the ecotoxicity of freshwater, which occurred due to the air, land runoff, and chemical discharge into the water bodies. FRS (kg Cu eq.) represents the amount of utilized fossil resources. PMF (kg PM2.5 eq.) defines the particles or droplets in the air. WSF (m3) and WCP (m3 consumed) express the overall amount of freshwater consumed during the process and the amount of water used, respectively. Overall, the investigated environmental impact categories were selected according to the Operational Guide to the ISO Standards to define the LCA approaches (Guinee et al., 2001). Moreover, the investigated environmental impact variables were obtained from the LCA studies performed elsewhere [5-7]. The average values of the selected environmental impact parameters are considered for assessment. However, some of the environmental impact data was not found in the literature. These results also revealed that there is limited research in the literature extensively investigating the environmental impacts of H2 production processes, and there is a serious gap in this regard.

3. RESULTS AND DISCUSSION

CO2 releases are considered major GHG sources because of their harmful effects on the environment. Therefore, the shift to a carbon-neutral industry and economy with sustainable energy production is one of the literature's most thoroughly investigated research subjects. Among the thermochemical processes, the highest GWP of 19.85 kgCO2 eq./kg H2 and AP 13.9 gSO2/kg H2 were obtained for the gasification process, while the relatively lowest GWP (10.85 kgCO2 eq./kg H2) and AP (8.7 gSO2/kg H2) values were observed for the steam reforming process. The gasification process for H2 production has utilized coal and, therefore, H2 production causes a higher GWP in most of the considered pathways, even with renewable energy input. In the electrolysis process for H2 production from water, relatively high GWP and AP values were obtained, most probably due to the energy utilization during the water-splitting process. On the other hand, compared to thermochemical processes, biological H2 production processes have the potential to considerably reduce CO2 releases when their substrates are derived from renewable resources or wastes. The PF is the most environmentally friendly H2 production process presenting low GWP (1.88 kgCO2 eq./kg H2) and AP (3.61 gSO2/kg H2) values, it is followed by DF and MEC processes. However, the integrated DF-MEC process presents considerably poor environmental performance with a GWP of 14.6 kgCO2 eq./kg H2 and AP of 103 gSO2/kg H2 compared to the other biological processes related to their superior energy and heat requirements by the production process. Hence, using renewable energy sources in production steps is crucial to preventing high GWP and AP values. Moreover, the highest WSF and WCP values were 5117.05 and 119.895 m3 electrolysis process, and it is followed by the MEC process. As expected, the gasification and steam reforming processes contributed the highest FRS and DF-MEC had the least FRS. The LU values of H2 production processes were in the order of DF>DF-MEC>Gasification>Electrolysis>Steam reforming. Moreover, the selected environmental impact parameters are normalized with the feature scaling normalization method to compare each bio-H2 production method using the following equation:

$$\text{Rank}_{\text{method},i} = \left(\left(\text{Rank}_{\text{method},i} - \text{Rank}_{\min}\right) / \left(\text{Rank}_{\max} - \text{Rank}_{\min}\right)\right) \times 10$$

Here, the ranking ranges from 0 to 10, with 0 presenting poor performance and 10 representing the ideal case (zero-environmental impacts). Lower values of selected environmental impact parameters are given higher rankings. In evaluated parameters, "0" is assigned to the highest environmental contaminations, while "10" defines the lowest contamination. Results of the environmental impact comparisons of H2 production methods are presented in Fig. 2.

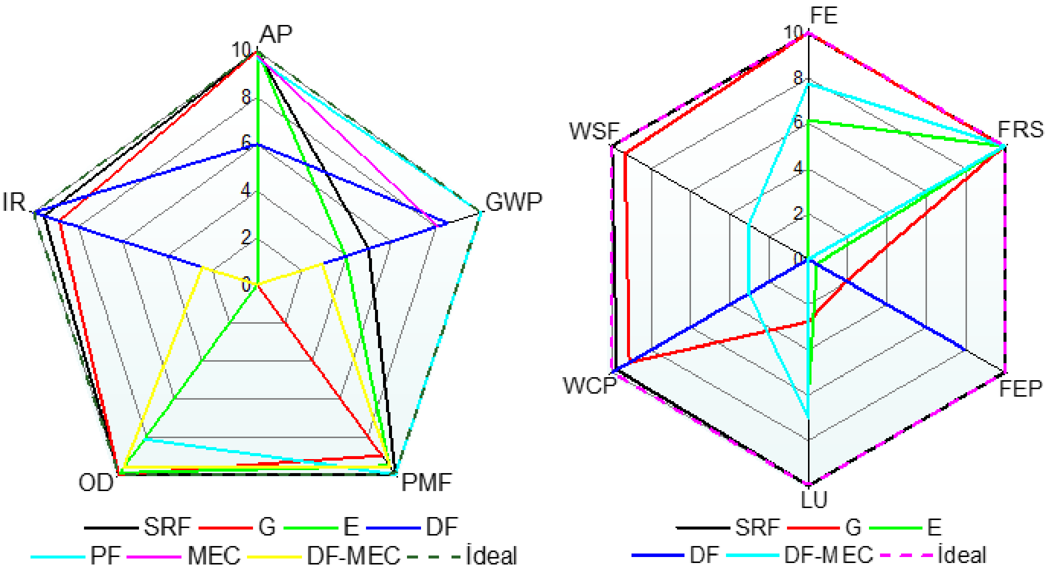


Fig. 2. Comparison of environmental impacts of H2 production methods from various feedstock by normalized ranking.

Regarding GWP (0/10) value, the gasification process presented the highest environmental contaminations. The GWP values were 3.96/10 for electrolysis and 4.98/10 for steam reforming, which have a significant potential to cause serious environmental effects due to CO2 emissions. The water electrolysis process presented the highest environmental damage to water resources with WSF (0/10) and WCP (0/10) values. On the other hand, among the biological processes MEC process achieves similar performance in the ideal case considering AP (9.78/10) and GWP (8.06/10) values. Moreover, the normalized ranking results

proved that the PF method presented ideal results (10/10) for PMF and GWP, and close results to ideal for AP (9.65/10) and OD (8.14/10), which are the most important parameters in environmental sustainability assessment. Among the biological processes, the worst scenario was observed for the DF-MEC process with the particularly lowest GWP (2.98/10), AP and FEP (0/10), WSF and WCP (3/10), and IR (2.45/10), based on the ranking results. Overall, the normalized rankings showed that the biological processes (except the integrated DF-MEC process) provided closer-to-ideal results in view of environmental sustainability, providing less ecotoxicity, water-mineral-fossil utilizations, and emissions. The advantage of biological processes phenomena is to release less CO2 and SO2, and minimum utilization of renewable energy sources for heat or as well as low water consumption, respectively.
Overall, replacing the energy sources used in the process with completely sustainable/renewable sources will make biological processes completely sustainable from an environmental point of view. Therefore, while existing biological processes need to be developed for commercial use, their environmental outputs should also be considered.

4. CONCLUSIONS

This paper evaluates and discusses the environmental impacts of six selected thermochemical and biological H2 production methods to foresee the processes' environmental sustainability levels and determine the measures to be taken in this regard. Results revealed that the gasification and steam reforming processes showed adverse environmental impacts, especially regarding air emissions. In the water electrolysis process, the most important environmental problem is observed in excess water use, considering the highest WSF and WCP values. On the other hand, environmental sustainability assessment results showed that the GWP and AP of biological processes (except the DF-MEC process) are almost close to ideal conditions compared to fossil fuel gasification, steam reforming, and water electrolysis processes. However, due to energy requirements in the process operation, the integrated DF-MEC process has high AP (14.8 kgCO2 eq./kg H2) and GWP (103 gSO2/kg H2). The present results showed that the most environmentally friendly method is PF with the lowest environmental impact parameters, and it is followed by the MEC process. Overall, producing H2 from biomass using biological processes is not yet a common method, it is still a developing area. However, this paper revealed that focusing on producing H2 from waste biomass will help minimize the use of fossil fuels, reduce the carbon footprint, produce clean and renewable H2, and decrease the environmental effect of fossil fuels and human activities.

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EXAMINING THE IMPACT OF GLOBAL CLIMATE CHANGE ON WOMEN IN TERMS OF HEALTH INEQUITY

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ABSTRACT
Climate change constitutes one of the most serious health threats facing humanity in the 21st century and affects environmental and social determinants of health such as clean air, safe drinking water, adequate food and safe shelter. It is an undeniable fact that climate change has the greatest impact on women, who make up the majority of the world's poor population, and that this unequal effect on women stems from another inequality that has developed in the historical process, "gender inequality". In the studies so far, it has been argued that socio-economic factors, culture and patriarchal norms play a role in the more effective of the vulnerability, which indicates the capacity of individuals to cope with the crisis threats or the crises created by climate change, on women. However, the aim of this study is to address the current enormity of established health inequalities for all women in the international arena, which are discussed in limited in the literature, especially indigenous women living in rural areas where the vulnerability to climate change is high in relation to poverty and unemployment, and to reveal in detail the important health inequality gaps created by the resulting injustices.

Keywords: Climate change; gender equality; health inequity; women; vulnerability

Climate change is an accelerating global threat that unevenly influences every country around the world and causing especially devastating environmental public health burdens (Khanal et al., 2022). According to the United Nations Framework Convention on Climate Change, climate change is defined as "change in climate attributable directly or indirectly to human activities, changing the composition of the planet's atmosphere and contributing to natural climate variability observed over similar time periods" (UNFCCC, 1992). Geoclimatic changes are explained through changes in land and ocean temperatures, sea level and acidity, precipitation patterns and wind patterns, land characteristics and use, soil conditions and extreme weather events (heavy rains, floods, extreme wind events, heat waves and drought) (Rupasinghe et al., 2022). About 40 billion tons of CO2 are emitted worldwide each year (including deforestation), and about half of these emissions accumulate in the atmosphere, contributing to global warming (Gaeta et al., 2022). In line with the Sixth Assessment Report of the UN's Intergovernmental Panel on Climate Change (IPCC) published in 2021 (IPCC, 2021), the 27th Conference of the Parties to the United Nations Framework Convention on Climate Change, Paris Agreement, held in Sharm el-Sheikh, Egypt, 6-20 November 2022 also emphasized once again that limiting warming to around 1.5°C requires global greenhouse gas emissions to peak before 2025 at the latest, and be reduced by 43% by 2030 relative to the 2019 level (UNFCC, 2022). According to the World Health Organization (WHO), environmental threats to human health at the global and regional level include: "climate change, depletion of the stratospheric ozone layer, changes in ecosystems due to loss of biodiversity, changes in the supply of fresh water and hydraulic systems, land degradation, urbanization and pressures on the food production system" (WHO, 2017) and it is estimated that by 2030, the cost of direct harm to health will be between US$ 2-4 billion per year, excluding costs in health-determining sectors such as agriculture, water and sanitation (WHO, 2021). It is expected that the health effects arising from climate change will worsen the burden on the already fragile health systems, especially in many socio-economically low-level regions via the increment of the diseases burdens (Berrang-Ford et al., 2012).

As stated at the beginning of the article, the destructiveness of climate change, which means "a global threat" and creates an unequal effect between countries, has an unequal distribution within countries. In other words, it would not be wrong to say that the destructiveness of the impact of climate change on different class identities is not equal. In this context, the impact of climate change on women, who constitute the majority of the world's poor population, has an undeniable magnitude. It is possible to say that this unequal effect on women stems from another inequality that has developed in the historical process, "gender inequality". To open a parenthesis here, gender, which expresses the naturalization of an inequality based on biological differences between women and men and the shaping of an unequal division of labor accordingly, has been decisive in the domination of men over women all over the world. The importance of gender within the framework of this study is that it plays a role in increasing women's vulnerability to climate change. As a matter of fact, this situation was frequently emphasized in the UN Reports during the process. In line with this acceptance, studies so far have been addressed after the link between gender inequality and climate change was formally acknowledged by the United Nations Human Rights Council (UNHRC) in March 2008 (UNDRR, 2020). The United Nations Sustainable Development Goals (SDG) have set out 17 Goals to achieve a better and more sustainable future for all by 2030, and in addition to combating climate change (Goal 13), Gender Equality (Goal 5) aims to develop gender equality especially to meet the needs of women in sustainable development (Assembly, 2015). However, the current enormity of entrenched health inequalities and the resulting injustices have led to significant health equity gaps internationally (Jayasinghe et al., 2022), especially for women living in rural areas, where the vulnerability to climate change is high concerning poverty, unemployment, cultural traditions, illiteracy, population density, and economy; hence studies on this field are scarce in the current literature. Gender-based inequalities can be diversified, which determines the vulnerability of individuals, which indicates the capacity of individuals to cope with the crisis threats or the crises created by climate change, to be more effective on women. Inequalities shaped by gender roles such as the burden of domestic care, patriarchal norms and values expose women to different dangers in crisis situations created by climate change. These inequalities sometimes greatly reduce or eliminate the possibility of women escaping from disasters (For example, because the news of the disaster spread in the public sphere is not heard by women who have been made immanent to the private sphere, women cannot leave the house without a man to escape to a safe area, traditional clothes restrict freedom of movement during escape). Sometimes, as in the case of the destruction of the means of production of women, who make up the majority of unpaid agricultural workers in the new post-crisis situation (due to damage to agricultural lands due to drought or excessive rainfall), it increases the vulnerability of women to climate change by creating an even more negative effect on their socio-economic position (Eastin, 2018; Talu, 2017). In the event of a decrease in resources due to climate change, sexual violence and harassment that women are exposed to in the process of obtaining these resources are among the situations that should be underlined. Because, women who have to travel longer distances during the day to access the decreasing resources such as water and firewood due to the crises created by climate change, or women in families who migrate due to the depletion of natural resources, which leads to rape, more harass, abuse, accidents and injuries (Varol, 2022).

While the effects of climate change on women can magnify health inequalities over time, the accelerating nature and unpredictability of climate change risk creating health inequalities that is an essential element of public health in many populations (Williams, 2018). Threats to women's health in emergencies can result from limited access to health services, sharp gender-based inequalities in financial and economic stability, and destructive social norms. Women face additional barriers during crises to accessing maternity, contraception and abortion services, and possibly exacerbating existing inequalities in reproductive health. Globally, women perform most of the healthcare and unpaid care work, but face barriers to meeting living costs and obtaining health insurance due to overrepresentation in low-paying jobs (Lee et al., 2020). For example; between 2015 and 2017, vector-borne diseases such as malaria, dengue, chikungunya, and Zika virus affected more women than men in Colombia between 2015 and 2017 (Ministry of Health and Social Protection, 2016). In pregnant women infected with Zika virus, abortion was deemed religious and culturally inappropriate, and some health care providers did not provide comprehensive information to patients and admitted that their counselling focused on the newborn's microcephaly risk instead (Forero-Martínez et al., 2020). Moreover, during the 2014 Ebola epidemic, maternal mortality and stillbirth rates increased in Sierra Leone (ACOG, 2010) as women had less access to antenatal and postnatal health care. Studies have shown that deaths are not caused by Ebola, but by factors that limit access to health care services during the crisis, thereby worsening maternal mortality. Furthermore, it has been revealed that the risk of infection increases as women, who make up 78% of healthcare workers in the USA and 70% of global healthcare workers, are more exposed to pathogens during the Covid-19 outbreak (Boniol et al., 2019). It is also stated that the death rate of women is higher in disasters (traditional social roles, trying to save their children, not being able to leave the elderly or home, not being able to swim, traditional clothes, waiting to be rescued, not understanding the warnings or not being able to reach them, etc.). Even if women somehow survive the disasters, it is reported that the immigrants are mostly female and this time they face the threat of both physical and sexual violence as mentioned before. It is stated that most of the women staying in shelters after the disaster are exposed to harassment, rape and violence (Varol, 2022).

On the other hand, especially in the European context, it has been observed that women are systematically at greater risk than men in conditions of heat stress, and mortality rates are higher among women than men,

based on differences in the response to thermal stress due to physiological characteristics in body temperature regulation as well as pre-existing socio-demographic characteristics in the sedentary community (Ellena et al., 2020; Marí-Dell'Olmo et al., 2019). Besides, as the climate crisis reduces agricultural production, there is an increase in cases such as women working in the agricultural sector, who are largely insecure, getting married (resurrected) for money or having to sell their bodies for food, as in the case of Kenya. This brings along problems such as violence, mental problems, sexually transmitted infections and an increase in unwanted pregnancies (Varol, 2022). Furthermore, most women agree that long-term changes in seasons and weather patterns due to climate change negatively affect food security, and food insecurity and malnutrition during pregnancy are closely associated with maternal micronutrient deficiencies, depression and anxiety, gestational diabetes and hypertension, and mortality (Bryson et al., 2021).
In summary, although women are the main solution to the climate change problem with their high productivity and environmental awareness, they have become direct targets because they are affected at the highest level by the climate crisis for which they are not responsible. Therefore, women and Indigenous women must be at the forefront of climate change action and decision-making at all levels if we address the gendered consequences of climate change impacts and the emerging risks to women's health equality and well-being.

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Gravitational Water Vortex Heat Exchanger as a Waste Heat Recovery Unit

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Abstract
A heat exchanger is a highly effective tool for waste heat recovery because it can transfer heat from one fluid to another without the two fluids coming into contact. This process enables the recovery and redistribution of waste heat generated by a system or industrial process, resulting in reduced energy consumption and carbon footprint. In the present study, gravitational water vortex heat exchanger (GWVHE) is used as a waste heat recovery unit. The idea of GWVHE originated by energy exchange through a gravitational water vortex, which is formed by the gravity effect. A large amount of energy exchange in the form of heat transfer therefore exists for a gravitational water vortex flow that is created artificially in a cylinder-shaped basin with a hole at the bottom if another fluid stream is introduced on the outer wall of the basin. A GWVHE is an attractive energy-saving device with a wide range of heat transfer applications, including in process industries and intermediate heat recovery systems, since it requires less amount of energy input. GWVHEs are a new class of thermal energy exchange devices and there is a lot of research potential in the development and testing of novel configurations for this family of heat exchangers (HEs). In previous studies, different design configurations were used to investigate the hydro-thermal properties of a GWVHE using both numerical and experimental methods. The first was a spiral flow configuration (SFC) of GWVHE in which rectangular spiral channels were constructed on the outer edge of the cylindrical basin. Cold fluid enters the basin tangentially to form a vortex, and hot fluid enters the spiral channel from the outside inlet. Based on the duration of contact and the volume differences between the two fluids, the SFC configuration had some drawbacks. Hence, a new configuration was developed in which a shell with baffles (SWB) was incorporated on the outer boundary of the basin to address these challenges with maximum contact area and the more volume of hot fluid. The effect of both free and forced vortex induced heat transfer characteristics for both SFC and SWB configurations was determined experimentally, and it was observed that SWB configuration transfers more heat than SFC regardless of the existence of the mixer.

The present study is the continuation of previous research on the heat exchange phenomenon of GWVHE and aims to improve GWVHEs effectiveness by addressing limitations identified in previous studies, such as failure to achieve maximum contact area, inability to form a vortex at low flow rates, and improved temperature distributions. In the present work, a novel configuration of GWVHE is proposed to achieve maximum possible contact area. Moreover, to obtain strong vortex formation at the center of the basin at low flow rates of cold fluid, the height to diameter ratio of the basin is adjusted to 0.54 instead of 1. The outcomes will provide a thermally efficient GWVHE configuration with maximum heat exchange area and an effective vortex air core at center of the basin.

WIND AND SOLAR-BASED ENERGY SYSTEM WITH HYDROGEN AND BATTERY STORAGES AND HEAT PUMP FOR SUSTAINABLE COMMUNITIES

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ABSTRACT
The proposed system uses solar and wind resources in a complementary way to compensate intermittencies, along with battery and hydrogen hybrid energy storage systems along with heat pumps. It is intended to meet the requirements, namely, non-thermal electricity, heat, domestic hot water, and hydrogen, of remote communities in a sustainable and integrated fashion. A bifacial PV plant and a wind farm is designed to produce power for the community and subsystems. The proposed system is analyzed with the first and second laws of thermodynamics by using energy and exergy aspects. Moreover, changing parameters are investigated in a parametric study to see their effects on overall performance. Since the demand side and source is dynamic, using wind and solar not a merely good for a remote community. Battery storage systems hydrogen and battery are used in the system and their analysis along with intermittent renewables and dynamic load is analyzed in a time-dependent spreadsheet with all changing parameters by the time. The round-trip energy efficiencies for hydrogen and battery storage systems are found to be 41.54% and 93.12%, respectively.

Keywords: Solar energy, wind energy, hydrogen, battery, heat pump.

1. INTRODUCTION
The demand for energy is growing under the effect of growing population and improving life quality. Industrialization, digitalization brought many advantages to our society like mobility and better life quality. However, greenhouse gas emissions and global warming is the by product of the development which is majorly powered by fossil fuel-based combustion. The Assessment Report Six (AR6) of Intergovernmental Panel on Climate Change (IPCC) presents that the global warming is already there both on land and ocean. The global temperature for ocean is increased 0.9 °C from 1850 to 1900 average global ocean temperature. The global land temperature is increased even more with 1.6 °C compared to the period between 1850 and 1900. The overall global temperature rise is reported as 1.1 °C when 2011 and 2020 period is compared with 50 years between 1850 and 1900 [1]. The solar and wind energy technologies are two of the fastest growing technologies among renewables. When they used together, the complementarity of these sources brings synergetic advantages. If the source produces power only with no process heat, the space heating process can be done via heat pump systems to upgrade the heat by using air, water, or ground source.

This study investigates solar and wind-driven systems with battery and hydrogen storage systems to meet requirements of communities in a sustainable manner. The objective of this study is to design the system by using solar and wind sources, to analyze the system with the first and second laws of thermodynamics, to carry out a parametric study in order to understand the effects of changing parameters on system performance, to conduct a case study for a community with actual data for source and demand.

2. SYSTEM DESCRIPTION AND ANALYSIS
Solar and wind energy sources are utilized with the proposed system to power the integrated system to produce power, heat, and hydrogen in order to provide electricity, space heating, domestic hot water, and hydrogen for communities in a sustainable and integrated fashion. The proposed system includes a bifacial PV plant, a wind farm, a ground source heat pump system, an anion-exchange membrane (AEM) electrolysis unit, a proton-exchange membrane (PEM) fuel cell unit, a battery storage.

The bifacial PV plant collects solar radiation and converts into power, along with the wind farm which converts mechanical energy into the power. Heat pump system is used to upgrade heat from underground and to deliver district heating and domestic hot water to the communities. In order to balance the mismatch between demand and supply of energy sources, an integrated unit with an AEM electrolyzer, a PEM fuel cell, and a battery storage unit is used. In the system analysis and assessment, we use the fundamental methodology from [2] and define the overall energy and exergy efficiencies as:

$$\eta_{en,ov} = \frac{\dot{W}_{El,net} + \dot{m}_{H_2} LHV_{H_2} + \dot{Q}_{Heating}}{\dot{Q}_{GHI} A_{FPV} + \frac{\dot{m}_{wind} V_{wind}^2}{2000} 0.593}$$

and

$$\eta_{ex,ov} = \frac{\dot{W}_{El,net} + \dot{m}_{H_2} ex_{H_2} + \dot{E}x_{\dot{Q}_{Heating}}}{\dot{Q}_{GHI} A_{FPV}\left(1 - \frac{4}{3}\frac{T_o}{T_{sun}}(1-\cos\delta)^{\frac{1}{4}} + \frac{1}{3}\left(\frac{T_o}{T_{sun}}\right)^4\right) + \frac{\dot{m}_{wind} V_{wind}^2}{2000} 0.593}$$

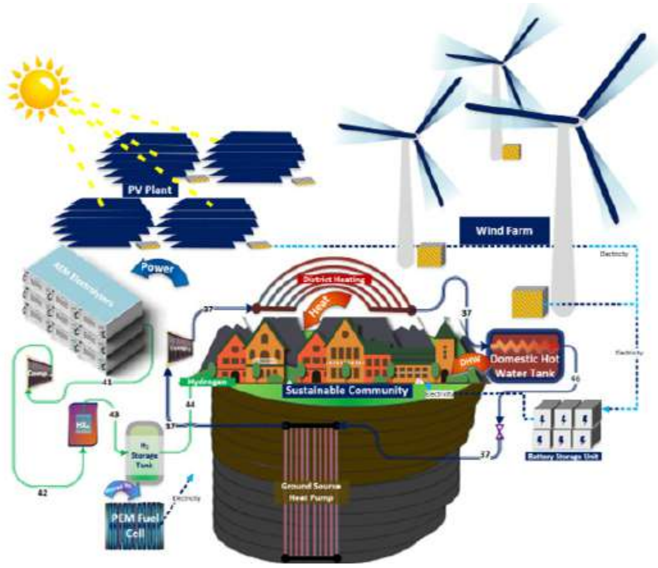

Fig. 1: Layout of the overall integrated system

3. RESULTS AND DISCUSSION

The proposed system consists of a wind farm with 20 MW of power generation capacity and a bifacial PV plant with 2 MWp of power generation capacity. A case study is carried out for 53000 of people in the town of Cochrane**.**

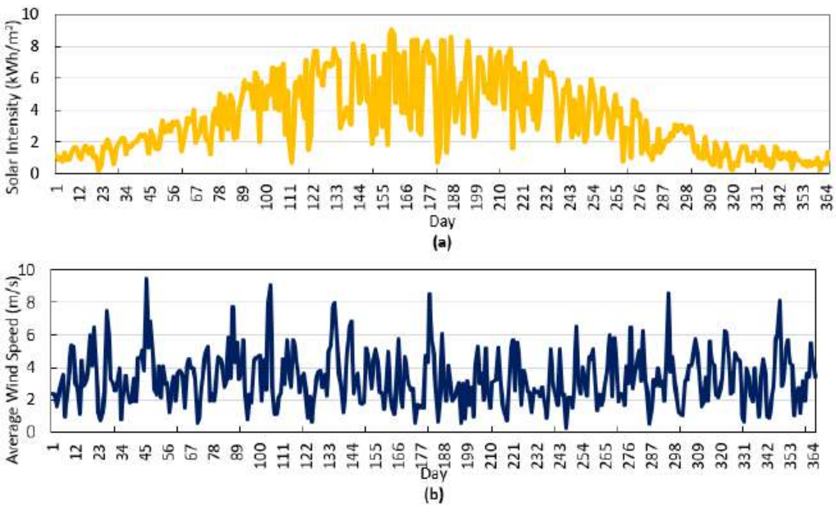

Fig. 2: Solar (a) and wind (b) energy potentials

In a typical meteorological year, they need 51 GWh of electricity and 23.8 GWh of heating. There is 1268.7 kWh/m2 annual solar radiation available to be utilized via bifacial PV plant. On the other hand, there is average wind speed of 7.3 m/s at 100m for the town of Cochrane in Ontario. Figure 2 shows the solar and wind energy potentials in a typical meteorological year. The round-trip energy efficiencies for hydrogen and battery storage systems are then found to be 41.54% and 93.12%, respectively.

4. CONCLUSIONS

The proposed system exploits the renewable sources in a complementary way by integrating solar and wind resources along with heat pump and storage systems. It is important to keep continuous energy supply with more than backup systems. The proposed system ensures the energy security for remote communities in an integrated and sustainable fashion. A 20 MW of wind and a 2 MWp bifacial soar PV system cooperates in synergy along with battery storage and hydrogen storage units in order to continuously supply energy with the round-trip energy efficiencies for hydrogen and battery storages as 41.54% and 93.12%, respectively. Remote communities also most vulnerable communities to effects of global warming. Therefore, ensuring their energy security in a sustainable way is a potential approach to act against global warming in a shorter period. The integrated energy systems for small communities can be considered as pilot applications before larger implementations. Also, these technologies are mature enough to ensure energy security and feasibility for vulnerable communities.

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ANALYZING FAST FASHION RETAILERS' EFFORTS TO REDUCE CARBON FOOTPRINT: THE CASE OF H&M AND LC WAIKIKI

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ABSTRACT
In today's world, with the increasing environmental concerns and awareness of consumers, the importance of the concept of sustainability has increased significantly. One of the most polluting industries in the world is the textile and apparel sector, which requires a detailed focus. This study looks at the fast fashion industry, which could have a negative impact on a sustainable world. In this regard, Swedish fast fashion retailer H&M and Turkish fast fashion retailer LC Waikiki (LCW) were examined separately in terms of their efforts to reduce carbon emissions within the scope of sustainable fashion concept. The study's findings demonstrate that consumers and the media pay close attention to the brands that compete on a global scale and investigate each aspect of their operations. Despite the fact that both companies have locations across several continents, H&M prioritizes sustainability with more specific actions.
Keywords: FAST FASHION, CARBON EMISSION, CARBON FOOTPRINT, SUSTAINABILITY

1.INTRODUCTION
The manufacturing industry applies the concept of sustainability to combat climate change, which is a result of a high level of carbon dioxide in the atmosphere[1]. The second-largest industry in the manufacturing industry is the textile and apparel sector [2] that is thought to be responbible for between 6-8% of all worldwide carbon emissions, or roughly 1.7 billion tonnes of carbon dioxide annually [3]. Carbon footprint is described by [4] as: "The carbon footprint is a measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product." Today, it is believed that the primary cause of global warming and climate change is an increase in carbon dioxide (CO_2) concentrations brought on by anthropogenic emissions. For this reason, studies on the effects of greenhouse gas accumulation in the atmosphere on climate change and its devastating consequences on the world are increasing day by day. One of the most remarkable scientific study findings is that doubling the atmospheric CO_2 concentration can result in +2.5 °C of global warming, and if this scenario persists until 2100, it can raise the sea level by an average of 70 cm [5,6].
The fashion industry's massive use of water, electricity, and raw materials along the production chain leads to the pressure on Earth's natural resources [7]. Especially fast fashion causes excessive damage to the ecosystem and leaves behind a planet that is inaccessible to future generations [8]. Fast fashion describes low-cost clothing brands that replicate popular high-end fashion trends that reflects the desires of young people, and helps average consumers to get the latest product or the newest fashion trend at a reasonable price [6,9]. While the fast fashion sector captures the latest trend and brings it to the consumer quickly, it also creates a significant carbon footprint and a number of social concerns. [10] The fast fashion industry needs to start taking financial responsibility for its emissions [11]. The fashion industry must collectively accept accountability for its environmental effects, including waste generation, CO_2 emissions, water, energy, and chemical use from fiber manufacturing to retail [8].
The structure of this paper is as follows. The case description and analysis of two massive fast fashion retailers will come after the explanation of the material and methodology. Following that, the findings will be discussed together with any implications for theory and practice. Finally, the paper will conclude with a brief summary and conclusion.

2.MATERIAL AND METHOD
In order to acquire a thorough understanding of how fast fashion businesses manage sustainably, a case study of the two major fast fashion giants H&M and LCW is conducted in this section. The case study is a well-known research method in business research, and obtaining data from various sources may aid in increasing the reliability of the results [12]. Therefore, the corporate website, annual sustainability reports, news media, official statistics, etc. were some of the sources used to collect the data for this study. There are a few reasons for choosing H&M and LCW as the study cases.

There are some similarities and differences between the two retailers chosen for this study. The first thing to note is that these two fast fashion brands operate internationally. They can be characterized as a globalizing retailer of fashion that steadily expands into new markets, gaining experience along the way. The Turkish market is served by the Swedish-based H&M brand, and LCW is one of its main competitors in the fast fashion industry. The product range of LCW and H&M is quite similar. However, they also have some different aspects from each other. While H&M has 4801 stores worldwide; LCW currently has only 1047 stores. H&M has 107,375 employees, while LCW has 54,000 employees [13]. Considering all these similarities and differences, the relative importance and activities of fast fashion brands on sustainability issues will be discussed within the scope of this research.

3.THE CASE STUDY OF SUSTAINABLE PRACTICES IN TERMS OF REDUCING CARBON FOOTPRINT APPLIED BY FAST FASHION GIANTS

3.1. H&M

H&M opened its first store in Västerås, Sweden in 1947 by Erling Persson. The company was listed on the Stockholm Stock Exchange in 1974. Not long after, in 1976 the first store outside Scandinavia opened in London. H&M continued to expand in Europe and began retailing online in 1998 with the domain name hm.com in 1997, according to data obtained through Whois. The opening of the first US store on Fifth Avenue in New York City on March 31, 2000 marked the first step in the company's expansion outside of Europe.

H&M is one of the firms that recognizes the significance of sustainability in the fashion sector and has integrated it into their supply chain [8]. Notwithstanding the difficulties provided by the Covid-19 epidemic, H&M has made progress in 2020 toward its objective of imposing a price on carbon to assume responsibility for the entire cost of the brand's climate effect [14]. H&M uses technology effectively to determine how they will achieve their sustainability goals. To forecast how their operations might contribute to future carbon reductions across the value cycle, they have taken the following actions: [15]

•Developing a Climate Positive Roadmap tool to forecast how operations may help reduce carbon emissions in the future. With the help of that tool, they are creating internal carbon pricing to increase corporate knowledge of the true cost of emissions and focus on mitigating future climate impact by directly tying emissions to a carbon price.

•Increasing the traceability of products. In order to track materials and goods from sourcing through recycling, they supported the creation of the standards that were required.

•Working with policymakers. To reduce carbon emissions by 55% and support the establishment of the 2030 target, they founded the Green Recovery Alliance with 180 other decision-makers, organizations, and other stakeholders. In addition, they signed a letter in favor of the Cambodian government's choice to invest in renewable, low-carbon energy sources rather than fossil fuel infrastructure.

•Maintaining the vision of sustainability in international regions. Based on each area in which they conduct business, they maintain their sustainability vision.

•Cooperating with third party institutions. H&M is a member of the steering committee for the UNFCCC Fashion Industry Charter for Climate Action and a signatory to the Fashion Pact. The brand is compelled by these actions to take action and work with lawmakers to develop legislation for a future with low carbon emissions.

Despite all these positive steps, there were some negative news in the media about H&M's "greenwashing". Some news about H&M were found on international news sites. Some news about H&M were found on international news sites. In this news, the brand was sued for "misleading" marketing promotions that falsely presented some of its products as "sustainable", contrary to what the brand originally claimed. The lawsuit, filed by a New York state resident, appears to reflect consumers' growing awareness of corporate greenwashing practices [16].

3.2. LCW

LCW was first introduced to the market as a wholesale brand in 1988. Established and registered in Paris, LCW has managed to attract attention with its sweatshirt designs, especially t-shirts. With the two founding partners of the brand ending the partnership in time, it passed to George Amouyal, the sole shareholder of LCW. Tema Tekstil, which maintains its name under the Taha Group and is the manufacturer and licensor of LCW in Turkey, acquired the worldwide rights of the LCW brand in 1997.

Examining the LCW brand reveals that there are no efforts targeted to directly lower the carbon footprint. The concept of sustainability has three dimensions: environmental, social and economic. LCW invests in each of these aspects respectively. Their efforts for contributing a sustainable business practices can be listes as follows: [17]

•Developing a Project that enables less water usage along supply chain activities. Waterless dyeing, chemical-free washing are among their objectives, and until now they achieved 20% water saving in their LCW Denim and LCW Green collections where they started this Project.

•Producing products in an organic way. They are investing for sustainable self-colored cotton production Project with the Ministry of Agriculture and Foresty in Turkey. In this way, producing colored cotton without using any chemical becomes possible.

•Working on the reuse of recyclable plastics in clothing and the reuse of products that are no longer worn by turning them into fibers.

•Creating a LCW Green Collection. In this collection, they support the circular economy and include items manufactured from recycled cotton and polyester yarn. By recycling plastic bottles that would otherwise wind up as trash in our forests and oceans, they help to protect the environment [18]. They reduced chemical use by 30 percent in jeans.

•Cooperating with third party institutions. A new recycling initiative is being carried out by LCW in cooperation with TOÇEV. They make these things reusable and guarantee that they get to individuals in need by setting up places in their stores where their consumers may donate their unworn clothing [18].

•Reusing of cardboard boxes. The carbon footprint can be reduced as a result of the use of cardboard boxes with various sustainable and environmentally friendly methods. LCW put the idea into practice by making cardboard boxes into toys. On their website, it was stated that "LCW is getting ready to win the hearts of children with its new campaign." Making delivery boxes simple to reuse sustainably can be considered as a move that could help reduce carbon footprint [19].

•Having internationally recognized certificates. LCW certifies the organic products in its collections and the production and processes of these products within the internationally recognized certification programs (Global Organic Textile Standard and Organic Content Standard). They are audited by independent auditing organizations in accordance with recycling criteria. [20].At the conference on sustainable brands that it attended in 2016, LCW presented its 2023 vision to its stakeholders. In keeping with its mission to promote sustainable practices for both people and the environment, they introduced the "Roadmap to Zero" awareness program. It shows that LCW is trying to make progress on this path.

CONCLUSION

As the fashion industry continues to expand despite its known negative effects on the environment, global awareness of their processes is also increasing [7]. In particular, fast fashion is a frequently discussed topic in the fashion industry. Given the fast fashion industry's well-documented negative environmental impacts, it is reasonable to conclude that these businesses should make sustainability the main priority of their operations.

Investment in the most up-to-date pollution control equipment is necessary, for example, to remove chemicals, heavy metals, and other dangerous substances from waste streams in order to ensure the textile industry's short-term sustainability [8]. This study examines two fast fashion brands' -H&M and LCW- efforts to manufacture sustainable products using environmentally friendly practices, as well as their long-term objectives in this regard.

The research that was carried out for both brands revealed that, both brands have taken different efforts toward sustainability. In particular, LCW has not made enough effort to carry out studies on carbon footprint, which is also the backbone of this study. Each year, H&M formally releases its sustainability reports. H&M details its actions in these reports, provides supporting data, and identifies its current position and desired future state. In contrast to H&M, which has several initiatives to lessen its carbon footprint, LCW does not have such a thorough program. In addition, while the H&M brand is included in the lists published by institutions such as S&P, Dow Jones and Corporate Knights that evaluate the sustainability performances of companies operating around the world, LCW has not yet had the opportunity to enter these lists. Although there is no sustainability report published every year, by consistently taking part in the sustainable brands conference, which is conducted every year with the involvement of local and international businesses, LCW demonstrates the value it places on the notion of sustainability.

The result of this research also revealed that although both brands prioritize sustainability, their efforts on carbon footprint are not sufficient. Despite being a member of the Dow Jones Sustainability Index and coming in at number 27 on Corporate Knights' list of the most sustainable businesses for 2020, the H&M brand is still accused of not being honest in its attempts to lower its carbon footprint. H&M must share information that shows how its efforts to reduce its carbon impact have been effective in order to avoid charges like "greenwashing." Although it is anticipated that investments made by businesses in sustainability would have a positive effect, these actions of brands that have high brand value are being closely monitored. Since the public is more familiar with brands that have a high brand value, they are rapidly made aware of any potential brand mistakes. As a result, this situation may cause a negative reputation of the brand. Accordingly, especially brands like H&M that have a high brand image, may be vulnerable for any kind of accusations such as greenwashing in their activities. Consistency between brands' promises and actions is important. For instance, based on Statisca's data, H&M was identified as the third brand in Europe with the largest carbon emission in 2021 [21]. Therefore, it is obvious that H&M needs to work more to lower its carbon emission rate. Lc Wakiki, on the other hand, does not have as much concrete data as H&M, but it needs to transform its sensitivity on carbon footprint emissions into data. Additionally, a proactive approach should be taken by LCW while simultaneously keeping an eye on the good and bad practices made by its rival H&M along this path.

The study has another important implications for marketing practitioners. The adoption of eco-friendly garments is directly influenced by consumers' environmental concerns, and since young people make a significant percentage of the fast fashion industry's target market [22], thus it is crucial to pay close attention to their expectations. The most profitable market for fashion industry is Gen Z customers, who have also shown a readiness to switch to more environmentally friendly production methods [23]. Generation Z is highly conscious of and motivated by ethical and environmental issues [24]. Furthermore, since they closely follow the news on social media, brands must be honest in their explanations of and justification for their actions.

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INVESTIGATION OF THE EFFECTS OF GLOBAL WARMING IN THE BÜYÜK MENDERES RIVER BASIN WITH THE INNOVATIVE ŞEN TEST

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ABSTRACT
The global warming caused by the greenhouse gas effect directs us to make more precise calculations on hydrological and meteorological characteristics day by day. Major disasters (drought, flood, etc.) caused by the climate crisis are a warning for us to better interpret and analyze these data and take the necessary precautions. In this context, the effects of global warming on precipitation were tried to be examined by taking the flow values in the Büyük Menderes Basin and using the Şen Innovative Trend Analysis (ITA) method. The statistical significance of the data obtained from the measurement station in the Büyük Menderes Basin was examined. As a result, while a non-monomatic decreasing trend was observed at Kayırlı station, a decreasing trend was observed at Amasya and Aydın Bridge stations.a non-monometric negative trend was observed, which reveals an undesirable result in terms of global warming.

Keywords: Global Warming, Time Series, Innovative Sen Test, Trend Analysis.

1. INTRODUCTION
In today's world, where global warming affects our lives in many areas, it is very important to develop sensitivities about this issue and to reveal the scale of the crisis with numerical data. In this context, it has become important to make the necessary plans and designs by considering the risk situations related to water resources management well. In this context, statistical analysis of the amount of flow rates in rivers contributes to our observation of the effects of the crisis. In this sense, it is important to examine the trends of stream flows.

Statistically different analyzes are used to examine the trends of hydrological data such as precipitation, temperature, and evaporation. Mann (1945)-Kendall (1975) (MK) test, slope estimator Sen (1968) and linear regression analysis (Haan, 1977) are the trend determination methods that we frequently encounter. These methods are frequently encountered in the literature.

Babak and Kamran (2016) examined the quantitative and qualitative changes in the groundwater feeding the Urmia Lake with three different trend analyzes. Arab Amiri and Gocić (2021) used Innovative (ITA) method and Mann-Kendall (MK) for analyzing precipitation changes at 28 stations in Serbia between 1946–2019. Only two stations showed instability in the calculated trends. The monotonic analysis indicated that half of stations (14 stations) have monotonic trend components, while the trend components of the other half are non-monotonic. The trends for three stations and Valjevo are recognized to be non-significant by the ITA method.

An investigation of the temporal rainfall variability has been carried out using a homogeneous monthly rainfall dataset of 559 rain gauges with more than 50 years of observation by Caloiero, Coscarelli and Ferrari (2018). The area under investigation is a large portion of the Italian peninsula, ranging from the Campania and the Apulia regions in the North, to Sicily in the South. a negative trend has been detected especially in winter and in autumn in the whole study area, whereas not well defined trend signals have been identified in summer and spring.

An innovative trend analysis (ITA) method is used for rainfall trend detection at 14 stations in the Yangtze River Delta (YRD) during 1961–2016. The slope and significance of the rainfall trends derived from the ITA method are compared with those from the classical trend analysis methods. The ITA shows significant increasing trends at the 99% confidence level in annual rainfall at all stations. While the same significant increasing trends are identified for summer and winter, decreasing trends dominate in spring and autumn. Contrasting trends are found for extreme rainfall with strong increasing trends in high rainfall in summer and winter and decreasing trends in low rainfall in spring and autumn Wang et al, 2020.

2. MATERIAL AND METHODS

The ITA method (Sen, 2012) visually presents the monotonous or non-monotonic trend definition. It provides great advantages thanks to its easy application. A time series with N elements is bisected by y1, n/2 = {x1, x2, … xn/2} and y2, n/2 = { xn/2+1, xn/2+2, …xn}. Then, both series are ordered from minimum to maximum or from maximum to minimum as shown in Equation (1) (Şen, 2012).

$$\begin{Bmatrix} \{r_1\} = \{\min(y_{1,n/2}), \dots y_i, \dots \max(y_{1,n/2})\}(1 < i < n/2) \\ \{r_2\} = \{\min(y_{2,n/2}), \dots y_j, \dots \max(y_{2,n/2})\}(1 < j < n/2) \\ or \\ \{r_1\} = \{\max(y_{1,n/2}), \dots y_i, \dots \min(y_{1,n/2})\}(1 < i < n/2) \\ \{r_2\} = \{\max(y_{2,n/2}), \dots y_j, \dots \min(y_{2,n/2})\}(1 < j < n/2) \end{Bmatrix}$$

Based on the half-split data, - a scatter diagram is drawn and a 1:1 straight line is drawn on the same diagram. If these used data are located on this added straight line, it is concluded that there is no trend. However, if the data concentrates on this sloping line, it is concluded that there is a monotonically increasing (decreasing) trend. Situations in which there is a transition from a descending (ascending) region to an ascending (descending) region are called a partially increasing (descending) non-monotonic trend. All these alternatives are presented in Fig. 1

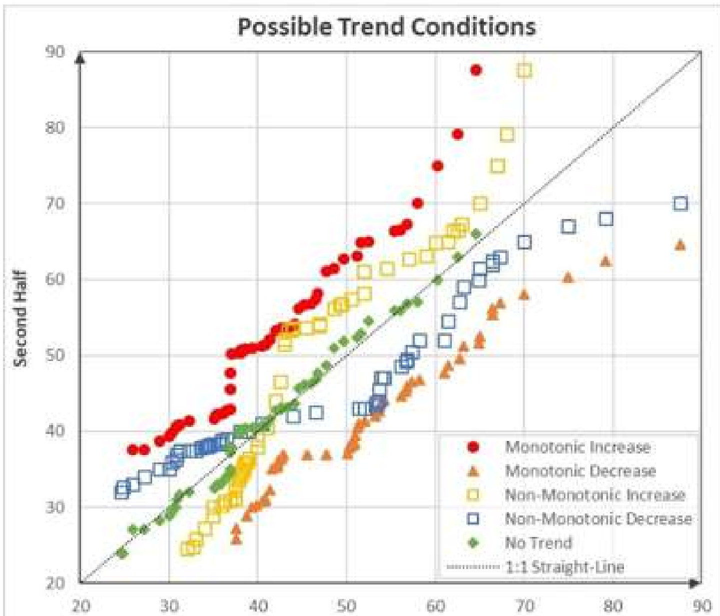

Fig. 1 Trend states according to Sen's ITA (Saplıoğlu & Güçlü, 2022)

3. Study Area and Data

Turkey has four climate types. The Black Sea region is rainy in all seasons. The Mediterranean climate is rainy-warm in winters and dry-hot in summers. The Mediterranean climate is always dominant in the southern and western coastal parts of Turkey. The Marmara region has a transitional climate between the Black Sea and the Mediterranean. The coastal parts of the Sea of Marmara connecting the Black Sea and the Aegean Sea are rainy in winter, cool-cold in summer and moderately dry, warm-hot. Continental climate type is dominant in most of Central, Eastern and Southeastern Anatolia (fig. 2).

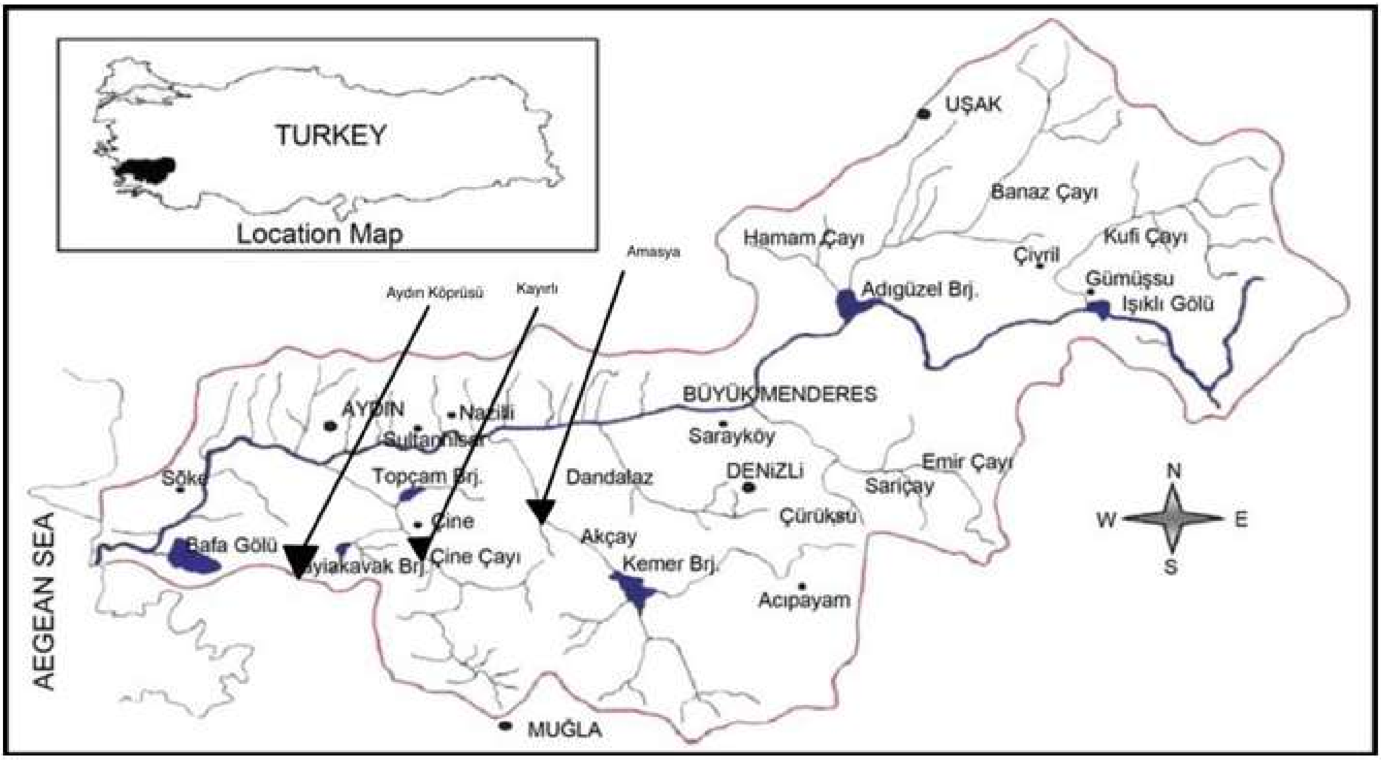

Fig 2. The locations of the stations on the Büyük Menderes Basin

General Directorate for State Hydraulic Works (DSI: Devlet Su Isleri, in Turkish) measured the data at Kayırlı, Kavunca and Çal stations for 30 years (see Table 1 and Fig. 3). The data are annual average discharge values (m3/s) measured with a limnigraph.

Tablo 1 Geographical data of Stations.

Station	Latitude (N)	Longitude (E)	Altitude (m)	Stream
Kayırlı	$37^o\ 25'\ 15"$	$28^o\ 07'\ 46"$	262	Çine
Amasya	$37^o\ 06'\ 32"$	$28^o\ 28'\ 50"$	155	Akçay
Aydın Köprüsü	$37^o\ 47'\ 02"$	$27^o\ 50'\ 03"$	25	Menderes

4. RESULT AND DISCUSSION

Flow data of three stations in the Büyük Menderes Basin were analyzed according to the ITA method. These data are divided into two parts as the first period between 1982 and 1997 and the second period between 1997 and 2020. Then, it was tried to understand whether there were trends in two axes in the scatter diagram by sorting them among themselves. Points on the 1:1 straight line indicate an increasing trend, while those below the line indicate a decreasing trend. In this context, the ITA method regarding the data of these 3 stations examined also offers us a visual interpretation opportunity. In this way, an easier and faster trend analysis can be made (Almazroui, M., & Şen, Z. (2020)..

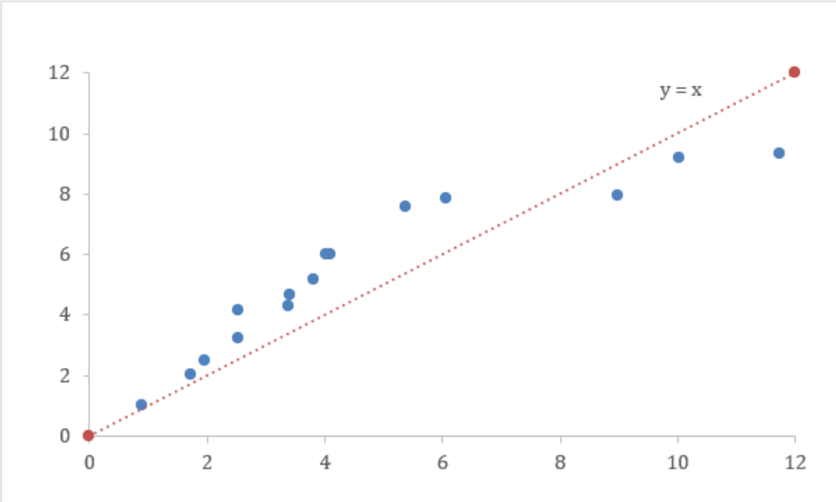

Fig 3 Proposed Method for Kayırlı Station

When looking at these three stations, 10 of the 15 data at Kayırlı station show that there is a positive trend, but they are located in a region very close to the 1:1 line. The 2 points are exactly on the line. The 3 dots indicate that there is a negative trend and they are located at a very far point from the line. Here is an indication that the decrease in current in recent years is more radical. According to Figure 1, it is observed that there is a non-monotonic decreasing trend.

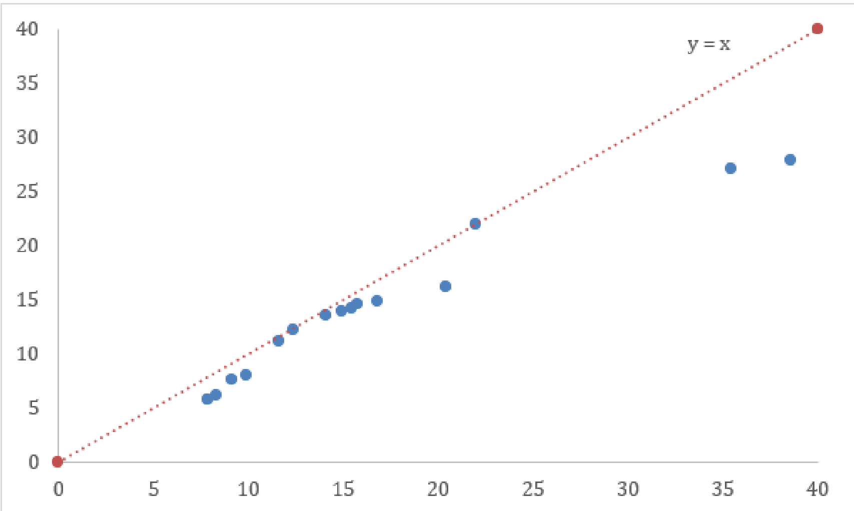

Fig 4 Proposed Method for Amasya Station

The data taken from Amasya station shows us that 3 points are only on the line and the remaining 12 points are below the line and the trend is negative. The fact that 3 points are on the line does not affect the general interpretation proportionally. The fact that the last two points are quite far from the direct shows that the negative trend of the trend has increased in recent years.

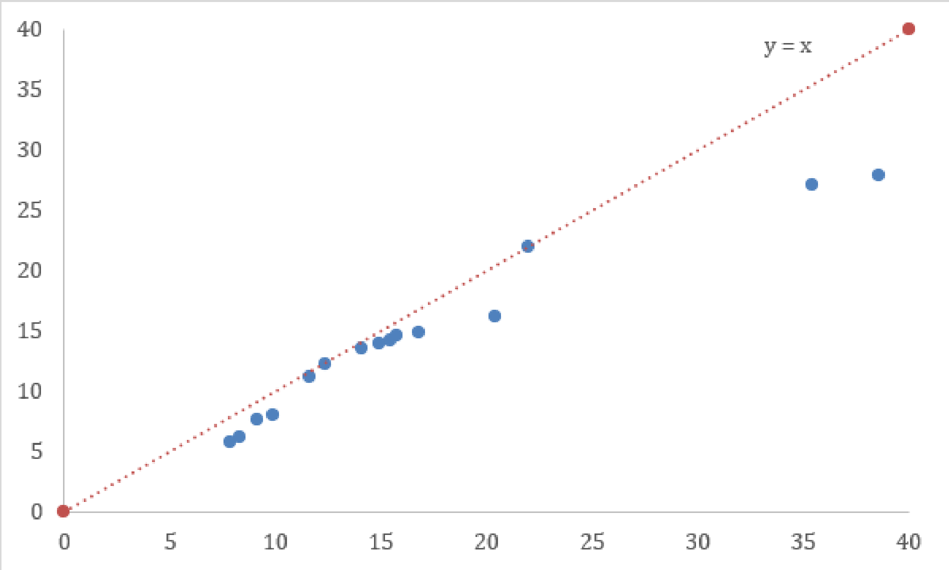

Fig 5 Proposed Method for Aydın Bridge Station

At the Aydın Bridge station, it meets the Amasya station with a table that supports it. While 2 points are on the line, 13 points are below the line. The fact that the last two points are gradually moving away from the line is also a visual indicator of the increase in the negative direction of the trend.

4. CONCLUSIONS

When the flow data of the 3 observation stations examined in the Büyük Menderes basin are analyzed according to the ITA method, findings indicating that the trend has decreased in all 3 stations are encountered. Especially in Amasya and Aydın Bridge stations, it is seen more clearly that the trend is decreasing.

The decrease in these flow values may be due to many reasons. However, the most important of these reasons is global warming and other related effects. In order to examine the effects of global warming on flow trends, different trend analysis methods can be applied on these data and comparisons can be made among themselves.

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SECAPSOFT SOFTWARE FOR DECISION MAKING, BASED ON DATA ANALYTICS AND CARBON REDUCTION

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ABSTRACT
Local governments that have signed the Presidents' Agreement (CoM) conduct greenhouse gas emission analyses within their provincial/district administrative borders and prepare the strategic roadmap of the sustainable energy and climate action plan (SECAP), which includes emission reduction targets. The SECAPSOFT software platform was developed in order to facilitate the process and increase data reliability by digitalizing the inventory data supply, which is the most important stage of this roadmap. With the software, greenhouse gas emission analysis can be made in areas such as residences, industrial facilities, commercial buildings and official institutions, transportation and waste management, and the determined emission reduction projections can be monitored. With the SECAPSOFT software, it is aimed to raise awareness among all stakeholders, to monitor the current greenhouse gas emission situation analysis and to take actions to increase environmental awareness.
Keywords: Sustainable Energy, Climate Action Plan, Carbon Emission, Data Analytics, Secap.

1.INTRODUCTION

As a result of the increase in greenhouse gas emissions caused by human activities, especially due to fossil fuel consumption, starting from the industrial revolution and increasing day by day, the negative effects of human health, the increase in natural disaster risks, the occurrence of mass live deaths, the decrease in natural resources and the emergence of resource wars have brought cities into action and has led to the implementation of various implementation actions on a local scale. Climate change is accepted as one of the biggest environmental problems on a global scale, and it affects every aspect of our lives, especially agriculture and food, clean water, energy and health, and makes it necessary for countries and cities to increase their efforts to solve these issues. In this context, the issue of combating and adapting to climate change comes to the fore.

Starting from the late 1980s, various studies have been carried out under the leadership of the United Nations and international organizations to reduce the negative impact and pressure of people on the climate system. As a result of these studies, The United Nations Framework Convention on Climate Change (UNFCCC) was established in 1992, the Kyoto Protocol (KP) in 1997 and the Paris Agreement (PA) in 2015. While UNFCCC, KP and PA introduce legal regulations to limit human related greenhouse gas emissions, it has also become increasingly active in international emissions trading, technology and capital movements (https://enerji.gov.tr).

Today, many city governments in the world have devoted a significant part of their local service policies to this issue and started to prepare and implement local climate change action plans. In the international community, many methodological studies have been carried out to support the preparation of local climate action plans, such as mitigation and adaptation, and these activities continue to shed light on the city governments of the countries (Talu, 2019). One of these studies, the Sustainable Energy Climate Action Plan (SECAP), is a strategic action plan with a global dimension that aims to reduce the negative effects of global climate change and to eliminate it over time. Many local governments in Turkey are preparing the SECAP roadmap as signatories within the scope of the Presidents Agreement.

With SECAP programs, local governments create "Sustainable Energy Climate and Action Plans" to be implemented at their local borders with the full participation of the city, in line with their targets of reducing carbon emissions by 40% by 2030 and being carbon-neutral by 2053. Each area, district and city has its own unique dynamics. For this reason, each city has different priorities in combating climate change. SECAP studies are also an important tool to determine these priorities (Municipality of Çorlu and Istanbul Enerji, 2023).

On the other hand, thanks to the increasing processing power of computers, the use of increasingly complex algorithms, and the ability to process rapidly increasing amounts of data with high speed and accuracy rates; the digitalization process, which can produce more efficient and effective solutions than traditional methods, has caused radical changes and developments in human life and management systems. It is envisaged that digital transformation, which is widely used in many fields, can be designed as a method that will facilitate meeting the needs of local governments that aim to reduce carbon emissions within the scope of SECAP studies. With the SECAPSOFT software, which was developed for this purpose and can be described as the digital transformation of SECAP studies, climate risk and vulnerability analyses can be revealed within the determined region boundaries; greenhouse gas emissions can be analysed and emission reduction targets can be determined in order to make the city resistant to climate change.

Greenhouse gas emission data of different locations will be collected and monitored. Greenhouse gas emission calculation analyses will be carried out in accordance with national and international legislation and standards, so it will be able to easily adapt to possible local legislation changes and additions. Greenhouse gas emission data will be accessed transparently through the software.

2.SECAPSOFT

SECAPSOFT is a web-based data collection and reporting software developed for tracking greenhouse gas emissions in a certain region, district, province or country. The values of different data sets (electricity, natural gas, coal, gasoline, diesel, wastewater treatment etc.) of greenhouse gas emissions, their current status, historical data and the changes in the targeted values over time can be monitored in detail.

The developed software can be monitored from a management centre. In the software, sub-management units (building-facility, institution, neighbourhood, district, province, region) can be defined and these administrative units can be accessed for data input with the necessary authorizations.

In the software, which has a detailed reporting and analysis capability, a graphical report of all types of data can be obtained, and regional situations, changes and targets can be followed on real maps thanks to the map module.

2.1. Modules

SECAPSOFT software program consists of different modules. These modules meet the main needs such as corporate structure and inventory, management, data set, reporting and mapping. It has been designed as modular so that it can be modified over time and new modules can be added if necessary.

2.1.1. Corporate structure and Inventory Module

The infrastructure of the program is designed to serve a single enterprise, as well as to cover buildings, facilities, institutions, districts, provinces and regions throughout the country. All relevant sub-units (institution, district, province) designed by the software administrator are authorized and allowed to create their own corporate tree and inventory system. In this way, after the administrator creates the main node of the hierarchical structure, he ensures that the sub-units enter the remaining inventory structure. If desired, the entire corporate tree structure and inventory system can also be entered by the administrator.

The inventory system can be associated with the corporate tree structure and thus all greenhouse gas sources in a particular region can be analysed. Greenhouse gas source types (fixed, transportation, waste, etc.) are defined dynamically and can be seen in detail in the reports.

2.1.2. Management Module

There is a need for an advanced authorization and management system in order to facilitate the management and to prevent the difficulties that may arise in case the system grows. For this purpose, the software developed allows to make data entry, authorization and regional administration. Each district or region has the right to manage the data related to it, and they will be prevented from seeing other data. The central management unit, on the other hand, has the opportunity to observe on all data.

2.1.3. Data Set Module

It is the main module in which data belonging to energy sources with different greenhouse gas emissions are entered and that creates a source for other modules. The information of each data source is entered into the system with the appropriate data structure. The greenhouse gas emission values to be generated by the data provided are calculated with a dynamic formulation and recorded. Data entry can be made with the data sets belonging to the system, as well as with the manual declaration.

In addition to dynamic formulation processes for data set operations, definitions for different unit sets can be added dynamically, and unit conversions can be made if needed.

It is also possible to define target values in order to follow the targeted data. In the reporting and map modules, target data and measured data can be compared.

2.1.4. Reporting Module

It is the module where the greenhouse gas data of different regions and locations can be reported and analysed by users within their authority. With the report module, the sources, types, amounts and changes of greenhouse gas emissions according to time can be analysed in detail. Report contents are authorized in such a way that each sub-unit can receive the report of its own resources. The administrator unit, on the other hand, can analyse the general report of all units comparatively.

Information on expected/targeted values can also be listed and graphs can be obtained from the report module. In this way, changes over time can be compared with expectations.

For example; Sector Based Greenhouse Gas Emission Chart is given in Figure 1, and Energy Consumption Sourced Greenhouse Gas Emission Chart is given in Figure 2.

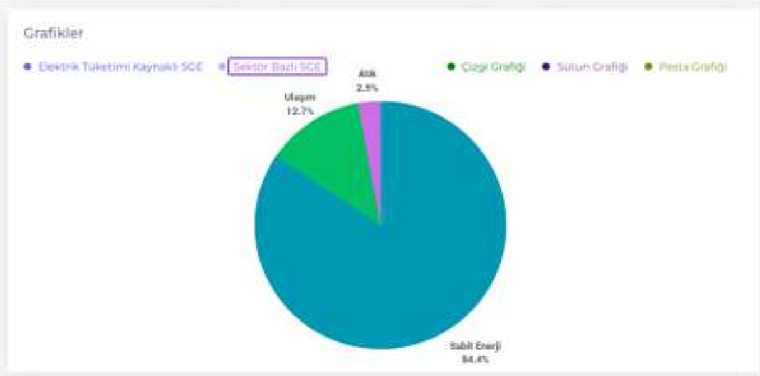

Fig. 1. Sector Based Greenhouse Gas Emission Chart

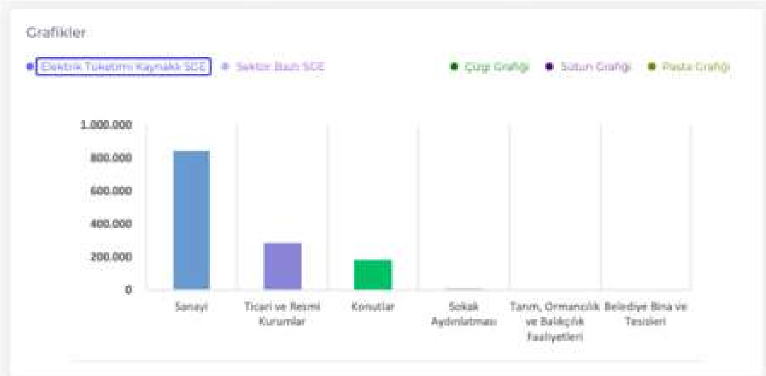

Fig. 2. Energy Consumption Sourced Greenhouse Gas Emission Chart

2.1.5. Map Module

The data can be analysed graphically in the report module as well as in the map module with appropriate colouring on real-scale maps. In this way, regional greenhouse gas emissions can be observed on real maps in a more detailed and understandable way. Greenhouse gas emission map of Turkey is given in Figure 3, and the greenhouse gas emission distribution map of Istanbul district is given in Figure 4.

Thanks to the additional features added to the map module, the greenhouse gas emission increase-decrease rates depending on time can be monitored on a regional or general scale.

Fig. 3. Greenhouse Gas Emission Turkey Map

Fig.4. The Greenhouse Gas Emission Distribution Map of Istanbul District

3. CONCLUSIONS

In our digitalizing world, experience and skills related to digital transformation have now become a necessity for the plans and implementations of almost all institutions. With the support of SECAPSOFT software developed in accordance with the requirements of the digital age, within the scope of compliance of local governments with international standards; by monitoring greenhouse gas emissions, it will be possible to prevent them from reaching serious levels. It will create an infrastructure for a sustainable and more liveable environment. Cities will become resistant to disasters caused by climate change by revealing short, medium and long-term implementation projects and strategic plans for local governments. The ability of management mechanisms to make decisions based on data analytics will be increased. In order to prevent global warming, it is of great importance to raise awareness and consciousness among stakeholders. SECAPSOFT Software will contribute to raise environmental awareness.

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DYNAMIC THERMAL MODELING OF A GREENHOUSE WITH HEATING, COOLING AND VENTILATION SYSTEM

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ABSTRACT
Although climate change directly affects air temperature, humidity or other weather conditions, there are many areas where indirect effects are also observed. Endurance in food production cannot be achieved in agricultural areas where drought or excessive precipitation is observed due to climate change. Therefore, sustainable, or controllable agriculture becomes very important. Greenhouses are simple buildings used for sustainable and controllable agriculture. However, adjusting the greenhouse indoor environment for efficient and sustainable food production is a complex problem. In this study, a dynamic simulation model was designed for the heating, cooling and ventilation of a greenhouse and annual simulations were taken in İzmir conditions. The developed HVAC system consists of a heating coil with humidifying, a cooling coil with dehumidifying, a fan and a transient thermal greenhouse model which is developed in MATLAB and implemented into TRNSYS software. Also, the growth of the tomato crop is implemented into greenhouse thermal model. The aim of the HVAC system in the developed dynamic simulation model is to keep the greenhouse inside temperature and relative humidity in range of optimum tomato growth. The optimum temperature for tomato growth is presented in the literature between 24°C and 26°C, also the optimum relative humidity of greenhouse inside air is presented between 40% and 60%. The simulation results shows that the annual average greenhouse inside temperature was 24.26°C, the humidity ratio of the inside air was 0.0089 kgH2O/kg-Dry-Air and the average relative humidity of the greenhouse inside was 47.64% in İzmir.
Keywords: Greenhouse, Energy modelling, HVAC, Thermal Management, Tomato

1. INTRODUCTION
Due to the increasing effect of climate change, agricultural land suffers from drought. This situation threatens us to face deprivation of food. Therefore, agriculture in a controllable climate is as essential as it that never been before. Greenhouses are the commonly used technique for controlled climate agriculture. However, it is more difficult to control the greenhouse's inside environment and determine the sizing of the heating, ventilation, and air conditioning (HVAC) system than houses due to the complexity of the greenhouse building structure. Some software can be used to determine the sizing of the HVAC system in complex buildings such as shopping malls, office buildings, and greenhouses. (Ibáñez et al., 2005) investigated the effect of the phase change material integrated walls, ceiling, and floor on the thermal performance of a building. The authors have done this investigation in Transient System Simulation (TRNSYS) software and validated the results with an experimental study. They concluded that when the appropriate overall heat transfer coefficient was used, the methodology presented in the study was more suitable. (Asadi et al., 2012) described a methodology for building retrofit strategies using TRNSYS and MATLAB simulations. They concluded that the results of the method demonstrate the practicability of the method to provide decision help for householders. Another study in the literature presented a dynamic thermal model in Integrated Environment Solutions Virtual Environment (IESVE) and compared the model results with the Energy House facility at Salford University. Authors suggested that dynamic thermal models perform well when accurately representing building physics(Ji et al., 2019). (Sudhakar et al., 2019) reviewed the studies about modeling a solar desiccant cooling system in TRNSYS and MATLAB software. The authors stated that TRNSYS software is commonly used to simulate many HVAC systems with building simulation. (Figaj et al., 2020) developed a dynamic simulation model of a house with a hybrid energy system for energy and economic analysis of the ground-solar-wind energy system in TRNSYS software. It is concluded that the primary energy use of the hybrid system was reduced by 66.6% compared to a conventional system consisting of a gas boiler and a chiller. In addition, the authors stated that the simple payback period of the hybrid system is 21.6 years because of the charge of the system components. (Narayanan et al., 2020) developed a simulation model of a renewable energy system for residential buildings using TRNSYS and MATLAB software. The authors' renewable energy system design includes photovoltaic panels, solar collectors, and fuel cells to provide the electricity and heat demand of a residential building. The literature review shows that most dynamic models were developed using computer program language

and carried out using software such as EnergyPlus, MATLAB, and TRNSYS to observe the thermal behavior of a building and integrate energy systems into the building. Also, it is observed that the greenhouse indoor climate has different components such as cover, inside air, soil, plastic mulch, and, most importantly, plants. Since plant evapotranspiration and evaporation from the ground produce massive moisture, humidity control in the greenhouse is essential. Additionally, plant growth affects the plant's evapotranspiration; therefore, plant growth should be implemented into greenhouse models.

2. MODELING

In the study, a transient numerical model is developed for an indoor greenhouse climate in a MATLAB environment. The developed model considers a greenhouse consisting of cover, plant, inside air, and plastic mulch, which is used to avoid evaporation from soil to inside air and soil. The greenhouse model is developed by taking (Reyes-Rosas et al., 2017) as a reference model and is modified from that model and validated with their results.

Additionally, some assumptions made for the greenhouse thermal model are listed following.
-The thermophysical properties of the materials are constant.
-Using plastic mulch in the greenhouse avoids evaporation from the ground to the inside air, so evaporation is neglected.
The governing energy equations for all aspects of the greenhouse are discretized with an explicit finite difference method, and the temperature of the components is determined. Wang and Deltour defined the crop temperature as a function of inside incident solar radiation and greenhouse inside air temperature.

$$T_v = -2.05 + 1.01T_i + 0.00425R_{si} \quad (1)$$

The temperature of vegetation is T_v the temperature of the greenhouse inside the air T_i and the inside solar radiation R_{si}.
The energy balance equation for the greenhouse cover is defined as

$$\rho_c c_{pc} th_c \frac{dT_c}{dt} = q_{ac} + q_{rcNET} - h_{ci}(T_c - T_i) - h_{co}(T_c - T_e) \quad (2)$$

Where ρ_c represents the density of the greenhouse cover material (kg m^{-3}), c_{pc} represents greenhouse cover's specific heat (J kg^{-1} K^{-1}), t_c represents the thickness of the cover (m), q_{ac} repres the radiation absorbed by the greenhouse cover (W m^{-2}) and q_{rcNET} represents the net thermal radi rate at the greenhouse cover (W m^{-2}).
mulch, T_{pm} is the temperature of the plastic mulch which covers the soil (K) and S_s is the surface

$$\rho_{pm} c_{p,pm} t_{pm} \frac{dT_{spm}}{dt} = q_{a,pm} - h_{si}\left(T_{pm} - T_i\right) - q_{sc} - q_{rsNET} \quad (3)$$

ρ_{spm} represents the density of the plastic mulch, $c_{p,pm}$ represents the specific heat of the plastic mulch, t_{pm} represents the thickness of the plastic mulch. Also, $q_{a,pm}$ represents the solar radiation absorbed by plastic mulch. q_{sc} indicates the heat transfer between soil and plastic mulch. q_{rsNET} represents the net radiative heat transfer on the soil surface.
The indoor air temperature of the greenhouse (T_i) is based on energy balance calculating the sensible heat fluxes transferred between the air and other greenhouse elements as follows

$$\rho_a c_{pa} \frac{V_g}{S_s} \frac{dT_i}{dt} = P_v L_{AI} h_{vi}(T_v - T_i) - h_{si}\left(T_i - T_{spm}\right) - \frac{S_c}{S_s} h_{ci}(T_i - T_c) - \rho_a c_{pa} \frac{G}{S_s} f_G (T_i - T_e) + \rho_a c_{pa} \frac{G_{AHU}}{S_s}(T_i - T_{AHU}) + q_{crop,evap} \quad (4)$$

Since the effect of the crop evapotranspiration on the greenhouse inside air is noticeable, the humidity transfer between the greenhouse inside air, crop, and the ventilation air is determined using the greenhouse inside air humidity balance. The following equations indicate the humidity balance of the greenhouse inside air.

$$\rho_a V_g \frac{dx}{dt} = \dot{m}_{crop} + \rho_a G(x_{amb} - x_i) - \rho_a G(x_i - x_{amb}) + \rho_a G_{AHU}(x_i - x_{AHU}) \quad (5)$$

Where $\dot{m}_{crop}$ is the evaporation of the crop, x_i represents the humidity ratio of the inside air, x_{amb} and x_{AHU} represent ambient air and ventilation air humidity ratio, respectively.

The literature review shows that the growth model in the studies for thermal modeling of a greenhouse is a gap. Thus, the growth model is added to the developed model for tomato production in a greenhouse using the study of (Fang et al., 2022). Crop leaf area index (LAI) and characteristic length of the crop change while it is growing. The LAI and characteristic length of the crop are a function of the day of transplanting. It is assumed that the tomato plant gives a harvest one hundred days after planting. Thus, there are three harvests in a year.
The following equation defines the leaf area index (LAI)

$$L_{AI} = \frac{1.29}{1 + e^{3.01 - 0.1251\, D_{at}}} \quad (6)$$

The following equation determines the characteristic length of the crop.

$$L_{cl} = \frac{109.22}{1 + e^{2.13 - 0.0532\, D_{at}}} \quad (7)$$

3. RESULTS

Figure 1 shows the monthly average temperature and humidity values on the psychometric chart for w/ HVAC unit and w/o HVAC unit. Monthly average values of the greenhouse indoor air are in the optimum range when using the HVAC unit greenhouse air conditioning. However, the monthly average temperature and humidity values of greenhouse w/o HVAC unit depend on the weather conditions, especially radiation and ambient temperature. For example, in December, the indoor greenhouse air has 13°C temperature and 40% relative humidity w/o HVAC. However, the greenhouse indoor air temperature and relative humidity are 20°C and 55%, respectively. In June, the indoor greenhouse air has 39°C temperature and 30% relative humidity w/o HVAC. However, the greenhouse indoor air temperature and relative humidity are 26.5°C and 42%, respectively.

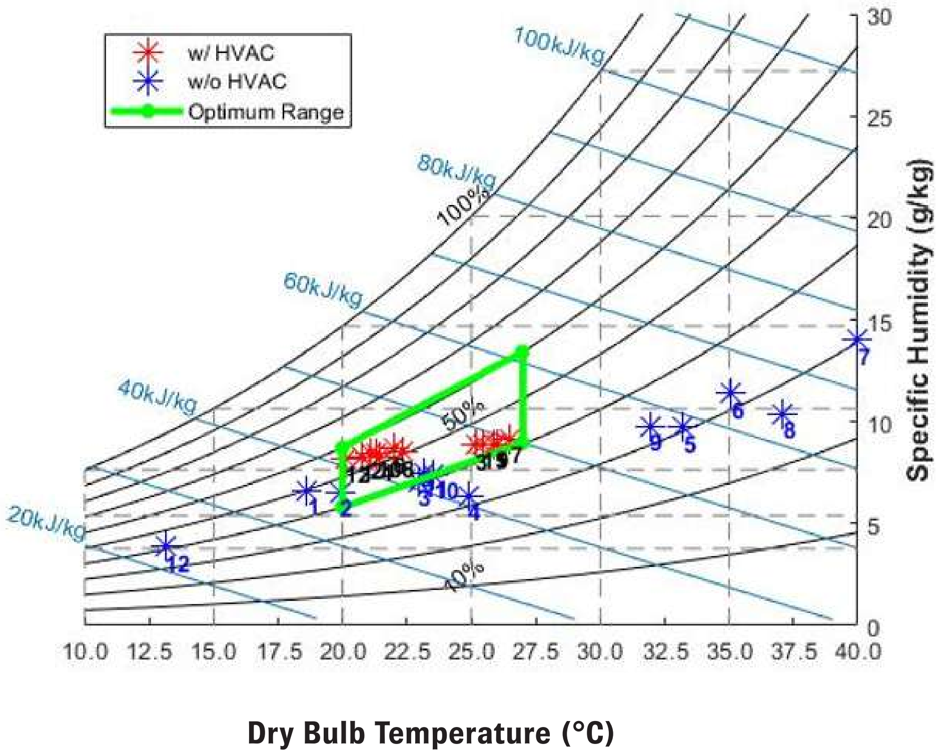

Figure 1. Monthly average temperature and humidity ratios values on psychometric diagram

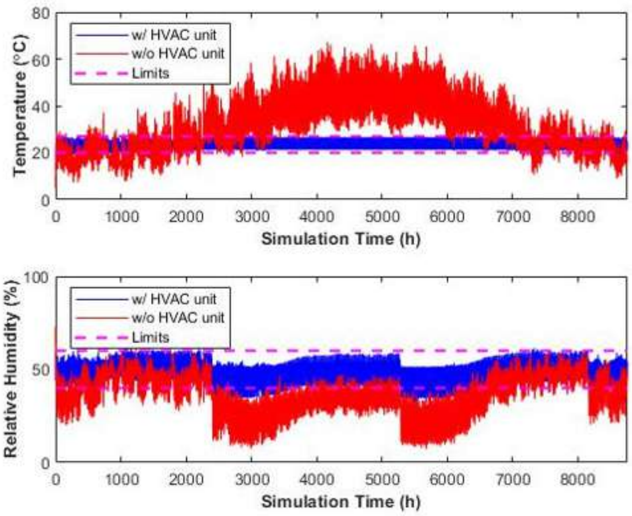

Figure 2. Temperature and relative humidity over time

Figure 2 shows the indoor greenhouse temperature and relative humidity w/ and w/o HVAC unit over time. For example, the indoor air temperature reaches 67.2°C in the summer season while w/o HVAC. The greenhouse's minimum indoor air temperature and relative humidity w/o HVAC are 5°C and 7.2%, respectively.

4. CONCLUSIONS

A dynamic simulation for a greenhouse w/ and w/o HVAC is carried out in this study. The results show that the greenhouse's indoor air temperature and relative humidity can be maintain in optimum growth range of the tomato w/ HVAC system. However, w/o HVAC system greenhouse's indoor air temperature rises to 65°C in summertime and the relative humidity decreases to 7.9%. Using HVAC system in greenhouse provides sustainable greenhouse climate for tomatoes.

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A LIFE CYCLE ASSESMENT STUDY FOR SUSTAINABLE DENIM FABRIC PRODUCTION

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ABSTRACT
Denim is a large industry which reached to 23 Billion USD market share by the end of 2022. Using cotton as primary fiber type, it is calculated that one pair of denim pants consume around 15000 liters water through production starting from fiber harvesting to garment process which includes various steps like pretreatment – dyeing – sizing – garment wash. Also, denim has huge waste problem because of large garment production capacity of around 1 billion pairs annual worldwide. These two issues forced the industry to focus on sustainable production solutions. This study is an example of the sustainable denim production applications of Maritaş Denim and gives early outcomes of life cycle assessment (LCA) of one specific denim fabric type.
Keywords: Denim, natural dye, LCA

1. INTRODUCTION
Turkiye is one of the world's major denim fabric production hubs. Since denim industry is known to have sustainable production concerns due to huge water, energy and chemical consumption and waste problem, there are various efforts on sustainable production solutions. These studies can be addressed as utilizing low-add on application methods, using fibers with higher Higg index instead of cotton, recycle, downcycle and upcycle of denim garment and using of ecological types instead of hydros and synthetic indigo dyes [1,2].

Like for the other fabric types, using natural dyes in denim fabric is an outcome for sustainable production approaches. Natural dyes have advantages like having less or non-ecological problems, being non-toxic and biodegradable [3]. Clay mineral is classified as natural dye example in pigment type and claimed to have UV resistance and antibacterial performance [4].

Maritaş Denim introduced denim fabric concept, so-called Terra Denim, which is based on dyeing the warp yarns by clay minerals instead of conventional indigo dyes with slasher method. The patented process completes dyeing with less number of slasher boxes and inherent anti-oxidant performance of the fabric is reported [5]. Maritaş Denim has also run LCA of Terra Denim fabric samples and the results are in accordance with the expected sustainable scores.

2. MATERIAL AND METHODS
Slasher dyeing of denim fabrics starts with making the warping beam. The warp beams are then put at the back of the dyeing and sizing machine. In slasher dyeing, warp yarns are dyed as open-width form and dyeing, drying, sizing processes are performed in the same machine continuously. The yarns sheet from each beam is pulled over and combined with the yarns from the other beams so that multiple sheets of yarns can be made. The dyeing is carried out in 4, 6 or 8 dyeing boxes. The conventional denim fabric production is characterized with indigo dye during warp dyeing. As known, indigo is a vat dye and is insoluble in water, therefore hydros is used to dissolve the color. During dyeing, the warp yarn enters the dye bath and comes out and goes upwards for oxidation which fixes the indigo dye inside the yarn. This process is repeated several times until a deep shade is reached. After dyeing the sheet of warp yarns is dried by heated cylinders. From the drier, the warp sheet is lead to the sizing section, and after sizing weaver's beams are produced.

Terra Denim production is completed within the same machinery, the difference is using clay minerals instead of indigo dyes. For this purpose, clay minerals with Turkiye origin has been dispersed in distilled water. The liquid phase of the obtained supernatant suspension has been removed, sludge has been dried and applied onto %100 cotton warp yarns via polymeric binder / mordant mixture. The process is followed by drying, sizing and weaving as done in indigo dyeing. Terra Denim collection has been produced with various color alternatives based on the clay mineral type. The existence of the clay mineral on denim sample has been justified with FTIR, DSC and UV-Vis analysis before [6]. The LCA analysis of the samples has been run with SimaPro software.

3. RESULTS AND DISCUSSION

Table 1 shows the Global Warming Potential (GWP100a) values of eq. CO2 kg. The LCA analysis has been run with three different Terra Denim fabric differing in color (grey, yellow and orange) and weight and indigo dyed fabric with each similar weight. The results clearly pointed that Terra Denim fabrics have av. %70 reduced GWP values with better sustainable performance.

Table 1. GWS100 kg CO2 eq. values

Sample	GWS100	Sample	GWS100
Terra Denim 1	1,43	Indıgo Dyed Denim 1	2,65
Terra Denim 2	1,43	Indıgo Dyed Denim 2	2,37
Terra Denim 3	1,43	Indıgo Dyed Denim 3	2,16

4. CONCLUSIONS

This study showed that utilizing clay mineral as dyeing agent in slasher line resulted with lower GWP and clearly labelled as more sustainable production approach.

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SUSTAINABILITY RELEVANCE IN MICRO-VOLUME HOUSING

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ABSTRACT
Human beings have started to create their own spaces over time, these spaces, which first appeared as a cave, later turned into the first primitive structures and changed over time to take the form of today's living spaces. Sustainability appears in both interior and building design areas due to its adaptation to changing conditions, efficient use of resources and transfer to future generations. In studies on sustainability in interior design, it is emphasized that it has a direct relationship with ecological sustainability through efficient use of energy and water, conservation of natural resources, etc. The aim of this study is to discuss the impact of the micro-volume concept, which is an example of changing residential life, on the environment we live in by addressing it through sustainability.
Keywords: Sustainability, Energy Conservation, Micro Housing, Ecology.

1. INTRODUCTION
Throughout history, one of the most basic needs of humanity has been to sustain its life in an area and to be protected from other external factors such as natural events. Thus, human beings started to create their own spaces over time. These areas first appeared as a cave, then turned into primitive structures and changed over time to take the form of today's living spaces. The main reason for these changes is based on many different factors. The geography where the person was born, migrations, traditions and customs, economic reasons, etc. factors have been an important factor in shaping the areas used by people.
In recent years, it is clear that change with the impact of technology has caused many different positive or negative effects on the environment and people. This situation has become impossible for people to ignore and has brought the concept of sustainability to the forefront, enabling people to adopt the idea of keeping the permanent alive and carrying it to the next generations. Sustainability is encountered in both interior design and building areas due to its adaptation to changing conditions, efficient use of resources and transfer to future generations. In studies on sustainability in interior design, it is emphasized that it has a direct relationship with ecological sustainability through efficient use of energy and water, conservation of natural resources, etc. The aim of this study is to discuss the impact of the micro-volume concept, which is an example of changing residential life, on the environment we live in by addressing it through sustainability.

2. MATERIAL AND METHODS
The aim of the study is to discuss the impact of the micro-volume concept, which is an example of changing residential life, on the environment we live in by addressing it through sustainability. In addition, within the scope of the study, the changing housing needs of people throughout history and the transition to micro-volume interiors will be discussed and sustainability in small-volume spaces will be evaluated through criteria such as effective energy use and water conservation. The relationship between the interior features of the selected micro-volume housing examples and sustainability is supported by literature studies.

2.1. Micro Volume Consept and Spatial Relationship
Although there is no single general definition of micro-volume, areas with volumes ranging between 14m²-20m² according to city densities are defined as micro-volume areas. They are small living spaces with living, working, resting and wet areas. Although micro-volumes have similar functions and square meters to studio apartments, they can be defined as volumes with smaller square meters in terms of area (Belentepe & Seçer Kariptaş, 2019). There are examples where micro volumes serve different purposes in line with the needs. It is seen that they are used in different functions such as an office, dormitory room or a hotel room, etc.
In the historical process, it is seen that people first individually, then crowded and gathered together, and then returned to individualization again today. In this context, we observe that space organizations have transformed from large volumes to multi-functional areas in small square meters. As the first examples of

living spaces are located in natural spaces, it is also seen that micro-volume spaces are mostly located in areas that can be depicted as natural spaces.

2.2 Development Process of Micro Volume Concept

There are different interpretations of the shelter form throughout history. Instead of being an escape from environmental factors, shelter has become a part of human social development. Thus, living, eating and sleeping areas in micro volumes began to be determined and shaped. Research also shows that the first settled shelters were small house pits, tree hollows and caves (Belentepe & Seçer Kariptaş, 2019).

With the transition to settled life, people first started to live together collectively due to geographical conditions and family structures. The new life model that emerged after World War II, the rapid urban population growth and the rapid increase in land prices narrowed people's areas of use and reduced the amount of square meters used. At the same time, factors such as the change in social family structures, working population, student potential and economic factors are among the factors that increase the demand for small housing. The high prices of land in the city center and close to the city center, and the need to obtain more housing and space in a certain square meter, have led to more work on small volumes in projects. A small dwelling is a building with dimensional changes on physical dimensions such as area, volume or number of rooms without losing its functionality. As for the numerical evaluations of small dwellings, some consider 60 m^2 as a limit (Dinç, 1978). Another opinion states 14m^2 per person as a limit (Dörter, 1988).

Micro volumes are widely preferred and used in America and Europe today. The common feature of these volumes is to solve more than one function together in a small space. When designing and constructing the space, attention is paid to the fact that the furniture should take up little space, be foldable or serve more than one function. In material selection, it is expected to be sustainable and self-sufficient, taking into account factors such as both economic and environmental design. Because the starting point of these volumes is to provide economic and environmentally friendly solutions to increasing population density and non-functional areas. The positioning of these volumes varies from one another. Sometimes they are built in a rural area, in nature, and sometimes in small areas of land in the city.

2.3 Sustainability in Micro Volume Housing Interiors

According to well-known definitions, sustainability is the ability to meet the needs of the present generation without hindering the ability of subsequent generations to meet the needs of future generations (WCED, 1987). In today's world, factors such as rapid urbanization and population growth, people's increasing search for comfort and developing technology cause the depletion of natural resources on earth at a great rate. For this reason, it has been decided that various researches and studies should be carried out to protect and reduce the consumption of resources. As a result of these social and physical studies developed with the emergence of environmental problems, the concept of "ecological life" was introduced and the awareness that human beings should live in harmony with nature has begun to be accepted. In the building sector, this concept has entered the literature with definitions such as ecological\green\sustainable architecture (Kayıhan and Tönük, 2011).

It is an undeniable fact that the lifespan of natural and local resources used as a result of the design, regardless of space or product, is not infinite. A solution proposal that prioritizes efficiency in water use will greatly increase the lifespan of the design in question. In architecture, the reusability of the water needed both in the construction phase and in landscaping is an important step in the conservation of water resources and efficiency in water use. In micro-volume spaces, systems that allow water to be reused are preferred. Systems that collect, filter and reuse rainwater support the efficient use of water.

In a sustainable design, it should be aimed to conserve energy and natural resources and to consume as little as possible of all resources used in the final product. In addition to resource and energy conservation, it will be possible to create flexible designs with materials that are selected with respect for the environment. The main factor in material conservation is to create changeable, modular and expandable designs. These conditions, which can also be achieved with the flexibility of the selected material, will enable the functional use of the product, interior or building. Especially in the selected materials, qualities such as being recyclable or reusable, long-lasting and durable, not creating pollution and waste during the extraction and production stages, not harming the environment during use and not needing much maintenance should be taken into consideration. Utilization of passive systems in cases where energy consumption such as heating and cooling is required, i.e. applications where there is no need for mechanical elements in the collection and transmission of solar energy to the environment to be heated, is one of the oldest methods. The idea of creating sustainable micro-volume areas at a lower cost, especially with panels added to roofs and facades, is widely used.

2.4 Investigation of Sustainability on a Micro Volume Housing Interior Example

In previous years, the sustainability of a good design was not one of the characteristics sought. However, today, it is seen that sustainability, which is one of the basic design principles, has the ability to increase the lifetime of the design and the target audience of the users. For this reason, a design's adoption of the principle of sustainability has become one of the main factors that increase the preferability of that design by a wider audience. When the Zero House example is examined in this context, the features it has in the context of sustainability make micro-volume living spaces interesting.

2.4.1. The Example of Zero House

Zero House, designed by architect Scott Specht, received the 2007 Texas Society of Architect's Design award. It is an example of micro-volume housing, as it is very economical in terms of the materials used and the organization of space, uses completely renewable energy sources and has zero carbon emissions (Architecturea Vivre/Maisons, 2008). It is an eco-friendly two-story prefabricated building with a 198 m2 usage area. All functions are controlled by smart home technology. Thanks to the sustainable energy sources it uses, carbon emissions are reduced to zero.

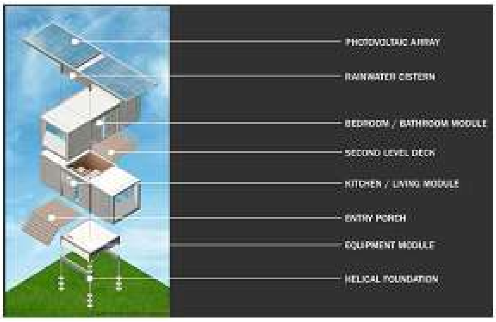

Fig.1. Zero House Living Quarters.

The ground floor consists of a living area, kitchen and dining area, entrance porch, service porch and a storage compartment; the second floor consists of two bedrooms, a bathroom and two terraces facing in different directions. The terraces on the upper floor form the roof of the spaces on the lower floor. This allows for sitting in the same open space. All the furniture is specially designed and the whole space is used in a balanced way and the organization is planned accordingly (URL1).

Natural fiber carpets are used as flooring material in the bedrooms and living area. The outer shell of the building is made of high strength, dust and corrosion resistant composite material, supported by steel frames to prevent corrosion. The cabin and wall panels are made of recyclable wood with a coating that does not require painting. Thus, the principle of sustainability is emphasized in the use of materials. It is designed to adapt to different climatic conditions (Akbaş, 2010).

Fig.1. Zero House Living Quarters.

The adjustable lighting installation in the building allows for over 100,000 hours of use. The PV (photovoltaic) solar panels used on the roof provide the energy needed by the house with the electricity it stores. Cell foam system that prevents heat and vapor flow in insulation, reflective mirror-heat glasses in windows, aero-gel panels made by vacuuming method in doors are used to ensure the use of the house with high energy efficiency. On the roof of the building, there is a cistern that collects rainwater with a capacity of approximately 10 m3 of water and makes the collected water drinkable thanks to two filtering mechanisms. The low water consumption toilet also contributes to water conservation with a similar effect (URL 2).

At the bottom of the Zero Hause there is an absorption unit for solid waste collection. This unit turns the waste into a clean, dry fertilizer that only needs to be cleaned twice a year. For this process, soil, water and the appropriate amount of waste are combined. Bacteria and microorganisms break down the active materials into clumps, releasing oxygen, resulting in a composite brick that only needs to be emptied twice a year (Roaf et al., 2007). The structure sits on the ground with four helical anchors. The foundation system touches the ground only at these four points and ensures that the environment is polluted as little as possible and less energy is used. Due to its high cost, the structure is not an effective use in the long term. However, the fact that it is designed to reduce the ecological footprint creates a different but reasonable living space for the users.

3. RESULTS AND DISCUSSION

The structure with micro-volume living space examined has a high cost. However, it is a candidate to be one of the most preferred housing types of the near future for reasons such as awareness of global warming, minimizing greenhouse gas emissions, being portable and easy to install, and offering the opportunity to live without being dependent on energy resources. A product or project created with a sustainable design approach should have qualities that interact with the environment, be sensitive, consume resources in a good way, have recycling potential, meet user needs in the right direction, maintain the price-product balance and incorporate aesthetic values.

4. CONCLUSIONS

The development of technology has made it possible to produce new solutions to issues such as how to obtain alternative and clean energy sources, how to dispose of waste, how to change consumption habits without affecting living standards for humanity, whose only way to survive is to protect the planet, with the design of micro-volume living spaces. Although the dissemination of these building examples and the design of new living spaces with the same principle may bring high economic costs in the first stage, the ecological gain obtained in the long term can shed light on many problems such as global warming. The development and expansion of micro-housing examples over time, together with technology, will enable the creation of living spaces that can meet the increasing need for housing and keep pace with economic and social changes. At the same time, it will ensure that designs are made with the awareness of creating sustainable environments and that individuals have the right to live in volumes that are free, comfortable and designed in accordance with their needs.

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CONTROLLER DESIGN THAT PROVIDES LIGHTING AUTOMATION FOR ENERGY EFFICIENCY IN BUILDINGS

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ABSTRACT

In this study, a DALI-2 compatible controller has been developed for lighting automation. A complete DALI lighting automation solution has been provided that can work together with all DALI peripherals, with the ability to integrate into different endpoints, will provide energy efficiency with scheduled functions and includes an embedded web interface customized with the concept of "human-centric lighting". Energy efficiency will be ensured in lighting places such as buildings, schools, hospitals where the automation solution will be used. At the same time, the physiological and psychological health of people who continue their daily lives in areas illuminated by "human-centric lighting" will be protected and their productivity will be increased.
Keywords: Green Building, Home Automation, Human-Centric Lighting, DALI, Dali Master

1. INTRODUCTION

As of today, technological developments are now developing even faster than in the past and are taking place in our daily lives. The shortcomings of technological products and solutions have become so widespread that they are seriously felt in our daily life. Technological developments have accelerated not only the Internet but also the electronics sector day by day. Devices that used to be difficult to imagine even in the past and their lower parts have become cheaper and cheaper. In particular, microcontrollers and similar tools that make devices smart are now appearing in all kinds of devices. With the development of production facilities, billions of devices are finding a place in our lives and are becoming more and more widespread. Of course, with technological developments, people's needs have increased and demands have been formed.

With the cheapening of technology, users have started using intelligent Building Automation Systems for savings purposes and end users, especially in the European Market, have started to demand automation systems. The impact of increasing energy prices and taxes on this situation is quite large. Consumers are becoming more aware of energy saving every day and tend to reduce inefficient consumption.

Energy efficiency in buildings according to the European Union and Turkish Legislation (Yuksekkaya, 2016), buildings are responsible for 40% of energy consumption and 36% of CO2 emissions in the European Union. New buildings usually need three to five liters of heating fuel per square meter per year, while older buildings consume an average of 25 liters. Some buildings can even consume up to 60 liters. Currently, 35% of the buildings in the EU are buildings older than 50 years. It is estimated that by increasing the energy efficiency of buildings, the implementation of energy efficiency measures in buildings can reduce the EU's total energy consumption by 5-6% by 2023 and create a lot of new job opportunities.

As in Turkey, as well as in Europe, studies have been conducted on the importance of building automation systems in the field of energy saving. The European Union obliges member states to have new public buildings starting in 2018, and all new buildings starting in 2020 to be energy-consuming buildings close to zero. In the report published by the European Commission in November 2017, it is seen that 20.8% of the energy consumed in buildings is consumed by lighting systems, and the same report states that as much as 60% of this energy can be saved when integrated with automation systems. This means that up to 12.5% of the total consumption can be saved. The biggest portion of this savings is the prevention of unnecessary consumption by automation. The concept of Smart Building could be defined as a set of communication technologies enabling different objects, sensors and functions within a building to communicate and interact with each other and also to be managed, controlled and automated in a remote way.

Together with lighting systems, air conditioning systems, they are among the most energy consuming systems in buildings. Especially in buildings such as residences, hospitals, public institutions, constantly burning lighting units make a serious amount of unnecessary energy consumption.

One of the goals of Turkey in 2023 is to reduce this non-essential consumption to a minimum and reduce energy imports with buildings close to zero energy. For this reason, building management systems are mandatory in newly constructed public buildings. Within the scope of the KABEV - Energy Efficiency In Public Buildings Project (P162769, 2019) carried out within the framework of the Ministry of Environment and Urbanization, it is aimed to reduce energy consumption in public buildings. The automation solution of the product to be designed within the scope of this study will be in a position to support the energy policy of our country and contribute to the goal of energy efficiency and savings.

2. DALI STANDARDS

The controller to be developed within the scope of the study will be compatible with DALI-2 standards, which are widely used all over the world in lighting automation, and will be able to integrate into systems running on network infrastructure with ethernet connectivity.
DALI (Digital Addressable Lighting Interface) communication standard was adopted as a standard in 2009 with IEC-62386 norm. It has entered among the international standards in the world in terms of home, building and emergency lighting control. This standard was designed and developed by the German society of electrical engineers (ZVEI) and, unlike other communication standards, it provided the possibility of communication with two cables without poles. Thus, it has brought a radical solution to the reverse binding problem experienced in the field. The priority feature in the messages brought with DALI-2 has increased the safety to the highest level in emergency lighting scenarios.

3. HUMAN-CENTRIC LIGHTING

Configurating and managing the light obtained from the artificial light sources in a way that it would support human morale, motivation and especially circadian biorhythm by controlling light in terms of spreading, severity and color tone called as “Human Centric Lighting”
Light is one of the most important regulators, influencers of the human life and hormonal order. From sunrise to sunset, seasonal changes have been searched in terms of characteristics of the geographic regions lived over the world and impacts created by these on the people living in these regions and after those evaluations striking effects/results have been found by the scientists over the years. (Memiş, 2019)
Color temperature is a characteristic of visible light that can significantly impact a space’s ambiance and functionality. It is measured in degrees Kelvin (K) on a scale that ranges from warm (yellow/orange) to cool (blue) and is an essential factor to consider in lighting design, photography, and other fields. The color temperature of a light source is determined by the amount of heat required to produce the light. For example, a candle flame has a color temperature of about 1900K, considered warm, while the midday sun has a color temperature of around 5500K, regarded as cool.
When people wake up in the morning, human body mechanism starts the day by trying to adapt itself to Kelvin (CCT) value of the daylight, which is at 2200 Kelvin level. This adaptation mechanism continues working in order to adapt itself depending on white light Kelvin (CCT) values provided by the artificial lighting applications in offices, schools, hospitals, workplaces, houses and similar places, where we may be at for a variety of purposes during the day. (Figure-1) Human-centrci lighting can adjust the light temperature and intensity according to our daily rhythm.

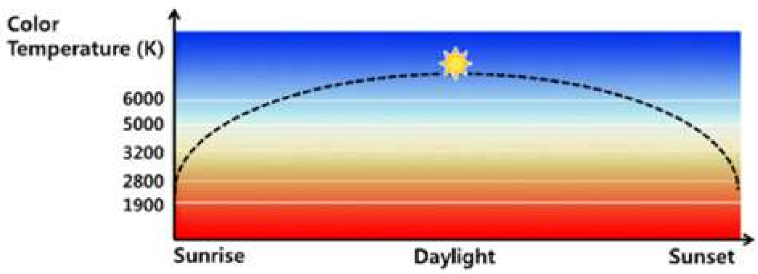

Fig.1. Color temperature variation throughout a single day

Fig.2. PCB Design

4. MOTIVATION

The main reason for this study is that digital methods are gaining importance in terms of energy efficiency in lighting automation in the Smart Building systems sector. Along with the automation solution provided by the DALI - 2 standard compatible controller, the focus will be on the title of "Human-Centric Lighting", which has been studied academically in recent years. The place, time, etc. located inside the controller. lighting automation will be made intelligent with parameter-dependent data sets and scheduling possibilities. In this way, both energy savings will be realized and the comforts of people living in illuminated areas will be provided.

In the study, a DALI-2 compatible controller designed for such purposes as easy control, easy fault detection and energy efficiency in lighting automation and interoperable with all DALI peripherals will be developed. With the ability to integrate into different endpoints, a complete DALI lighting automation solution will be provided, which will ensure energy efficiency with scheduled functions and include an embedded web interface customized with the concept of "human-centric lighting". Together with the multi-master feature it supports, it is possible to use DALI input/output and DALI sensor products together. In this way, it has been ensured that a complete solution can be offered only with DALI without the need for other automation systems.

5. CONTROLLER DESIGN STUDIES

At the beginning of the study, the studies in the literature (Maaspuro, 2015; Robinson, 2015; Matijevics, 2011; Sysala et al., 2016; Qipeng et al., 2014) and the products that may be similar were examined in detail. In similar product reviews, criteria such as mechanical and hardware designs of products, user interfaces have been taken into account.

According to the standards (IEC 62386-101) for the controller, in accordance with the electrical data, the circuit design was made so that the line voltage will be 18V DC and 250mA current capacity. Timing calculations have been made for data receiving and data sending structures, including 24-bit, 16-bit, 8-bit. Experiments have been conducted using DMA and Timer peripherals for the microcontroller to manage these timings. During the design process, additional windings were added to the basic transformer designs for additional output values requirements, and the appropriate number of windings and wire cross-sections were determined. With the technical data obtained and the experience gained from the preliminary trials, hardware and mechanical design and software development studies were carried out.

In hardware design studies; Schematic designs of the physical layer required for DALI-2 and the isolation-protected communication layer required for DALI-2 communication and the design of the supply source that will feed the 2 x DALI line were made. In the mechanical design studies; case design was made for the installation of the developed hardware and in accordance with IP protection standards. In embedded software design studies; The software algorithm of the communication protocols determined for DALI communication and DALI communication objects and parameters are designed to be compatible with the RTOS (Real-Time Operating System) system.

Prototype products have been developed with the data obtained as a result of design studies. The schematic designed has been turned into a Printed Circuit Board (PCB) design by taking into account the EMC (Electromagnetic Compatibility) and LVD (Low Voltage Directive) compatibility. When designing the PCB, it was drawn taking into account its suitability for the plastic box to be used in the product. (Figure-2).

5. APPLICATION OF THE CONTROLLER

The controller developed in the study has found many application areas in residential projects, shopping malls and office campuses. As an example, lighting and mechanical automation have been carried out for energy efficiency at JustWork Istanbul office campus, which is located in Meydan shopping center in Umraniye, Istanbul and has about 100 offices of different sizes. JustWork is a 24/7 open shared workspace designed as a counterpart to the office campuses of technology companies such as Google, Facebook, Amazon in America. There are about 300 automation devices in this project based on the productivity of employees.

In the project, scenarios suitable for the human-centric lighting concept have been applied in all working offices for energy efficiency. With the help of sensors placed in each office separated by glass partitions to detect the entire room, unnecessary lighting of the lights has been prevented when there are no people in the room. Especially in the evening, with the sensors located in the corridors, DALI Master controller's gradual dimming function enabled energy savings without creating a dark environment by reducing it to 100% first, then 50% for the desired time and 10% after a while when people enter the corridor. In the daylight areas of the office, with constant light control, the lights are turned off in unnecessary cases and the desired target value of lighting is provided by dimming in necessary cases. By constantly preventing the lights from burning to the maximum, the life of lighting products has been extended. In addition, with the intelligent error notification of the DALI Master product, malfunctioning drivers and LEDs can be detected in the field. This contributes to the sustainability of the building and reduces maintenance costs. (Figure-3)

In the measurements made, it was determined that 20% savings were achieved in lighting and 30% savings in air conditioning as energy consumption values.

Fig.3. JustWork office campus

7. CONCLUSIONS

Intelligent building lighting control will be carried out with the DALI-2 standard compatible controller with ethernet, web interface developed within the scope of the study (Figure-4). In the places where the automation solution is used, a high contribution to energy efficiency will be made by performing intelligent building lighting control due to the web interface customized with the centralized control, imaging and human-centric lighting concept offered by the controller device. The lighting automation solution revealed within the scope of the study will be able to be used in health centers, offices, educational institutions and areas where greenhouse and farm animals are raised, which are important items in the agricultural sector. Energy savings will be achieved with the automation opportunity offered by the controller.

Fig.4. Controller

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UST BIOSPHERE TECHNOLOGIES FOR SOLVING GLOBAL ENVIRONMENTAL PROBLEMS

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ABSTRACT

The solution of such global environmental problems as climate change, waste accumulation, land degradation is possible using new biospheric technologies such as second-level string transport and the concept of a linear city. Unitsky's string transport allows not only to solve any problems of cargo and passenger transportation, but is also the most environmentally friendly and safest of the existing transport systems, aimed at preserving the environment and climate. The concept of a linear city offers options for solving urgent urban problems of air pollution, waste disposal and land degradation as a result of zoning.
Keywords: String transport, linear city, rail electric vehicles, unimobile, KFH «Unisky»

1. INTRODUCTION

To achieve the goals of sustainable development of civilization, significant efforts should be made due to the huge inertia of the natural resource-intensive trends of several countries (export-raw material model of the economy), which in turn will lead to a decrease in the anthropogenic load on the climate. An important feature of such changes will be the ecological sustainability of the environment. Issues that need to be urgently solved is: depleting valuable natural resources for temporary economic growth; serious impact of polluted environment on human health; natural resource orientation of exports; accumulation of hard-to-recycle waste production. To solve them, it is necessary to create conditions for the development of science-intensive industries and fundamentally new technologies, primarily in system-forming industries such as transport, industrial and civil infrastructure, energetics, agriculture.

With the aim of further technological development and conservation of natural resources, UST Inc. (Minsk, Republic of Belarus) offers a comprehensive solution that combines biosphere technologies and the transport industry: transport infrastructure complexes of the "second level"; Unitsky String Transport (uST); design-construction part (linear uCity cities, including elements of biotechnology); organic agriculture.

A developed transport infrastructure largely determines the investment potential of countries (regions) and is one of the most important factors that stimulates the economy, trade, development and implementation of innovative technologies, and increases welfare in general. However, already at the stage of construction of traditional roads and railways, negative aspects appear with significantly harm the environment. For example, when natural soils are covered with an artificial roadway, the natural living cover is transformed into an artificial dead surface, which leads to the destruction of growing plants, changes in the relief and migration routes of wild animals. Also indurated (by 10% in comparison with the natural occurrence of soil) earthen embankment of a traditional road becomes a man-made low-pressure dam. Compaction of the productive soils and their replacement by earthen embankments of roads change natural groundwater and surface water flows, which leads to swamping of the adjacent territories on the one side and drying out on the other. These factors increase natural fluxes of major greenhouse gases, which, together with vehicle exhaust gases, become a critical climate burden.

Unlike traditional transport solutions, in which advanced environmental developments must be integrated and have to adapt to existing features, UST complexes are initially developed considering all current world requirements (Unitsky, Tsyrlin, (2020). This transport system is a string-rail track structure on supports, along which unmanned rail electric vehicles (named unimobile) move (Fig. 1), which, due to the simplicity of their design (the absence of massive drives, powerful frames, heavy undercarriages and wheelsets), are characterized by low consumption of structural materials, excellent aerodynamics, high energy efficiency and do not require significant costs for their production.

Figure1. Different types of rolling stock uST (EcoTechnoPark (Marjina Gorka town, Republic of Belarus, 2020)

Due to low land acquisition, reduced resource intensity of preliminary stressing of the rail-string transport overpasses, low power consumption and simplified integration with communication systems, uST already at this stage allows to reduce the environmental load compared to traditional modes of transport. Another significant advantage is the preservation of the natural soil cover, on which it is possible to develop the associated infrastructure and use it for agriculture. As a result, one of the effective options for using land cover to reduce greenhouse gas emissions is to plant crops under the "second level" road (Fig. 2), which in principle cannot be done under roads built on the surface of the earth – at the "first level".

Figure 2. Land use option under the rail-string transport overpass

MATERIAL AND METHODS

In particular, the effect of reducing emissions of the main greenhouse gases was calculated using the example of tuberous sunflower (Helianthus tuberosus L.), as one of the options for introduced agricultural crops. To study the effect of growing Helianthus tuberosus L. on greenhouse gas fluxes, as a process of reducing the negative impact on the climate, preference was given to the chamber method as the most efficient and easy to implement, which allows localizing the object under study as a source of gases exchange and accurately measuring CO2, CH4 and N2O fluxes. In March 2020, a measuring platform was equipped by soil frames (Fig. 3), on which the fluxes of CO2, CH4 and N2O were measured using emission chambers (dark and transparent).

Figure 3. Measuring plot, KFH «Unisky» (a –soil frames, b – transparent chamber)

Carbon dioxide was determined in real time using an infrared gas analyzer LI-820 (LI-COR), gas samples of methane and N2O were determined on a gas chromatograph with electron capture (ECD) and flame ionization (FID) detectors. The chromatograph was calibrated according to gas standards at the beginning and after 12 samples. The infrared gas analyzer was calibrated to gas standards before each measurement company.

CO2 measurements were conducted on clear days, from dawn (minimum PAR value) to the peak of PAR value at 12–2 pm. The concentration of CO2 in the chamber was recorded at intervals of 5 seconds; also, every 5 seconds, time, temperature inside and outside the chamber, PAR, and the serial number of the measurement were automatically recorded. The exposure time of each measurement depended on the flow rate, but did not exceed 10 minutes, since after this time the equilibrium concentration of CO2 is established in the chamber and the flow estimate is distorted. For each measurement stable conditions were respected. (temperature amplitude inside the chamber within 1.5°C, PAR dynamics - no more than 10%).

Measuring the fluxes of methane and nitrous oxide, air samples were taken at regular intervals into pre-vacuum sealed flasks (60 ml). For one measurement, 5 samples were taken with an interval of 5 minutes. The flow rates of CO2, CH4, and N2O were calculated according to the ideal gas law, based on the changes in concentration with time in the chamber. Methane and nitrous oxide fluxes and their statistical processing were carried out in the R© software environment using the Flux and CaTools package. Processing with these packets eliminated interference due to turbulence and pressure fluctuations caused by the chamber installation, as well as from an increase in saturation and microclimatic effects from covering the site with the chamber.

RESULTS AND DISCUSSION

The measurements lasted for 5 months (from May to September), while the fluxes of the main greenhouse gases in the other months were conditionally assumed to be zero. To calculate the annual dynamics of the CO2 flux, all monthly measurements of the carbon dioxide concentration from each soil frame were considered. The results of measurements showed that CO2 emission prevailed in May (0.8 t/ha per year), in June there was a significant absorption of carbon dioxide (−4.4 t/ha per year), which peaked in July (−5.9 t/ha per year) and began to gradually decrease to -5.6 t/ha per year in August and -5.1 t/ha per year in September.

From May to September, methane emissions from the studied sites (Table 1) were insignificant.

Table 1. Site T1 (07.06.2020) CO2, CH4 и N2O concentration

nr	CO_2ppm	N_2Oppb	CH_4ppb	hour	plot_id	t_air	tsoil_2	ts_5	ts_10	vol	area
1	448,65	319,03	2034,49	12:33:00	T1_I	28	22,3	18,2	18,2	0,234	0,49
2	566,10	317,69	2030,88	12:38:00	T1_I	28	22,3	18,2	18,2	0,234	0,49
3	731,46	314,29	2024,48	12:43:00	T1_I	28	22,3	18,2	18,2	0,234	0,49
4	863,85	301,44	2018,75	12:48:00	T1_I	28	22,3	18,2	18,2	0,234	0,49
5	985,67	316,34	2007,21	12:53:00	T1_I	28	22,3	18,2	18,2	0,234	0,49
6	432,99	310,77	2015,67	12:33:40	T1_II	28	22,3	18,2	18,2	0,234	0,49
7	521,99	305,25	1954,40	12:38:40	T1_II	28	22,3	18,2	18,2	0,234	0,49
8	645,18	319,13	2024,56	12:43:40	T1_II	28	22,3	18,2	18,2	0,234	0,49
9	774,12	315,68	2015,03	12:48:40	T1_II	28	22,3	18,2	18,2	0,234	0,49
10	871,66	320,01	2035,08	12:53:40	T1_II	28	22,3	18,2	18,2	0,234	0,49
11	445,91	325,27	2045,79	12:34:10	T1_III	28	22,3	18,2	18,2	0,234	0,49
12	547,84	315,69	2034,30	12:39:10	T1_III	28	22,3	18,2	18,2	0,234	0,49
13	689,74	318,61	2019,54	12:44:10	T1_III	28	22,3	18,2	18,2	0,234	0,49
14	786,01	318,87	2024,52	12:49:10	T1_III	28	22,3	18,2	18,2	0,234	0,49
15	915,06	317,74	2020,67	12:54:10	T1_III	28	22,3	18,2	18,2	0,234	0,49

The results obtained is explained by the fact that these sites were subjected to human impact and, as a result, the soil became more saturated with oxygen, as a result of which the dominance of methane oxidation turned this area into insignificant methane runoff (Fig. 4).

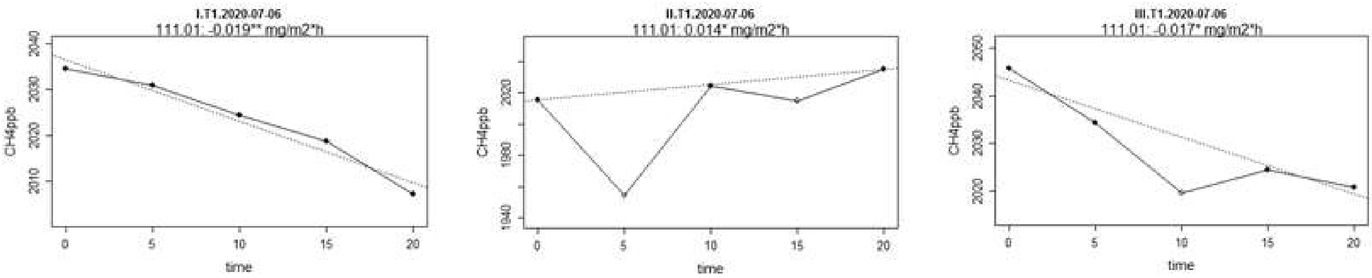

Figure 4. Methane emission 07.06.2020

Given the low quantitative values of natural nitrous oxide emissions, the timing of the study was chosen to coincide with the conditions (Burlo et al., 2016) under which the maximum flux of this greenhouse gas is possible (after sharp stable positive temperature and high humidity). However, N2O fluxes at the studied sites were insignificant (Fig. 5).

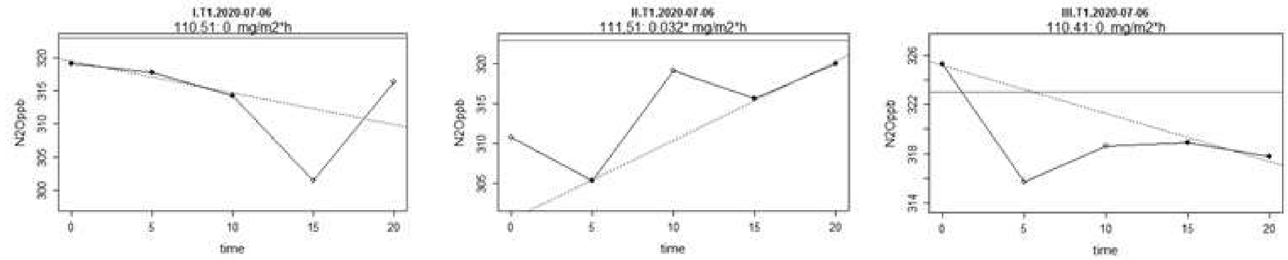

Figure 5. N2O emission 07.06.2020

Fig.4. Linear uCity city plan (option)

The concept of a linear city contributes to the reduction of harmful emissions into the urban atmosphere, the reduction of road construction costs, the elimination of traffic accidents and the restoration of an environmentally friendly comfortable environment. Such a city is cluster-type urban settlement, where the surface of the earth is meant for pedestrians and green plants, while transport, energy and information networks are elevated above the ground on the "second level". There is only one mode of transportation in the city - horizontal lifts connecting the high-rise towers, spaced at 500 meters and more (up to 3 km) from each other and placed along one line, or several parallel and intersecting lines. Linear cities can be built in the mountains, desert and waterlogged areas, including complex terrain, as well as on the sea shelf.

The roofs of the houses are made in the form of glazed greenhouses, which are united with each other by a central communication corridor 2–3 m wide, meant for laying engineering networks and servicing technological transport. The use of building roofs for greenhouses reduces water consumption for growing organic products, and additionally solves the problem of seasonal availability of fresh products. At the same time, such houses did not take away the land from nature - the soil from under the foundation, even if it was desert sand, was moved to the roof, enriched with humus, and a garden was planted on it. The city not only did not take away the land from the planet's biosphere, but, on the contrary, added it, increasing its fertility to the level of humus.

At the ends of such a "horizontal skyscraper" are equipped technical rooms and installed freight elevators. The basement floor is located on a common foundation for the entire length of the building and has a technical passage in the center 2–3 m wide for service equipment. There is space for growing microgreens and mushrooms, keeping quails and other small birds and animals, as well as for breeding aquaculture. In order to jointly operate the building and manage technological processes at all levels, a condominium is organized. The use of these biotechnologies provides for waste-free processes of year-round cultivation and consumption of organic food. Instead of waste at the end of the technological agricultural cycle in the linear city cluster, uTerra biological humus is obtained, which is returned here in the cluster in the form of organic fertilizers to the new cycle.

CONCLUSIONS

Unitsky's String Transport (uST) allows to preserve the natural land cover, which can be used for growing crops. On the example of the considered agriculture, the absorption of about 4 t / ha per year of CO_2 is ensured (which corresponds to 1 km of the length of a traditional road), while the environment is not polluted and the natural fluxes of CH_4 and N_2O do not increase, which is a favorable factor for the climate and ecology.
The considered innovative transport does not violate the nature and, among other things, allows preserving the natural migration routes of wild animals. As a result, the area through which the string-rail road's pass can be used for organic agriculture, which, in turn, creates a minimal environmental burden on the biosphere. Biospheric technologies of the linear city (greenhouse construction of roofs, cultivation of basidiomycetes, quails and aquacultures in the basement, vermicomposting of waste) significantly improve the balance of human-nature relations and make it possible to globally reduce the anthropogenic load.

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RECYCLING PEROVSKITE MATERIALS FOR SUSTAINABLE SOLAR TECHNOLOGIES: RECOVERY OF HIGH COST FTO SUBSTRATES

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ABSTRACT
Perovskite is a promising material for renewable energy production due to its high efficiency and low cost. However, in the production process of perovskite solar cells, toxic and flammable solvents are used, which can pose environmental and health risks if not managed properly. The disposal of waste materials generated during the production process is also concerning from an environmental standpoint. Therefore, recycling perovskite materials can be more cost-effective than producing new materials from scratch, especially if the recycled materials can be used to make high-quality electronic devices. Recycling can help reduce the environmental impact of perovskite production by reducing the amount of waste generated and the amount of energy used in the production process. In this study, a recycling process was carried out to recover high-cost FTO substrates, one of the important layers in perovskite solar cell production. The recycled FTOs almost maintained their optical and electrical properties, demonstrating the potential to develop sustainable solar technologies.
Keywords: Recycle process, perovskite, solar cell, fluorine-doped tin dioxide (FTO).

1. INTRODUCTION
Global warming is a pressing issue that results from the increase of greenhouse gases in the atmosphere, mainly due to the combustion of fossil fuels. Solar cells offer a sustainable and eco-friendly solution to counteract global warming by providing clean and renewable energy. The use of solar cells can reduce our reliance on fossil fuels and limit the release of greenhouse gases into the atmosphere. Perovskite solar cells (PSCs) utilize a perovskite material as the active layer to convert sunlight into electricity. These solar cells are a promising technology for solar energy generation, as they currently exhibit a high power conversion efficiency of over 25.8% (Kim et al., 2021). Additionally, PSCs are relatively cheap to produce compared to other types of solar cells, making them commercially attractive. Despite their high power conversion efficiencies and cost-effectiveness, the commercialization of PSCs is hindered by their component instability, particularly in humid environments. The perovskite material used in PSCs is highly sensitive to moisture, which leads to device degradation and decreased performance over time (Chowdhury et al., 2021). Researchers are striving to enhance the stability of PSCs to make them more viable for commercial use. Recently, studies have been conducted on the recycling of the layers that make up the cell, indicating the significance of transparent conductive oxide (TCO) recycling. Huang et al. demonstrated the recycling of FTO using DMF solution of glass/FTO/CH3NH3Pb3-xClx/spiro-MeOTAD/Ag planar perovskite solar cell. The cleaned FTO substrates showed favorable electrical and optical properties for device remanufacturing (Huang et al., 2016). Moreover, the same group recovered both FTO and TiO2 by employing DMF solution for glass/FTO/c-TiO2 or (c-TiO2/m-TiO2)/spiroMeOTAD/Ag mesoporous perovskite solar cell, saving and focusing on a clean environment (Huang et al., 2016). TCO thin films, such as fluorine-doped tin dioxide (FTO) and indium tin oxide (ITO), are crucial components in PSCs as they function as the front contact of the device. However, the use of commercial FTO and ITO in PSCs can have drawbacks, such as high manufacturing costs and long payback times. The production of certain electronic devices is costly due to the materials used in their production, which necessitate high-temperature and high-vacuum production processes to achieve the desired purity and crystalline structure required for optimal electrical properties and performance. Table 1 presents the properties and price differences of commercially produced FTO glasses utilized in perovskite solar cells of different brands.

Table 1. Commercial FTOs used in perovskite cell production and their properties.

Brand	Thickness	Resistivity	Price	Commercial
Ossila (100 pack)	600 nm	6-9 Ω/sq	£240.00	(Ossila,2022)
Greatcell (100 Pack)	-	15 Ω/sq	AUD$454.79	(Greatcell, 2022)
Shelpent (100 pack)	320-340 nm	15 Ω/sq	199 USD	(Shelpent, 2022)
MTI Corp. (25 pack)	200 nm	12-14 Ω/sq	113,57 USD	(MIT, 2022)
Ultrananotech (100 pack)	-	15-17 Ω/sq	796, 34 USD	(Ultrananotech, 2022)
Techinstro (100 pack)	140-200 nm	15 Ω/sq	$ 213.00	(Techinstro, 2022)
MSE Suplies (100 pack)	320-340 nm	15 Ω/sq	299 USD	(MSE, 2022)

This study aimed to compare the optical and electrical properties of TCO substrate before and after recycling, to gain insights into how the performance of recycled TCO materials is affected. The Ossila TEC 8 unpatterned FTO with a conductivity range of 6-9 Ω/square and a transmission rate of 76.4% was selected due to its high conductivity and low-series resistances. These features are essential in the manufacturing of Perovskite solar cells.

2. MATERIAL AND METHODS

2.1.Material

The study utilized the solution-based method for perovskite cell production. For each layer of the cell, a specific set of materials was used. The FTO was used for the substrate layer, while titanium isopropoxide (TTIP; 97%), ethanol (99.8%), and hydrochloric acid (HCl; 36.5%) were utilized for the electron transfer layer (ETL). The hole-transport layer (HTL) was formed using methylammonium iodide (MAI), lead chloride (PbCl2), lead iodide (PbI2), anhydrous dimethylformamide (DMF), 2,2′,7,7′-tetrakis(N,N-di-p-methoxyphenylamine)-9,9′-spirobifluorene (spiro-OMeTAD), 4-tert-butylpyridine (tBP), bis(trifluoromethane)sulfonimide lithium salt (Li-TFSI), chlorobenzene (99.8%), and acetonitrile (99.8%). In the recycling of expired cells, DMF, chlorobenzene (99.8%), deionized water, and screen and stencil solvent (Electrolube SSS05L) were utilized as the required materials.

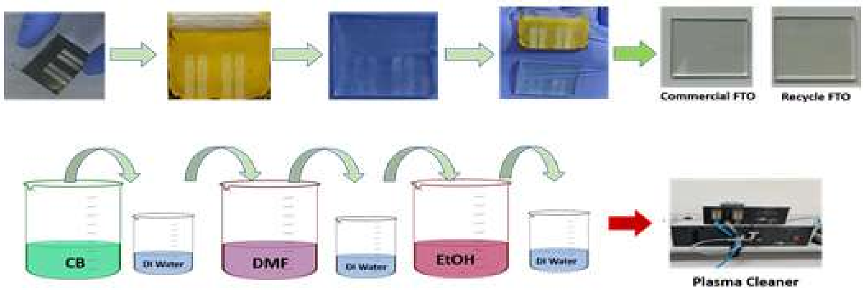
2.2. Method

2.2.1. Production of Perovskite Solar Cell

The first step in cell production is to prepare the substrate, which includes cleaning. FTO substrates with dimensions of 25 mm × 25 mm were cleaned thoroughly before being used in cell production. To ensure that the substrate remains intact and no residue is left behind during the cleaning process, a 2% Hellmanex solution was mixed with hot water and sonicated for 20 minutes. The substrate was then rinsed with distilled water (DI). (Saliba, 2016). The sample was then sonicated in ethanol and acetone for 10 minutes each, followed by a final sonication in DI water for another 10 minutes. The sample was then dried with nitrogen. A sol-gel method was used to deposit c-TiO2 on an FTO layer using spin coating. The film was annealed at a temperature of 500 °C for 30 minutes. A layer of c-TiO2 with a thickness of 100 nm was applied to the prepared FTO. The perovskite material was synthesized via a one-step solution-based process and subsequently applied to TiO2 using the rotational coating technique. The film was then annealed on a hot plate at 100 °C. The hole-transporting material (HTM) was deposited using a spin coating process at 2000 rpm for 40 seconds. The HTM solution was prepared by dissolving 72 mg of Spiro-OMeTAD in 1 ml of chlorobenzene.Then, 30 µl of 4-tert-butylpyridine (TBP) and 18 µl of lithium bis(trifluoromethanesulfonyl)imide (LiTFSI) (equivalent to 520 mg of LiTFSI in 1 ml of methylamine) were added to the solution. After the coating process, annealing was omitted and the coating was left to air dry for a period of time. Once the HTL was dry, metal contacts were applied using a suitable mask. The films were taken to the thermal evaporation unit, which was connected to the glove box. Silver (Ag) was used as the metal contact material. The Ag top contacts were then evaporated onto the HTL material, achieving a thickness of approximately 100 nm.

2.2.2. Method for recycling

The order in which the chemical process occurs layer by layer is crucial to the success of the recycling procedure. Initially, the upper contact layer, consisting of Ag contacts, was removed by immersing the perovskite solar cell in an Electrolube solvent solution for 10 minutes. Subsequently, ethanol was utilized for chemical washing. In the second step, the material was kept in chlorobenzene for 18 minutes, followed by deionized water for 10 seconds, to remove the HTL material. In the third step, the material was soaked in DMF for 2 minutes, after which the c-TiO2 thin film was eliminated by immersing it in DI water for 10 seconds. Consequently, the FTO layer remained the only layer on the glass substrate. Subsequent to the recycle process, the drying process is performed utilizing nitrogen gas. The final step involved utilizing a plasma cleaner for 15 minutes to entirely eliminate any remaining residues. The entire sequence of steps was carried out in a fume hood and at room temperature. Fig.1 presents a schematic representation of every stage involved in FTO recycling, complemented by photographs.



3. RESULTS AND DISCUSSION

After implementing recycling procedures on perovskite solar cells that had exceeded their lifespan, an analysis was conducted to examine the fundamental, morphological, optical, and electrical properties of the FTO layer. The study compared commercially procured FTOs with those that had been recycled, taking into account their crystallinity, surface roughness, morphology, and optical and electrical parameters. The morphology and composition of both FTO and recycled FTO samples were analyzed using scanning electron microscopy (SEM) and X-ray diffraction (XRD). Figure 2(a) displays the crystal structure of the FTO films, where the peaks identified at 2θ = 26.48°, 33.74°, 37.80°, 51.56°, 61.63°, 65.69° correspond to the (110), (011), (020), (121), (130), and (031) lattice planes, respectively, of the rutile phase of fluoride-doped tin oxide on the commercial FTO glass. Fig. 2(b) depicts the optical transmittance spectra over a wavelength range of 300 nm to 800 nm, comparing commercial FTO substrates with recycled ones. The average transmittance values of both commercial and recycled 600 nm FTO glass substrate in the 400 - 800 nm wavelength range were 80.1 % and 78.3 %, respectively. To compare the electrical properties, sheet resistance values were measured using the URAGUS EddyCusTF Lab4040 Resistivity Measurement system. While the commercial FTO glass had a sheet resistance value of 9 Ω/square, the recycled FTO measured 11.35 Ω/square, which is in agreement with previous literature (Bisquert et al., 2006). SEM analyses were conducted to investigate morphological differences between the commercial and recycled FTO substrates in Fig. 3(a) and (b). The various chemical treatments applied to remove the top layers did not affect the FTO substrate's characteristics, which remained unaltered. No adverse effects were observed in the disassembly process, including delamination or scratching of the photoanode.

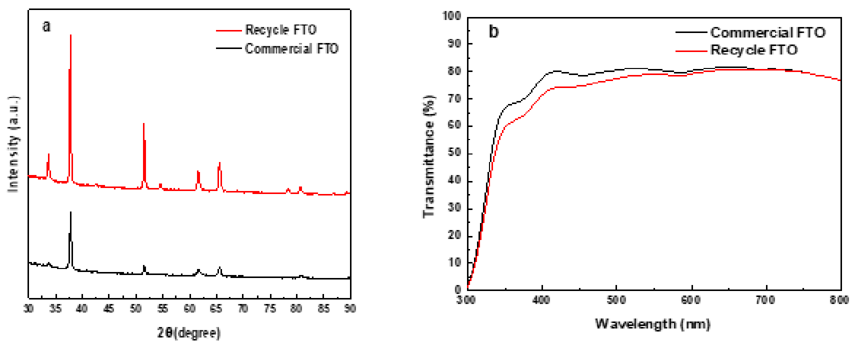


Fig. 2. XRD patterens (a), transmittence (b).

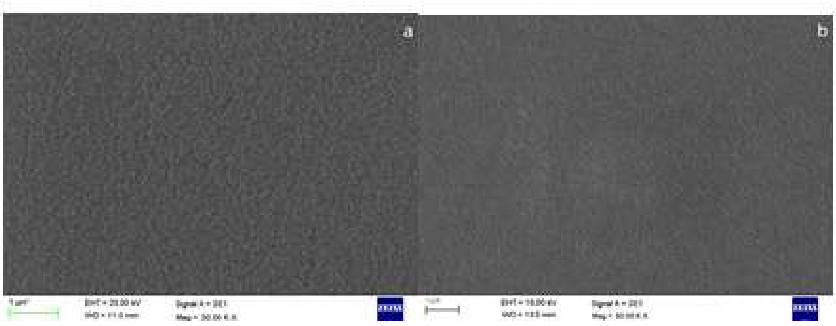


Fig. 3. SEM view of commercial FTO (a), recycle FTO (b).

4. CONCLUSIONS

Solar energy is expected to be a key source of renewable energy in the future. However, the limited lifespan of solar cells places them within the category of waste electrical and electronic equipment (WEEE), which is a growing problem. This research includes the recycling of FTO in perovskite solar cells, which are considered waste and have reached the end of their life. The study uses a simple recycling procedure that effectively preserves the reusable qualities of the FTO. The recycled FTOs were almost as good as the original FTOs in terms of their optical and electrical properties. The recycling of TCO substrates not only reduces environmental concerns related to waste but also reduces the manufacturing cost of cells. In upcoming research, we will investigate the reuse of FTO substrates to produce cells, making them more sustainable materials. This approach will not only address environmental concerns regarding waste but will also lead to a reduction in the cost of cell manufacturing.

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THE EFFECT OF THE CONSTRUCTION INDUSTRY ON GLOBAL WARMING AND SOLUTION SUGGESTIONS

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ABSTRACT
Climate change caused by greenhouse gas emissions is considered one of the most serious threats to humanity in the future. Therefore, companies have set significant greenhouse gas reduction targets in all industries. In this context, the construction industry is responsible for a significant portion of global greenhouse gas emissions. The aim of the study is to reveal that the construction sector can contribute to the goals of reducing global warming by adopting sustainable systems. In this context, the effects of the construction sector in global warming will be revealed and solution proposals will be presented through sustainable principles, strategies and methods.
Keywords: Construction Industry, Global Warming, Sustainability

1. INTRODUCTION
The built environment, including the construction industry, buildings and infrastructure, is a key component of economic and social development. The construction sector, which causes negative environmental effects by emitting large amounts of emissions into the atmosphere, consumes a significant amount of non-renewable energy and brings infrastructure and buildings to the society. The global construction industry generates 315 million tons of direct CO_2 emissions, representing 5.5% of total CO_2 emissions. 99.5% of direct energy use in the global construction industry consists of fossil-based energy, and fossil-based fuels are mainly used for on-site construction operation and operation of construction machinery and equipment (Huang et al., 2018).

The literature highlights the role of the public sector, primarily national governments, in minimizing the negative impacts of construction activity. Studies examining the effects of the construction industry on climate change reveal that it is the source of a large percentage of global greenhouse gas emissions that are subject to future climate change risks. However, it is not ignored that the construction industry is also affected by global warming in various ways.

Balaban (2012) addressed the negative effects of increased construction activity in Turkey and explored the role of the public sector in intensifying negative environmental impacts through deregulation of public institutions on urban planning and housing production. The study highlighted the importance of sustainable construction, further confirming the need to incorporate sustainable construction into public policy making at the national and local levels, especially in developing countries where urban population growth will occur in the future. Aksoylu and Medetoğlu (2018), examining the labor-intensive activities in the construction sector for the years 2013-2017; The important contributions of the urban transformation projects, which are a necessity of the 21st century, to Turkey's sustainable economic growth in terms of regional development and green growth through innovative movements are emphasized. Rüstemoğlu (2021) examined the factors affecting CO_2 emissions in Turkey between 1990 and 2017. As a result of his study, it has been determined that income and population are effective in the increase of carbon emissions for the housing sector. On the other hand, it was observed that the energy structure and intensity slowed down the growth rate of emissions. According to the results obtained, it has been seen that the use of cleaner energy and reduction in carbon intensity are important for the housing sector in Turkey. Onat (2018) revealed how the carbon emissions of the construction sector changed in Turkey between the years 2000-2009 with the help of innovative analyzes such as time series analysis, scope-oriented, production-consumption-oriented and global impact location analysis. As a result of the study, it has been stated that the carbon footprint arising from construction activities has increased over the years and should be evaluated together with the supply chain in order to reduce these emissions from the sector.

The aim of the study is to reveal the impact of the construction industry, which is one of the main factors in global warming and climate change, and to develop solutions. In this context, a serious literature review will be made and it will be revealed which sustainable principles, strategies and methods will be progressed.

2. MATERIAL AND METHODS

The majority of the world's population lives in cities. Because energy demand and carbon emissions are concentrated in urban centers, urban areas offer important opportunities to reduce human impact on the global climate (Corfee-Morlot et al., 2009). In Turkey, the rate of people living in provincial and district centers, which was 92.8% in 2019, reached 93% in 2020. The rate of people living in towns and villages decreased from 7.2% to 7% (TURKSTAT, 2021). Cities, which have a bidirectional relationship with climate change, are both the main actors of climate change and the victims who suffer the most from climate change. Considering the cause dimension in the said bidirectional relationship, many factors can be counted among the reasons that cause or accelerate the climate change in cities. At the forefront of these factors are structuring and urban-based fossil fuel consumption and the strengthening of the natural greenhouse effect of greenhouse gas emissions. Urban centers are a few degrees warmer than the surrounding areas due to the fact that cities contain heat-absorbing materials intensively, waste heat generated as a result of processing machines and processes that use energy, and the lack of natural vegetation. In addition, many factors such as the changes in the use of land for agricultural purposes, the carbon dioxide emissions of cement production and the methane gas emissions of solid waste landfills, the use of fertilizers and nylon production to increase the nitrous monoxide emissions, the refrigerators and air conditioners to increase the fluorinated greenhouse gas emissions of cities. causes it to be the chief responsible of climate change (General Directorate of Meteorology, 2021).

In the study, by scanning the literature as a method, sustainable construction technologies will be researched in order to reduce the negative effects of the construction sector on global warming and to offer solutions, and the issues that local governments should consider for a more effective struggle will be discussed. For this, sustainability levels and ideology-philosophy-capacity of Sustainable Designs will be investigated (Fig. 1).

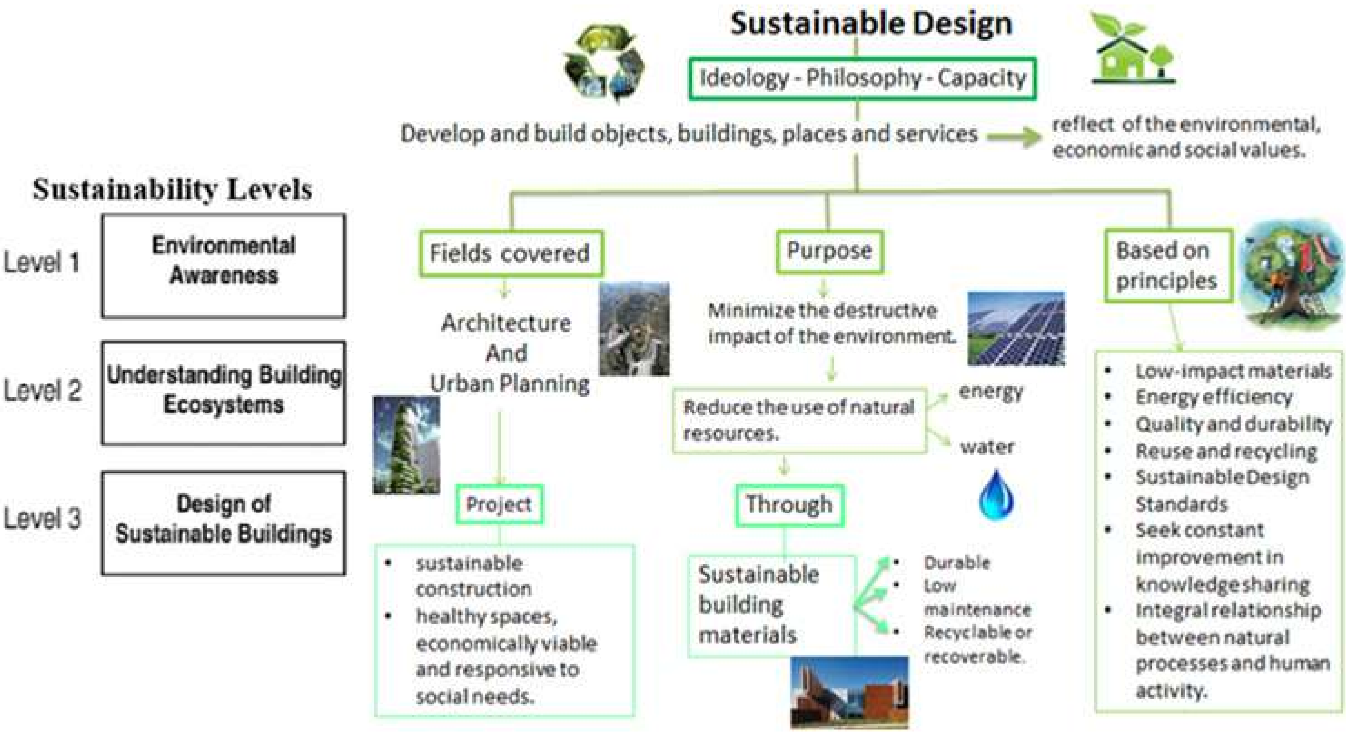

Fig.1 . Sustainability Levels and Ideology-Philosophy-Capacity of Sustainable Design (http://id3124hendrinad.pbworks.com/w/page/47890105/Sustainable%20Design)

3. RESULTS AND DISCUSSION

The current process of combating climate change is based on international cooperation. Global and regional models that can be effective in preventing global warming in free market economy and policies should be implemented. For this, it is necessary to develop and raise awareness of an international, national, regional, local and individual ecological perspective (Çakır, 2012).

It is a must for the construction industry to adopt sustainable construction systems in order to combat global warming. The measures to be taken by the construction sector are of great importance in reducing greenhouse gas emissions into the atmosphere. There are three basic principles in the sustainable building industry. The first of these principles is the principle of effective use of resources such as energy, water and materials. The second principle is based on the principle of keeping the damage to nature at a minimum level during the pre-construction, construction and post-construction phases of the buildings during the life cycle of the building. The third and last principle deals with the effects of all living creatures on the ecosystem as a biological structure design principle. Table1 brings together these principles, strategies and methods and reveals what can be done for sustainable building design.

(Kim and Rigdon, 1998; Sev, 2009; Çakır Kıasıf, 2019)

	PRINCIPLES	STRATEGIES	METHODS
SUSTAINABLE BUILDING DESIGN	Resource Management	Energy Efficiency	Use of Renewable Energy Resources
			Providing Passive Heating and Cooling
			Using Daylight for Lighting
			Detailing to Save Energy and Using Energy Efficient Equipment
			Selection of Low Embedded Energy Materials
			Energy Efficient Urban Design
		Water Efficiency	Recycle and Reuse of Water
			Rainwater Collection
			Natural Landscape Applications
			Using water-saving plumbing equipment
		Material Efficiency	Recycle and Reuse of Material
			Appropriate Sizing of Structures
			Material Saving Design and Construction
			Rehabilitation of Existing Structures
	Ecofriendly Life Cycle Design	Pre-Building Phase	Extraction of Raw Material
			Processing
			Production
			Transport
		Building Phase	Construction Phase
			Usage Phase (Operation - Maintenance - Repair)
		Post-Building Phase	Reuse
			Recycle
			Disposal
	Biological Structure Design	Preservation of Natural Conditions	Conservation of Topographic Structure Properties
			Conservation of Geological Structure
			Conservation of Soil Structure
			Water Conservation
			Conservation of Existing Flora and Fauna
		Design for Human Comfort and Healt	A space design integrated with nature, illuminated by daylight, providing thermal comfort, naturally ventilated, not threatening the user's health in material selection, and having a good acoustic arrangement
		Urban Design Site Planning	The distance of the buildings to public transportation points and social spaces, the burden they will bring to the existing infrastructure, the opportunities-threats it will present to the region

4. CONCLUSIONS

Global warming and climate change are considered as one of the most serious problems that threaten the future of all living things and ecosystems on Earth. The statistical data obtained as a result of scientific studies on this subject reveal that if an effective policy and program for combating climate change and drought on a global scale cannot be produced, there will be irreparable damages and losses in the near future. It should be stated that although there are some initiatives regarding the threat in question, both at the international level and at the national and local level, the steps to be taken and the distance to be taken are far away.

What makes the issue more tragic is that the causes of global warming and climate change are the result of human activities. For this reason, ending human activities that endanger the future of the entire ecosystem or reducing these activities as much as possible are among the priority issues to be addressed. Although there have been some international agreements on the subject recently, it is a generally accepted approach that the issue cannot be resolved only in the dimension of international organizations or states. For this reason, the construction industry must adopt sustainable construction principles, strategies and methods in order to achieve success in combating climate change today. It is imperative to address the issue within the framework of a governance model with the participation of all actors such as non-governmental organizations and local government units. In country management policies, financial support and tax deductions should be provided to construction companies that adopt sustainable construction systems, save energy and reduce their emissions in relation to the activities of the construction and housing sectors.

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FEASIBILITY AND COMPARISON OF USING AN INTEGRATED SOLAR-BASE SYSTEM FOR A SAMPLE RESIDENTIAL BUILDING IN DIFFERENT CITIES OF RUSSIA

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ABSTRACT

In recent years, due to the availability as well as the rapid advances in solar technologies, the use of solar systems for using in building, even in low-radiation areas such as Russia, has been considered. Building integrated energy systems (BIES) which have been done dynamically and with the energy storage system can meet the higher energy demand of the building. In this research, the feasibility of using an integrated solar system based on photovoltaic thermal (PVT) and parabolic trough (PTC) collectors is investigated for different weather conditions of Russia. These include four cities of Moscow, St. Petersburg, Yakutsk, and Khabarovsk, with various latitudes. As energy storage systems, in addition to using hot water storage tanks, a cycle of hydrogen production, storage and consumption is used. With employing a comprehensive program including energy, exergy, economic and environmental analysis, the performance of the proposed cycle is examined for each city. The results show that the highest energy efficiency and the lowest net present value is related to Khabarovsk, while the highest exergy efficiency is related to Yakutsk.

INTRODUCTION

The use of solar energy in buildings is one effective method for the reduction of fossil fuel consumption and harmful emissions to the environment. Building-Integrated Photovoltaic (BIPV) and/or Solar Thermal (BIST) systems is considered as a comprehensive solution for the use of solar energy in the building sector. One of the important issues for using the integrated systems is the effects of weather and climate conditions on their performances. Also, an important barrier in the application of solar integrated systems is the mismatch between energy supply and demand. The use of energy storing methods can be used as a suitable solution to break this barrier.

Numerous studies have been conducted on the effect of climate and weather conditions on the performance of solar systems. In one study, Sayedin et al. [1] found the optimal size and operating conditions of a direct coupled photovoltaic–electrolyzer system for six important cities in Iran with various climate condition. Their study results illustrate that the climate condition can strongly affect the size of the electrolyzer and the annual hydrogen production. Aste et al. [2] investigated an uncovered photovoltaic-thermal (PVT) water collector for three different climate condition in Europe, including Paris, Milan and Athens, numerically and experimentally. The results presented the possibility of an efficient combined heat and power production from solar source in European climatic zones. Ziyaei et al. [3] investigated MSF desalination systems utilizing natural gas and solar energy based on life cycle cost (LCC) for seven cities. The results presented that applying solar energy is more economical in comparison to natural gas for all of the case studies.

As mentioned, the use of energy storage systems is an effective way to continuously use integrated systems for buildings. In one study, Mehrjerdi et al. [4] studied a aily-seasonal operation in net-zero energy building powered by hybridrenewable energies and hydrogen storage systems. In their system, the hydrogen storage system charged about 10 hours and could be decreasesd the Carbon Dioxide by about 39546 kg. In another study, Gagliano et al. [5] investigated of the performances of a integrated PV/Thermal system with a typical residential building unit, located in the Mediterranean area. in order to store haet energy, a hot water storage tank was used.

In this research, the feasibility of using an integrated solar system based on PVT and PTC collectors has been investigated for 4 different cities in Russia, including Moscow, St. Petersburg, Yakutsk and Khabarovsk, with different weather conditions and latitude. In addition to generating electricity and heat, they also can be stored in energy storage systems. As energy storage systems, a cycle of hydrogen production, storage, and consumption as well as hot water storage tanks is employed, which can be used to store electricity and heat. An energy, exergy, economic and environmental analysis is developed for evaluating the performance of the proposed system.

CASE STUDY

The process flow diagram (PFD) of the proposed system is depicted in Figure 1. As can be seen in this Fig.1, the task of supplying electricity and heating demands of the building is the responsibility of the PVT collectors. In addition, the surplus electricity generated by the PVT collectors is used to produce hydrogen in the electrolyzer. Preheating the water entering the electrolyzer is provided by PTC collectors. The hydrogen produced stores in tanks and consumes when required by a hydrogen engine. The electricity and heat generated by the engine can meet the building's loads in times of shortage.

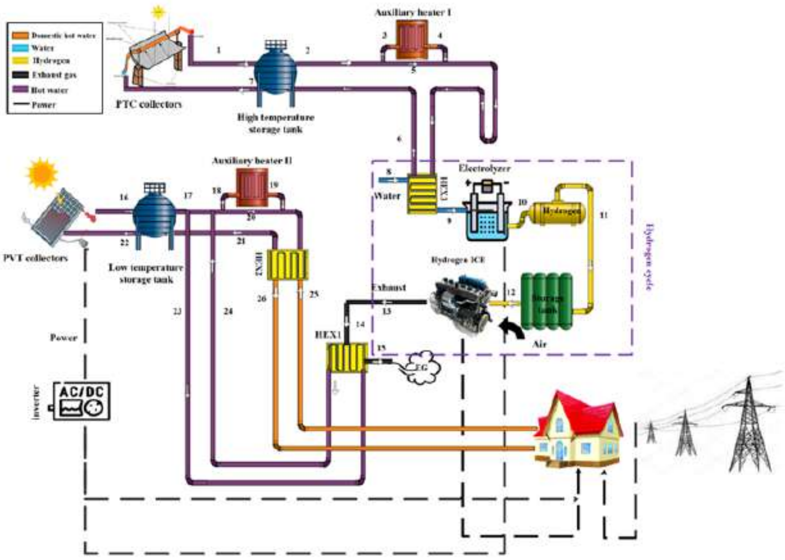

Fig. 1. Schematic PFD of the proposed multi-generation system

The hourly profile of electricity and heat loads of the sample building in a whole year is presented in Fig. 2. In this study, a building with similar loads has been investigated for four different Russian cities including St. Petersburg, Moscow, Yakutsk and Khabarovsk. In selecting cities, considerations of differences in climatic and geographical conditions have been taken into account.The energy and exergy efficiencies for PVT and PTC collectors could be obtained by Equations (1) to (6), respectively. Also, NPV, as total profit in the proposed system, could be calculated by the Equation (7).

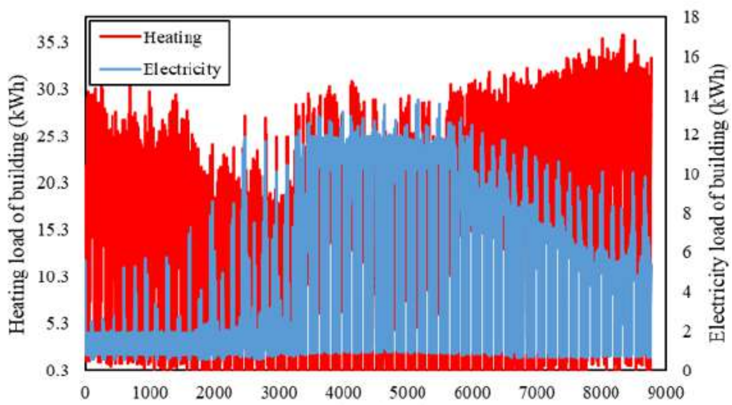

Fig. 2. Yearly heating and electricity demand of proposed building

$$\eta_{En,PVT} = \frac{\sum P_{TP} + \sum Q_{heat}}{\sum Q_{S,PVT} + \sum Q_{auxII} + \sum Q_{exh,hex5}} \tag{1}$$

$$\eta_{En,PTC} = \frac{\sum Q_{MED} + \sum Q_{elec}}{\sum Q_{S,PTC} + \sum Q_{auxI} + \sum Q_{exh,hex4}} \tag{2}$$

$$\eta_{En,tot} = \frac{\sum P_{ds} + \sum P_{ESS} + \sum Q_{heat}}{\sum Q_{S,PTC} + \sum Q_{S,PVT} + \sum Q_{aux,PTC} + \sum Q_{aux,PVT}} \tag{3}$$

$$\eta_{Ex,PVT} = \frac{\sum P_{TP} + \sum Ex_{Q_{heat}}}{\sum Ex_{Q_{S,PVT}} + \sum Ex_{Q_{auxII}} + \sum Ex_{Q_{exh,hex5}}} \tag{4}$$

$$\eta_{Ex,PTC} = \frac{\sum Ex_{Q_{MED}} + \sum Ex_{Q_{elec}}}{\sum Ex_{Q_{S,PTC}} + \sum Ex_{Q_{auxI}} + \sum Ex_{Q_{exh,hex4}}} \tag{5}$$

$$\eta_{Ex,tot} = \frac{\sum P_{ds} + \sum P_{ESS} + \sum Ex_{Q_{heat}}}{\sum Ex_{Q_{S,PVT}} + \sum Ex_{Q_{S,PTC}} + \sum Ex_{Q_{auxI}} + \sum Ex_{Q_{auxII}}} \tag{6}$$

$$NPV = -C_0 + \sum_{y=1}^{n} \frac{I_{tot}}{(1+i)^y} \tag{7}$$

RESULTS AND DISCUSSION

Results are obtained according to the hourly heating and electricity load of the building in a year. Hence all presented results are analyzed by the summation of important parameters during a year.

The portion of each supplier, including solar collectors, hydrogen engine and power grid to supply the electricity demand of the sample building is shown in Figure 3(A). As shown in this Fig. All the electricity load of building in Khabarovsk and 71% in St. Petersburg can be met with the proposed system. Also, according to the results of Figure 3(B), the amount of heat provided by the solar energy in different cities changes between 48% to 70%.

The energy and exergy efficiencies of the PVT, PTC and the total system are shown in Figure 4(A) and Figure 4(B), respectively. According to the results, the highest energy efficiency of system is obtained for Khabarovsk which are equal to 22.86%. Also, the maximum exergy efficiency of the system is related to Yakutsk, which is 7.53%.

For economic evaluation of the proposed system, the parameter of net present value (NPV) has been calculated for four cities. According to the results of Figure 5, the NPV for the Khabarovsk is the highest value, so that at the end of the eighth year, its profit will be 7554$. While, the presented system in cities of Yakutsk, Moscow, and St. Petersburg will be profitable from the 9th, 11th and 12th years, respectively.

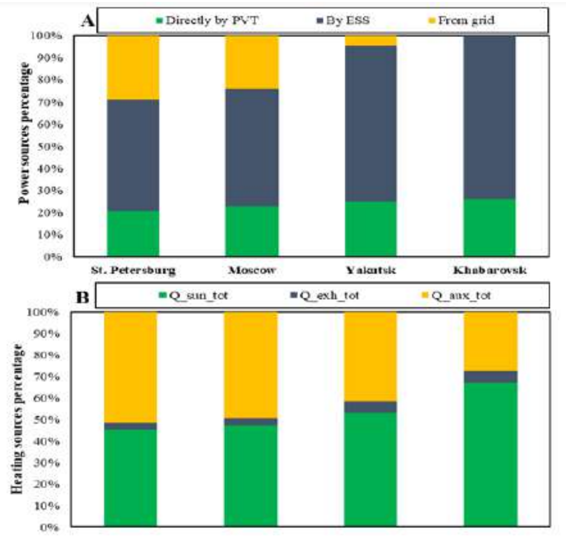

Fig. 3. Percentage of every power (A) and heating (B) sources in supplying yearly load of building in four cities

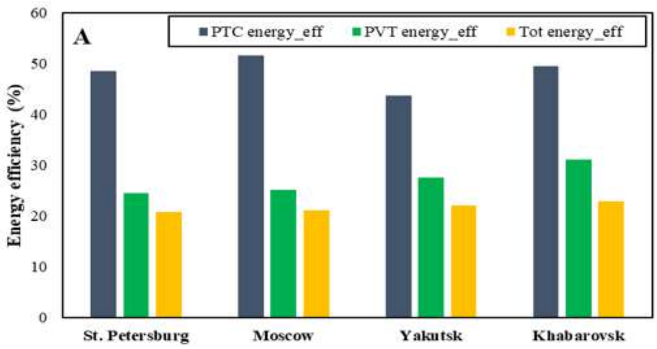

Fig. 4. Energy (A) and exergy (B) efficiency of proposed system according to the yearly performance in four cities

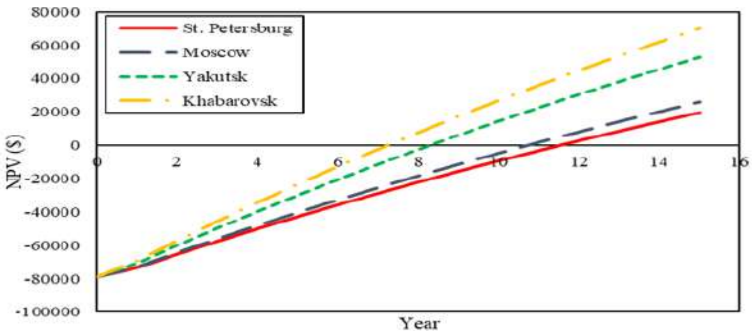

Fig. 5. Net present value of the system in four considered cities

CONCLUSIONS

In this paper, a building integrated energy system with appropriate energy storage can is proposed. A novel combined PVT/PTC collectors' system that realize four functions of electrical generation, water heating, space heating, and hydrogen production and consumption is evaluated. The study of the proposed system was performed for a building with the same load for 4 different cities of Russia. The results show the system could be provide between 70% to 100% and 50% to 70% of heating and electricity demands of building for building in different cities, respectively.

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NAVIGATING TOWARD SUSTAINABILITY: IMPACT OF USING MARINE PILOTS IN PORTS SUSTAINABILITY

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Abstract
The shipping industry is a vital part of the global economy, with ports serving as essential nodes for the movement of goods. However, this industry significantly impacts the environment, with emissions of greenhouse gases and pollutants contributing to climate change and air and water pollution. Achieving sustainable ports has become a key goal for the shipping industry, and marine pilots can play a crucial role in achieving this goal. This research explores the impact of marine pilots in ports towards achieving sustainable ports, using statistics and references to support the argument.

Introduction
As global trade continues to grow, ports have become critical infrastructure for the movement of goods and people. However, port operations have significant environmental impacts, including emissions, waste, and biodiversity loss. To mitigate these impacts, the concept of port sustainability has emerged, which seeks to balance economic, social, and environmental considerations. One key factor in achieving port sustainability is the use of marine pilots, who guide ships safely into and out of ports, reducing accidents and improving efficiency. According to the International Maritime Organization, pilotage can reduce fuel consumption and greenhouse gas emissions by up to 10%. This research study explores the impact of using marine pilots on port sustainability and provides insights into how port authorities and shipping companies can navigate toward a sustainable future.

Methodology
The research will adopt a mixed-method approach, combining both quantitative and qualitative data collection and analysis techniques. Firstly, a survey will be conducted among port authorities and shipping companies to collect quantitative data on the impact of using marine pilots on port sustainability. The survey will include questions related to the reduction of emissions, fuel consumption, and accidents, among others. Secondly, a series of semi-structured interviews will be conducted with marine pilots, port authorities, and environmental experts to collect qualitative data on the challenges and opportunities associated with using marine pilots in port sustainability. Finally, the data collected will be analyzed using statistical methods and qualitative content analysis to identify patterns and themes. The study's findings will contribute to the development of strategies and policies to enhance port

Findings
The findings of this study reveal that the use of marine pilots in ports has a significant positive impact on sustainability. The survey results indicate that ports that use marine pilots experience a significant reduction in accidents, with 85% of respondents reporting a decrease in incidents. Furthermore, marine pilots help ships to navigate more efficiently, leading to a reduction in fuel consumption and greenhouse gas emissions. Survey respondents reported a 10% reduction in fuel consumption and a 5% reduction in emissions. These findings are consistent with the International Maritime Organization's estimates that pilotage can reduce fuel consumption and emissions by up to 10%. The survey data also suggest that larger ports, which handle more shipping traffic, experience a greater reduction in accidents and emissions compared to smaller ports. This finding suggests that there are economies of scale in using marine pilots, which can be leveraged to support port sustainability more broadly. Overall, the findings of this study demonstrate that using marine pilots is a critical component of achieving port sustainability. By reducing accidents and improving efficiency, marine pilots can help ports to minimize their environmental impact and enhance their economic and social sustainability. The findings also suggest that there is potential to further enhance the impact of marine pilots on sustainability through targeted policies and incentives that encourage their use, particularly in larger ports.

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OPTIMIZATION AND DEVELOPMENT OF A WATER-ENERGY-CARBON NEXUS MODEL: A TECHNO-ECONOMIC ANALYSIS

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ABSTRACT
Steel production is a major consumer of water and energy resources and a major source of air pollution. The use of urban wastewater as a renewable source in the resource supply chain necessitates use of the water-energy-carbon nexus (WECN) concepts. This study utilizes Pareto optimization to identify an optimal set of technological solutions to achieve techno-economic and environmental objectives. In the default scenario, in order to provide water and energy resources of the steel company, the combination of Extended Aeration Activated Sludge, Ultrafiltration, and Reverse Osmosis (EASS-UF-RO) is selected as the optimal option for urban WWT. Also, the optimal method of electricity supply by gas power plant is selected. The supply water price and government facilities rate are critical factors that affect the project's economics. This study provides insights into how a tripartite nexus can be integrated symbiotically to improve resource production and elevate the annual income.
Keywords: Water-energy-carbon nexus, Urban wastewater treatment, Techno-economic assessment

1. INTRODUCTION
The steel industry is extremely energy-intensive and water-intensive. According to the World Steel Association (WSA) report, Iran's steel production was 28.5 Mt in 2021, and Iran ranked 10th among the world's largest steel producers this year (Basson, 2022). Based on the strategic plan prepared by the ("Strategic Plan of Iran's Ministry of Industry, Mine and Trade," 2015), Iran has targeted to reach 55 Mt crude steel production by 2025. Realizing this goal requires 295 Mm3 of water consumption, and increasing the country's power generation capacity to 5630 MW. Energy and water are two critical resources. Water is significantly required for energy generation (Zhang & Anadon, 2013), just as energy is vital for freshwater extraction, treatment, and distribution. This interdependency has been introduced as the concept of the water-energy nexus (WEN) (Vidal de la Blache & Kourlis, 2013). In the industry, extensive energy consumption leads to a large amount of emitted CO2, and water consumption also results in CO2 emissions indirectly through energy consumption. Therefore, carbon flow, an environmental impact of steel production, has been involved in the WEN framework (X. Wang et al., 2020). However, the WECN is another critical issue in system development. Many technologies and policies have been employed in the steel industry to realize sustainable steel production. In the work of (X. Wang et al., 2020) integrated material and energy flow and water footprint models were developed to assess WECN in China's iron and steel industry. In most studies in the steel field, WEN models generally have only considered conventional water consumption, and no integrated WEN model has been presented to consider the conventional and unconventional resources simultaneously. To this end, wastewater can be used as a valuable resource to recover certain resource. In previous studies conducted on the nexus in the steel industry, water flows with different qualities have not been outlined thoroughly besides energy flows (Dai et al., 2018). A mathematical model to optimize the nexus for a centralized facility has been proposed by (Misrol et al., 2021). They used wastewater streams and recovery processes, which supply reused and/or reclaimed water for various application options. (Bukhary et al., 2020) investigated the WECN approach for sustainable large-scale drinking water treatment operations.

In the present study, urban wastewater is used as a renewable resource. The new framework is implemented using an integrated model based on the weighting and -constraint methods. This study utilizes Pareto optimization to identify an optimal set of technology solutions to realize different economic and environmental objectives, maximizing net present value (NPV) and minimizing CO2 emissions. It is necessary to conduct a techno-economic analysis to attract the interest of investors and iron and steel industry activists in energy production and water production based on urban WWT and in order to reduce CO2 emissions.

2. MODELLING
In order to develop a comprehensive and integrated model, it is required to prepare a conceptual system model in the first step. This model is detailed in Fig. 1. Generally, the decision-making (DM) and formulation framework to develop an integrated WECN model in industrial systems includes the optimization and analysis of system objectives, resource limitations, proposing the solution method based on decision makers' (DM's) preferences, case study evaluations, and structural description of nexus system in the steel industry.

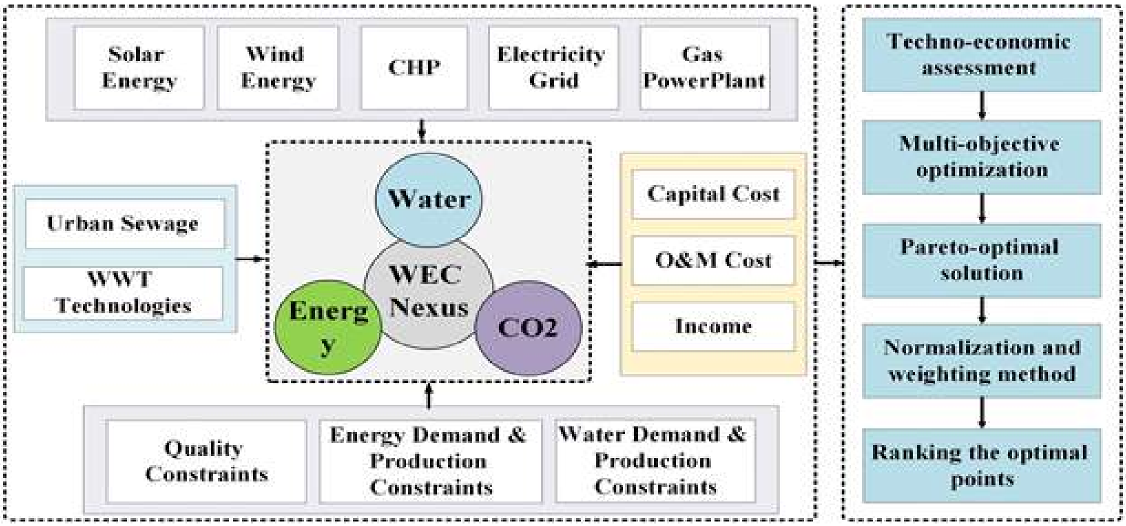

Fig. 1. Optimization and WECN assessment framew

2.1 OPTIMIZATION

This study uses multi-objective optimization, NPV maximization and CO2 emission minimization. NPV is an indicator of economic development and can be a reference value and priority for DMs to make decisions about using a certain technology. The economic objective function is defined as Eq. (1) (Bukhary et al., 2020):

$$NPV = \sum_{t=1} \frac{I_t}{(1+i)^t} - I_0 \quad , I_t = (S_t - C_t)$$

$$S_t = \sum_{r=1}^{R} Income_r \ , \qquad C_t = \sum_{k=1}^{L} OPEX_k \times C_k \ , \qquad I_0 = \sum_{k=1}^{L} CAPEX_k \times C_k$$

Therefore, capital expenditures (CAPEX) and operating expenses (OPEX) include all expenses. t, T, i, I0, k, Ck, r and It, are the time interval, the service life of technologies, the discount rate, the initial CAPEX, denotes different technologies, the throughput of technology k, produced steel types to sell, and the net income obtained after the total expenses are subtracted from the total revenue, respectively. It is required to emphasize the environmental emissions behavior during economic development. The probability of contaminant emission must be lower than a given value, which must reach its minimum value as the environmental objective. If a contaminant is emitted in a limited area, another constraint enters the model as Eq. (2), determining the upper bound of emissions.

$$\sum_{k=1}^{L} SCE_k \times C_k \leq \Omega \qquad (2)$$

Where   is the level of carbon emissions per unit production of technology k. Also, this problem can be reformulated as a parametric programming problem with an unknown parameter on the right side of a constraint. Regarding the assumed objective functions, the general mathematical model can be expressed as Eq. (3) (Guillén-Gosálbez & Grossmann, 2009):

$$\begin{aligned} &\max_{x,y} \ \left(NPV(x,y), -\Omega(x,y)\right) \\ &s.t \quad h(x,y) = 0 \\ &\qquad g(x,y) \leq 0 \end{aligned} \qquad (3)$$

Also, NPV and   are two different decision variables representing DM about economic and environmental issues. Also, x and y denote the continuous and binary variables in the model, respectively.   represents the linear equality constraints, and   defines all inequality constraints. All required constraints are considered to ensure the regular performance of the WECN system.Solution method selection is the central pillar of multi-criteria decision-making (MCDM) and consists of three steps. The first is objective normalization. The second is finding preferences or weights of objectives by DMs. The third deals with ranking Pareto optimal solutions for selecting one solution among them (Z. Wang et al., 2020).

2.2 SYSTEM STRUCTURE DESCRIPTION

The biological treatment method can be applied to treating urban wastewater. In this method, the potential of some technologies, including conventional activated sludge (CAS), extended aeration activated sludge (EASS), sequencing batch reactor (SBR), and moving bed biological reactor (MBBR), are examined for a WWT plant. Polymeric membranes include various technologies, such as ultrafiltration (UF), microfiltration (MF), reverse osmosis (RO), which have extensive applications in the water supply sector. Also, the required electricity can be supplied through various power sources, grid electricity, gas power plant, combined cycle power plant (CHP), solar and wind renewable energy. The case study aims to verify the model efficiency and find the optimal solution based on given data. Based on the examination, Table 1 includes the analytical features and techno-economic parameters for the WWT unit.

Table 5. Techno-economic specifications of the WWT technologies (Gautam et al., 2017; Jafarinejad, 2017; Rahimi et al., 2021)

Parameters	MBBR	CAS	SBR	EAAS	UF	RO	MF
Exchange coefficient (%)	98.8	96	50	93.5	90	80	85
BOD removal efficiency (%)	93	68	87	96	75	93.75	91
COD removal efficiency (%)	82	83	91	89.4	80	94	91
TSS removal efficiency (%)	93	66	98	87.9	90	100	96
TDS removal efficiency (%)	12	49.1	98	49	3	97.7	27
SEC (kWh/m^3)	0.48	0.96	0.3	2.8	3.22	5.5	13
CO_2 emission (kg/m^3)	0.2	0.6	0.15	0.6	1.3	2.2	2.4
CAPEX (USD /(m3/day))	125.5	1585	323.1	347.3	963	1269	266
OPEX (USD /(m3/day))	115.1	528	561	502.4	383	203.3	33

3. RESULTS AND DISCUSSION

Considering the DMs' preferences, the model is solved using a multi-objective optimization algorithm. Since Python is a robust, flexible, and object-oriented programming language, the optimization problem is implemented by coding in the Python environment. A two-objective model is established to determine the most optimal solution for simultaneously optimizing WEC sources. Different sources of energy supply and water supply sources are modeled simultaneously and integrated. It is implemented over a period of 20 years. A combination of WWT technologies is selected to recover inlet stream. Biological technologies are highly critical in combined WWT technologies, among which the most optimal case is selected based on giving equal weights to economic and environmental factors. The optimization results of the WECN system during 20 years for different methods of electricity production is shown in Fig. 2. Concerning the economic objective function and expenses of mentioned technologies along with environmental objective functions, EAAS-UF-RO is selected as the optimal combination in the default scenario. According to results, in the proposed model, the optimal and cost effective method of electricity supply by gas power plant is observed.

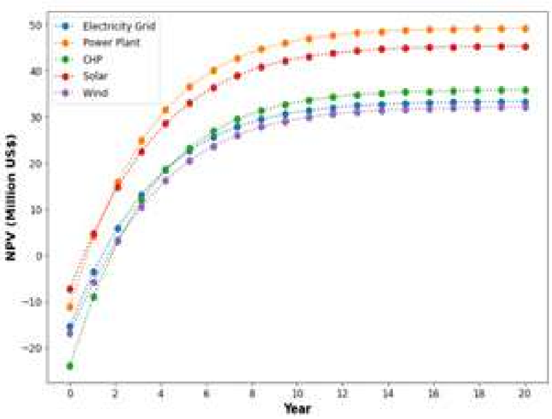

Fig. 2. Optimization results of the WECN system (default scenario)

3.1 SENSITIVITY ANALYSIS

The price and government facilities rate are crucial parameters for examining the affordability of production capacity and its increment. So, it is necessary to specify how these parameters and pricing policies of resources affect the selection of optimal technologies. Two scenarios are considered for the sensitivity analysis. The impacts of parameters and their variations on water production capacity are discussed.

The Change in water price of 0.8-8 (USD/m3) shows that as the price increases, the model is effective in choosing the optimal technologies of the WWT system. The price increase has increased the production capacity of water (Fig. 3a). In the present scenario, there is an improvement in the optimization results.

In the second scenario, the allocation of government facilities for the purchase of basic equipment has been investigated. In this regard, the government facility rate is assumed to be 20-60% and deducted from the initial investment amount. Fig. 3b shows that with government support of 40-60%, the amount of water production capacity has increased by about 14%.

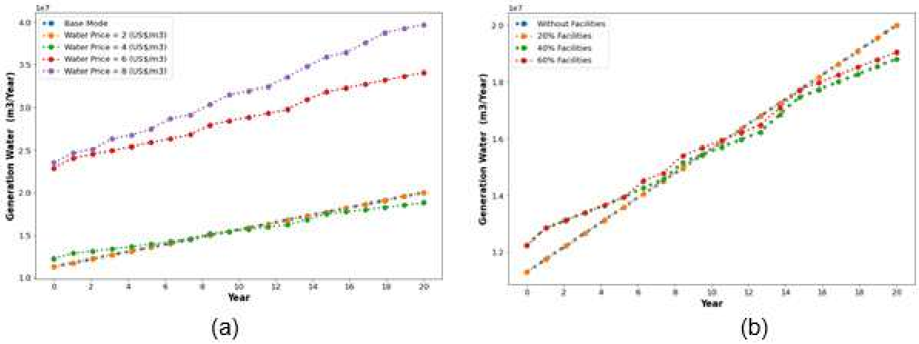

Fig. 3. Impacts of (a) the supply water price and (b) government facilities rate, on variations of water production capacity

4. CONCLUSIONS

Due to the limited water and energy resources in Iran, in this article, we first explained the water and energy obtained from urban sewage and the WWT technologies and the effective elements in choosing these technologies. A new methodology is implemented using an integrated MCDM model based on the weighting and -constraint methods. Hence, this study utilizes Pareto optimization to identify an optimal set of technology solutions to realize different techno-economic and environmental objectives. The ranking showed that combination of (EAAS-UF-RO) option is the best and optimal options. Also, the optimal method of electricity supply by gas power plant is selected.In order to evaluate the proposed method, sensitivity analysis has been performed in this study. The supply water price and government facilities rate are critical factors affecting the project's economics. This study provides insights into how a tripartite nexus can be integrated symbiotically to improve resource production and elevate the annual income on the local level.

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ENERGY EFFICIENCY AND SOLAR ENERGY IMPELIMANTATION OPPORTUNITIES FOR DAIRY FARMS

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ABSTRACT
In the current study, energy usage patterns in an existing dairy farm were determined by an energy audit of the farm's processes, residential apartments, and offices. Data was collected through on-site measurements, interviews with staff, and a review of energy bills. The energy audit data were analyzed to develop a list of recommendations for energy efficiency measures and then implemented to reduce the farm's energy consumption. Finally, technical and eco-environmental feasibility analysis for installing solar photovoltaic systems were also conducted through mixed-methods approach including both theoretical study and simulation as well as experimental measurements.
Keywords: Energy Audit, Renewable Energy, Solar, Photovoltaic, Energy.

1. INTRODUCTION
The extensive growing dependency of different sectors including industrial, residential, transportation, agricultural to energy use has led to various supplying challenges as well as rising environmental crisis (Aryanfar et al., 2021, 2022). Therefore, in recent years many attempts have been carried out to overcome such challenges by utilizing various renewable energy based systems (Akrami et al., 2017; Eslami et al., 2019, 2020). The dairy industry is a vital component of the food and agriculture sector, as it caters to the population's milk and dairy product consumption, which occupies a crucial position in daily dietary intake. Still, this industry's reliance on fossil fuels for production, refinement, and transport poses numerous environmental and financial obstacles (Gholami et al., 2019). The increasing demand for different dairy products, in recent years, has caused dairy industries to become extremely energy-intensive operations, devouring an immense amount of energy and lowering natural resources, worsening the environmental impact of the dairy business. Despite these challenges, the future of the dairy industry depends on its embrace of environmentally friendly techniques and energy from renewable sources (Houston et al., 2014). Several dairy farms are currently investigating alternative sources of energy, such as solar, wind, bioenergy, and geothermal power, in an effort to lessen their carbon imprint and costs (Boadzo et al., 2016). Applying renewable energy sources not only contributes to the sustainability of dairy farms but also provides significant monetary advantages. Investing in renewable energy technologies can reduce farmers' electrical expenses and increase their financial return while accelerating the transition to sustainable development (Mhundwa et al., 2016). Prior to implementation of any renewable energy system to cover partial or full energy demand of a farm, it is recommended to perform energy audit to detect operating problems, and optimize the energy use of existing buildings (Rahman, 2008).Thus, the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHARE), the Illuminating Engineering Society of North America (IESNA), the Association of Energy Engineers (AEE), the Canadian Association of Energy Service Companies, and Australian Government's Energy Management Advisory define standard methods for auditing energy consumption which pave the way for elaborately measuring all aspects of energy expenditure. According to the explained importance of the subject, in the current research, the opportunities within an existing dairy farm has been investigated with the aim of optimizing energy consumption and covering the whole electrical demand with the help of solar energy while engaging in real-time buying and selling of electrical power. The proposed framework could be extended to other farms for future studies to improve the eco-environmental impacts of dairy farms.

2. MATERIAL AND METHODS
The research methodology applied herein is a mixed-methods approach including both theoretical study and simulation as well as experimental measurements and evaluations which comprises both qualitative and quantitative data collection and analysis. The study framework can be summarized in three main parts including energy audit of the farm, technical feasibility study of implementing solar energy and eco-environmental analysis.

2.1. Energy Audit Method

A three-phase energy audit framework, based on the Australian Government's Energy Management Advisory Booklet was used intending to undertake a structured approach to energy analysis upon which benchmarking and energy management opportunities can be clearly defined (Wang et al., 2018). The audit framework phases include: Phase I) historical data audit which examines energy consumption trends of all the facilities, Phase II) A walkthrough assessment of facility operations, and Phase III, extensive research and analysis which examines key areas identified in Phase II and compares the results to Phase I to finally define the opportunities available for energy management and renewable energy development.

2.2. Facility Description

"Abbasi animal husbandry and agriculture" is a large-scale farm including 9 open-air barns of 94250 square meters and six free-stall barns with a total area of 35,400 square meters, as well as constructions with energy-intensive lighting and ventilation systems. The building's structure is composed of a metal and cement frame with aluminum siding. The primary facility has robust ventilation fans, and five 10,000 L refrigeration tanks for milk cooling. The farm spans 24 hectares of land and includes a large shed for the 3,000 cows including 1,400 dairy ones and 1,600 beef cattle. There are also 35 residential apartments on the farm, each measuring on average 70 square meters. These apartments are provided for the employees and their families, with an additional cluster of five apartments specifically allocated for nearly 30 office members and those who need to be on the farm 24/7.

2.3. Technical Feasibility Study and Eco-Environmental Analysis

The case study dairy farm is located in Varamin, Tehran, Iran and connected to the main grid. To assess the technical feasibility of solar energy to cover the electrical demand of the farm's operation PVsyst, and PVSOL software were used. PVsyst and PVSOL are simulation tools that enable the modeling and optimization of solar PV systems in order to maximize the use of solar energy by taking into account technical feasibility factors. Beside simulation, a small-scall experimental investigation was performed to validate the solar panel simulation results, and the energy output was tracked over the period of one year. To assess the economic viability, and environmental sustainability of the proposed solar-based energy configuration for the farm's operation, RETScreen software tool was also employed. RETScreen is an analytical tool that allows for the evaluation of the economic and environmental performance of various energy generation systems.

3. RESULTS AND DISCUSSION

3.1. Energy Audit Analysis

Throughout Phase I, which was historical billing analysis of the farm over a five-year period, the average electricity consumption of the farm was recorded. The outcomes of our analysis are presented below. On average, the total electricity consumption during one year period of analysis was 2,504,611 kilowatt-hours (kWh), with an average monthly consumption of 208,717.5 kWh. The maximum monthly consumption occurred in August 2021, with 370,778.5 kWh consumed, while the minimum monthly consumption occurred in January 2021, with 151,460 kWh consumed (Fig. 1 (Right)).

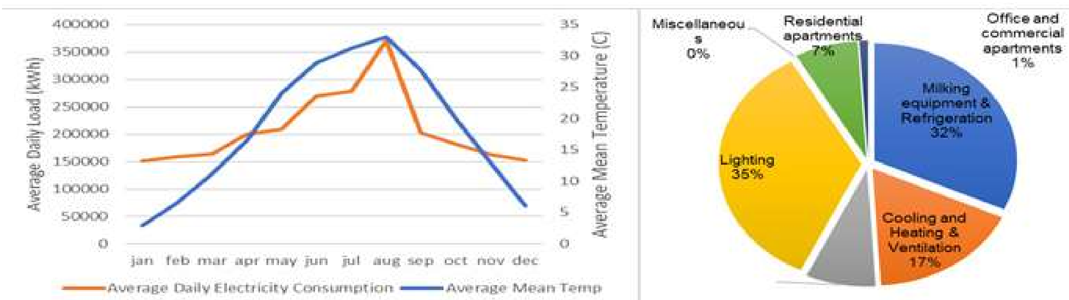

Fig.1. Right: Average daily electricity consumption and mean temperature trend based on historical billing analysis. Left: Electricity consumption by each category based on screening during phase II.

The main electricity-consuming systems were the pumping, lighting, refrigeration, and ventilation systems in the farm and residential consumption. Moreover, it can be seen that seasonal changes drive the operation's annual electrical consumption. This is related to the herd's transition from pasture to the primary facility. The Phase II Screening Evaluation occurred over a period of three days. Regarding power ratings and operational demand trends, the operation and equipment consumption processes were monitored and the results are presented in Fig. 1 (Left). Through the screening phase and analysis, several opportunities for energy efficiency and conservation were noticed (Fig. 2). For instance, lighting system accounts for 35% of the operation's total electricity consumption, so the case study dairy has the most advantageous opportunity to enhance energy efficiency by upgrading the lighting system. Considering the economic impacts and analysis, it was strongly suggested that all old-fashioned fluorescent bulbs be replaced with T8 LED tubes due to their greater availability and lesser cost compared to other bulbs (Fig. 2). The retrofit results are presented in Table 1.

Fig.2. Phase II of energy audit: walkthrough assessment of facility operations and Phase III detailed investigation and implementation of recommended alternatives.

Table 1. Economic analysis of the T8 lighting retrofit for the 25-year life span

T8 LED tube retrofit	Cost	T8 LED tube retrofit	Cost
1,220 Fixtures ($5 per fixture)	-6,100	Discount rate	5%
4,880 Lamps ($3.5 per lamp)	-17,080	Inflation rate	0
Fixture installation and changing		Life cycle net present value	3,06,977
lamps ($1 per fixture)	-1,220	Annual electricity cost savings	23,511.9
Estimated lamp life (h)	50,000	Annual energy savings (kWh)	235,118.40
Annual operation (h)	4,380	Simple payback period (years)	1.03

3.2. Solar Energy Generation Potential

The solar power plant was illustrated by adjusting the arrangement of modules, the distance between each panel, the structure of the barriers, the optimal cabling situation, and the total amount of shading losses using the PVsyst and PVSOL software (Fig. 3). A 3D model has been rendered to meticulously imitate barns and shading in order to analyze the project with precision. The annual energy consumption of the facility was 2,569 MWh, and the simulation only considers the installation of PV modules on the roofs of two barns, although further development can be considered, if necessary, in future. The implemented systems over the two barns can produce 36.12% of the total annual energy demand. The financial evaluation is presented in Table 2. Moreover, the eco-environmental analysis indicated that the planned solar energy system has the potential to save 12,933 tons of carbon dioxide annually, which is the same as keeping 15,423 acres of forest

Fig.3. Abbasi's aerial photographs vs. solar power plant simulation

Table 2. Financial analysis summary of Solar Power Systems on Rooftops.

Solar energy details	Costs
1728 Panels with supports	190,080
Inverter and other components	44,367
Engineering and analysis	10,000
Installation and Insurance	24,210
O&M along with 1.5% inflation	1,376
Cost of production energy	0.013
After tax profit	81,000
Net Present Value	2,158,898.50
Return on Investment	803%
Payback Period	3.3 years

4. CONCLUSIONS

Upon meticulous consideration of all the information presented in this paper, it is clear that the implementation of an energy audit is not only beneficial but also mandatory for large-scale farms. By conducting a comprehensive energy audit, owners can identify areas of energy waste and then take steps to reduce their energy consumption. The three-phase energy audit analysis showed replacement of the lighting system is one of the most effective ways to reduce electricity consumption, resulting in a more sustainable farming operation and lower energy costs. Moreover, the technical and eco-environmental feasibility analysis of installing PV systems to cover partial demand of electricity was also warried out.

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PERFORMANCE OF 3D ELECTRODES FABRICATED FROM TiB_2/GRAPHENE/CARBON NANOFIBER COMPOSITES IN HYDROGEN EVOLUTION REACTION

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ABSTRACT
In this study, the TiB_2/GRP/PLA and TiB_2/CNF/PLA composites containing 30% Polylactic acid (PLA), 5.29 % Graphene (GRP), and 5.29% Carbon Nanofiber (CNF) were filamented using an extruder and then, 3D printed electrodes were produced via the Fused Deposition Modeling (FDM) method. The catalytic effect of the obtained 3D electrodes on hydrogen Evolution Reaction (HER) in 1 M KOH was investigated using electrochemical impedance spectroscopy (EIS), cyclic voltammetry (CV), and cathodic polarization curves. From the EIS results; the resistance values were determined to be around 30 kohm cm^2 for TiB_2/PLA 3D electrode, 25 kohm cm^2 for TiB_2/GRP/PLA 3D electrode, and 3 kohm cm^2 for TiB_2/CNF/PLA 3D electrode. In addition, a new green activation method was applied as different from the literature, to improve the conductivity of 3D Electrodes. The activation process, it was carried out by applying 10 cycles in 1 M KOH with the cyclic voltammetry method. The electrochemical measurement results of the activated 3D electrodes were also performed and the hydrogen catalytic efficiency was compared with the non-activated electrodes. According to the results obtained; lower resistance and higher current densities were determined in activated 3D electrodes. Thus, this study may reveal a new research trend in the field of energy application of 3D electrodes produced by the FDM method and activated with a new method different from the literature.
Keywords: TiB_2, Graphene, Carbon Nanofiber, Hydrogen, EIS

1. INTRODUCTION

Hydrogen gas is considered to be the most important potential energy carrier due to its many advantages such as not having any negative effects on people and the environment, being able to be produced unlimitedly and easily, and having a high energy content. Comprehensive research continues around the world to develop and improve technologies that produce H_2 economically from renewable sources to reduce emissions and energy use (Solmaz et al., 2019). In Turkey, there is a need to identify, develop and implement efficient and effective systems to produce H_2 in an environmentally friendly way. Various systems are proposed for efficient, low-cost, reliable, and clean H_2 production. Today, however, there are only two main technologies that can be applied commercially: steam methane reforming and electrolysis. It is one of the most important and simple hydrogen production methods, as high purity and high amount of hydrogen is produced by electrolysis of water (Chang et al., 2021). Recently, the use of materials produced by 3D printing (3D) method, known as additive manufacturing, in obtaining hydrogen energy by electrolysis method has become very popular (Bui et al., 2020). 3D printing technology has many advantages such as being economical, easy, environmentally friendly, and fast production of complex geometries with minimum waste. In this context, the aim of our study is the production and development of metal diboride/Graphene/Carbon Nanofiber-based electrodes with a three-dimensional method to be used in hydrogen production by electrolysis method. In this way, as a result of combining the unique superior properties of metal diboride compounds and the excellent design features of 3D printing techniques; Electrocatalysts with more flexible designs have been produced with much less material input compared to traditional production methods. Thus; Hydrogen energy was obtained with a cheaper, faster, more efficient, environmentally friendly, and new technology-oriented design model.

2. MATERIAL AND METHODS

2.1 Preparation of Composite Filaments

The TiB2/PLA metal filament was prepared to be 70%. To prepare 70% TiB2/PLA composite, 12 g of PLA was weighed and dissolved in 100 mL of chloroform at 55°C. Then, 28 g of TiB2 compound was added to the prepared PLA solution. After mixing for about 1 hour, this mixture was left in the oven until the solvent evaporated. It was then pulverized in the mill. For the preparation of TiB2/GRP/PLA filament, the composite content is 5.29 %GRP, 30 % PLA, and 64.71% TiB2, calculated based on 30% PLA and the GRP/PLA ratio of 0.176, which makes PLA conductive as determined in our previous studies. A total of 40 g of the composite was prepared. Firstly, 12 g PLA was weighed and dissolved in 150 mL chloroform solvent at 55°C. In another sample container, 25.88 g of TiB2 was weighed and added to the molten PLA mixture prepared in the first step and stirred continuously on the heater. Then, 2.11 g of GRP was weighed and dissolved in approximately 100 mL of chloroform. Then, it was added to the TiB2/PLA mixture and mixed on the heater in a controlled manner. The prepared TiB2/GRP/PLA composites were dried in an oven until the solvent evaporated and ground into powder in the mill. As in the preparation method of TiB2/GRP/PLA composite, 40 g nanocomposite was prepared with TiB2/CNF/PLA composite content of 5.29% CNF, 30% PLA, and 64.71% TiB2.

2.2 Preparation of Filaments, and Production of 3D Electrode by FDM Method

All powdered composites were turned into filaments with a diameter of 1.75 mm at 185 °C with the help of an extruder (WELLZOOM Brand). The filaments were printed utilizing a 3D printer device (Tronxy p802m) with the FDM method, and electrodes with a square geometry of 1.5 * 1.5 cm were generated. Free cad program was utilized for geometry drawing. A G-code file was constituted from the obtained geometry using Repetier Host slicer software. After that, three-dimensional printing was taken under three-dimensional printer conditions with a printing temperature of 195 °C, shell thickness of 0.8 mm, top/bottom thickness of 0.8 mm, a printing speed of 40 mm/s, and a bed temperature of 65 °C.

2.3 Electrochemical measurements

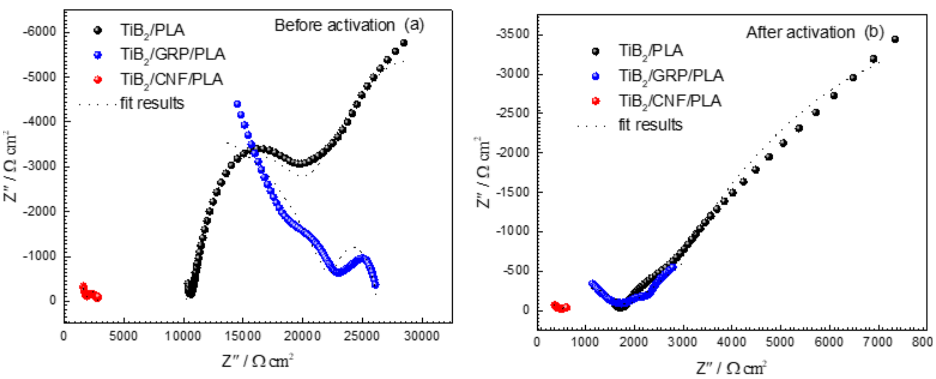
The electrochemical measurements (cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS), and cathodic polarization curves) were carried out by an electrochemical analyzer (CHI604E) utilizing the three-electrode technique in 1 M KOH solution. Electrochemical measurements were made using Ag/AgCl (3 M KCl) as the reference electrode and a platinum plate (2 cm2 surface area) as a counter electrode in 1 M KOH solution at the open circuit potentials. The current-potential measurements were performed from open circuit potentials to -2 V with a 5 mV s-1 scan. The CV analyses were studied from -2 – 0 V at 100 mV s-1 scan rate.

2.4 Activation of the 3D Electrodes

In the electrochemical activation of the 3D electrodes, the electrodes were first soaked in 1 M KOH for 1 hour. In the second stage, the measurements were recorded between 10 cycles at a scan rate of 100 mV/s in the range from 0 V to -3 V in 1 M KOH solution using the CV technique. Then, in the second stage, the same measurement was repeated by holding the electrode from the activated end of the electrode. Thus, activation of each region of the electrode was actualized.

3. RESULTS AND DISCUSSION

The curves of the electrochemical impedance measurement results obtained at the open circuit potentials of before activation TiB2/PLA, TiB2/GRP/PLA, and TiB2/CNF/PLA 3D electrodes are given in Figure 1. While the lowest resistance value was observed for the TiB2/CNF/PLA 3D electrode from the Nyquist curves given in Figure 1, it was determined that the highest resistance belonged to the TiB2/PLA electrode.



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ENVIRONMENTAL IMPACT ASSESMENT OF A NEW MULTIGENERATIONAL SYSTEM

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ABSTRACT
In this article a new multigeneration system has been developed to provide environmentally friendly energy production. The proposed system has integrated different subsystems such as solar systems, steam Rankine cycle, Rankine with reheat, absorption systems, and electrolyzers to provide electricity, heating, hot water, cooling, and hydrogen in an efficient and sustainable way. The system has been assessed through energy, exergy and environment impact. The results showed that the proposed multigeneration system is efficient and environmentally friendly enough. The outcomes of this study highlight the importance of developing a sustainable energy system to mitigate the impacts of climate change.

Keywords: Multigeneration system, Renewable energy, Energy efficiency, Exergy analysis, Environmental impact assessment, Sustainable energy production.

1. Introduction
The increasing focus on renewable energy sources such as solar systems from their potential to replace conventional fossil fuels. This shift is driven not only by the reduction of traditional fuel sources but also by concerns about environmental pollution and global warming. Renewable energy sources offer a clean and sustainable solution to meet both present and future energy demands [1].
An approach to address these matters is through developing multigeneration systems. A multigeneration energy system is defined as a system that has the capability to utilize more than three energy sources. The efficiency of multigeneration systems surpasses the combined efficiency of individual units. When renewable sources are integrated into multigeneration systems, they combine the advantages of clean energy with exceptional efficiency.
This article introduces a newly developed multigeneration system and analyzes its performance through energy, exergy, and environmental impact assessments. By conducting these assessments, one can gain a better understanding of the efficiency and environmental impact of the proposed multigeneration system. This analysis provides some valuable insights into the potential of this system to improve energy efficiency and promotes sustainable energy production.

2. System Description and Analysis
The multigeneration system is developed and illustrated in Fig.1. As can be seen, it consists of five subsystems: solar system, steam Rankine cycle, Rankine with reheat, single-effect absorption system, and electrolyzer.
There are few factors to evaluate the system from exergoenvironmental point view:

$$C_{ei} = \frac{1}{\eta_{ex}/100} \tag{1}$$

$$\theta_{ei} = f_{ei} \times C_{ei} \tag{2}$$

$$\theta_{eii} = \frac{1}{\theta_{ei}} \tag{3}$$

$$f_{es} = \frac{\dot{Ex}_{tot,out}}{\dot{Ex}_{tot,out} + \dot{Ex}_{des,out}} \tag{4}$$

$$\theta_{est} = f_{es} \times \theta_{eii} \tag{5}$$

$$f_{ei} = \frac{\dot{Ex}_{des,out}}{\dot{Ex}_{in}} \tag{6}$$

where $\dot{Ex}_{tot,out}$ and $\dot{Ex}_{in}$ are the total exergy destruction rate and input exergy rate, respectively. θ_{est} is the exergy sustainability factor, f_{es} is the exergy stability index, θ_{eii} is the exergoenvironmental impact improvement, θ_{ei} is the exergoenvironmental impact factor, C_{ei} is the exergoenvironmental impact coefficient, f_{ei} is the exergoenvironmental impact index, and η_{ex} refers to the overall exergy efficiency.

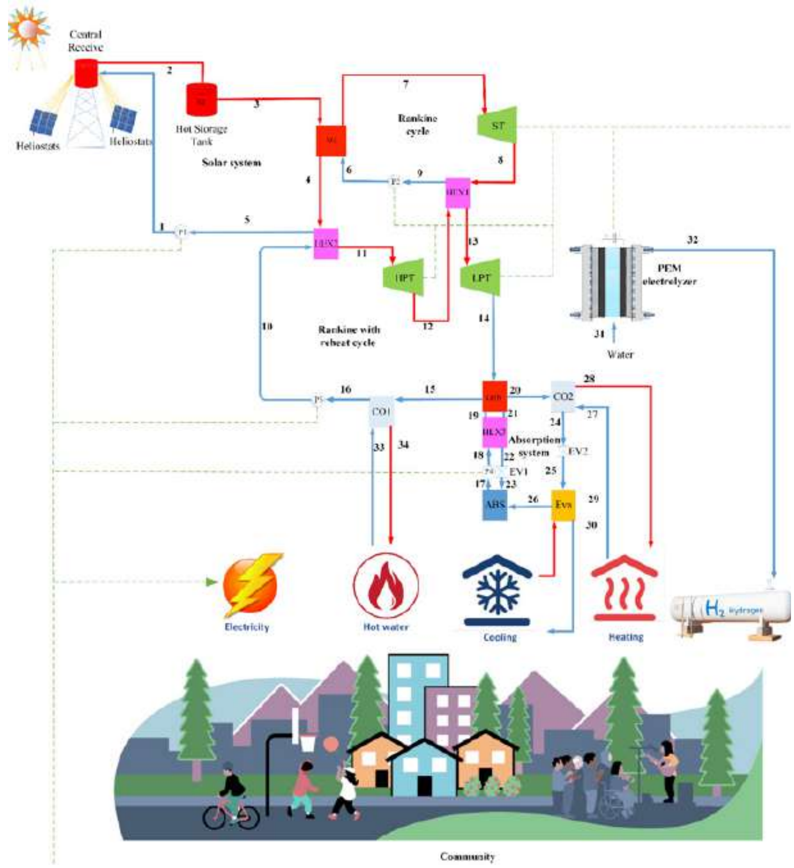

Fig.1: Developed multigeneration system

3. Results and Discussions

The effect of ambient temperature on the energy and exergy efficiencies of the steam Rankine cycle (SRC) is demonstrated in Fig. 2. As can be seen, the ambient temperature has no effect on the energy efficiency of the SRC since thermal losses have not been taken into account. However, increasing the ambient temperature results in a decrease in the exergy efficiency of the steam generator and consequently an increase in the exergy efficiency of the SRC.

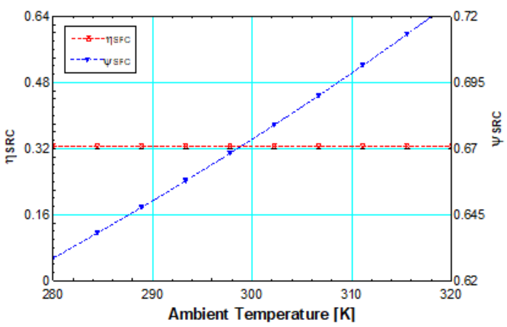

Fig. 2: Effect of ambient temperature on the energy and exergy efficiencies of the SRC

4. Conclusions

This article proposes a new multigeneration system that integrates various subsystems to provide sustainable and environmentally friendly energy production. The energy and exergy efficiencies of the steam Rankine cycle has found to be 32.47 and 66.91 % respectively. Energy efficiency analysis showed that the proposed system is efficient for example. The exergy efficiency analysis also demonstrated that the system has high efficiency in converting energy into useful work. These results indicate that the proposed multigeneration system has the potential to significantly reduce energy waste and promote sustainable energy production.

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MINIMIZATION OF GREENHOUSE GAS EMISSIONS FROM GROUNDWATER TREATMENT USING BIOCHAR DERIVED BY SOLAR PYROLYSIS IN COMPLIANCE WITH EU GREEN DEAL

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ABSTRACT
According to the European Union (EU) Green Deal, the treatment of water resources is in the "Tertiary" category, and it is aimed to reduce greenhouse gas emissions by 30% in the long term. In addition, according to the 6th Assessment report published by the International Panel on Climate Change (IPCC), the treatment of water resources is seen as an important source of greenhouse gas emissions. In the light of this information, when the literature is examined, it is seen that there is a limited perspective on the reduction of greenhouse gas emissions from groundwater treatment, and there is a technical gap especially regarding removal methods. As an innovative technique, biochar adsorption could be foreseen as one of the most economical and effective methods that can be applied. In this study, variables were defined, and a hypothesis was formed in order to formulate this research question, which we could not find an answer to in the literature. In this study, it is aimed to minimize greenhouse gas emissions using biochar application to reduce greenhouse gas emissions arising from groundwater treatment within the scope of compliance with the Green Deal. This study presents an overview to show the potential of biochar application on the reduction of GHG emissions. This study has recommended to minimize nitrous oxide (N2O) and carbon dioxide (CO2) emissions from groundwater treatment by producing biochar from carob (Ceratonia siliqua) seeds, pomegranate (Punica Granatum) peel and Turkish Coffee (Coffea Turkish) residue by solar pyrolysis method.
Keywords: Biochar, CO2, N2O, groundwater treatment, minimization.

1. INTRODUCTION
The Green Deal is the new growth strategy of the European Union (EU) that includes the main goals of zeroing net greenhouse gas emissions by 2050 and ending the dependence of economic growth on resource use (EU 2019). With the European Green Deal, a strategy has been proposed that foresees zero greenhouse gas (GHG) emissions of the EU by 2050 (EU 2021). According to EU Green Deal, 55% of reduction should be obtained on over all the GHG emissions until 2030 (EU 2021). Within the scope of the Green Deal, the EU envisages reducing the greenhouse gas emission value from water sector by 30% until 2030 (EU 2021). According to the European Union (EU) Green Deal, the treatment of water resources is in the "Tertiary" category (EU 2021). In terms of groundwater formation and content, it is considered as one of these sources with the potential to emit greenhouse gases in water resources, especially due to physicochemical and biochemical processes. In terms of aquifer structure, it is seen as one of the sources with the potential to emit greenhouse gases in water resources, especially due to physicochemical and biochemical processes. On the other hand, studies in the literature are focused on wastewater treatment. There are limited number of studies on groundwater treatment. Especially the use of nitrogen-containing fertilizers for agricultural purposes may cause nitrous oxide (N2O) formation in groundwater due to the infiltration of these fertilizers from the soil. N2O is a potent greenhouse gas (IPCC 2022) with a global warming potential of 273 times greater than carbon dioxide (CO2) over a 100-year time scale and is one of the primary anthropogenic greenhouse gases that damage the ozone layer. Agricultural activities are seen as one of the largest contributors to the global anthropogenic NO budget. The main anthropogenic source contributing to the formation of N2O in aquifers is agriculture, as the use of fertilizers has led to groundwater pollution by inorganic nitrogen (N) (mainly nitrate (NO3−)). After entering the aquifer, inorganic N is transported and affected by various geochemical processes that produce and consume N2O. The accumulation of N2O in groundwater is mainly due to denitrification and to a lesser extent nitrification. Its formation also depends on geochemical parameters (NO3−, dissolved oxygen, ammonium and dissolved organic carbon) as well as hydrogeological parameters (groundwater table fluctuations and aquifer permeability) (Jiang vd., 2020).

Groundwater contains carbon dioxide (CO2) due to its geogenic structure and water-rock interactions (Gibert et al., 2019; Alreshedi et al., 2022). Carbonic acid is formed due to the dissolution of CO2 in water, which turns into bicarbonate (HCO3-) and this is a two-way reaction. When groundwater is exposed to the atmosphere, CO2 is released into the atmosphere and calcite (CaCO3) precipitates. For this reason, it is predicted that CO2 emissions may occur due to the treatment of groundwater. Due to the carbon sequestration capacity of the biochar, it can adsorb CO2 emissions (Qambrani et al., 2017). Studies are generally aimed at the removal of CO2 emissions originating from the soil with biochar.

It is foreseen in this direction that the CO_2 emission arising from the treatment of groundwater will be captured by the biochar. It is estimated that the biochar will greatly affect the carbon dynamics in the groundwater and store the carbon in its body. Biochar has attracted great attention in recent years due to its important role in solving many environmental problems (Qambrani et al., 2017). It is less expensive than other treatment methods and can immediately adsorb greenhouse gas emissions from the soil. It is anticipated that this will also apply to groundwater treatment. In the literature, there are studies on the capture of N_2O and CO_2 emissions from agricultural sources with biochar (Qambrani et al., 2017).

Biochar is described as a black carbon produced using thermal or hydrothermal conversion of biomass for environmental remedies (Yapıcıoğlu and Yeşilnacar 2023). Recently, many researchers have focused on the application of adsorbents such as biomass energy sources (Yapıcıoğlu and Yeşilnacar 2022). Biochar is a good adsorber of CO_2 in the soil. Also, it could immediately adsorb ammonia in the soil (Yapıcıoğlu and Yeşilnacar 2023). The mechanism of biochar to remove N_2O is as follows: Denitrification is an important mechanism to reduce nitrate (NO_3^-) in groundwater. The biochar is thought to act as an electron shuttle to reduce N_2O. Biochar is a persistent compound that can remain in soil and water for many years. Biochar quickly absorbs ammonia from the soil and acts as a buffer, thus indirectly reducing ammonia evaporation (Qambrani et al., 2017). This mechanism can also work for the aquatic environment. In addition, biochar is an effective adsorber of dissolved ammonium and nitrate that cause N_2O emission to the atmosphere (Qambrani et al., 2017; Yapıcıoğlu and Yeşilnacar, 2022). Therefore, biochar application can be applied as a possible method for N_2O reduction in water. Groundwater is considered as one of the most important sources of indirect greenhouse gas emissions according to the IPCC (2022) report (IPCC, 2022). Methodologies on this subject are inadequate and open to development. In this study proposal, research will be conducted on whether the greenhouse gas emission from groundwater treatment can be eliminated with biochar. This study aimed to recommend a new and innovative methodology which is biochar application to reduce GHG emissions originated from groundwater treatment in terms of the minimization aim of EU Green Deal.

2. MATERIAL AND METHODS

On this research question, a literature review was made using ISI Web of Knowledge, Web of Science (WOS) and Google Scholar databases covering the last ten years and an evaluation matrix was created. The compilation was filtered towards the research question and the matrix was colored according to its proximity to the project proposal and the number of citations it received (green: high, yellow: medium, orange: low). The literature review matrix (LDM) was created by considering the green studies. In this study, the literature review and recommendation on this research question has been given in details. The conceptual model and graphical abstract of this recommended study is given in Figure 1.

Fig.1. Conceptual Model of The Recommended Research

The research area is Harran Plain located at southeastern of Turkey which is very rich in terms of groundwater resources potential. Groundwater samples are planned to be sampled from Bolatlar, Yaygılı and Uğraklı wells located in the Harran Plain twice, before and after irrigation, at the beginning of each month and at the end of the month. Solar pyrolysis method, which is an example of original and renewable energy, will be used for biochar production. In this study proposal, biochar will be produced from carob (Ceratonia Siliqua) seeds, pomegranate (Punica Granatum) peels and Turkish Coffee (Coffea Turkish) residues by solar pyrolysis method. The reason for choosing three different biomass is that Turkish coffee is mineral, pomegranate peel is cellulosic, and carob seed is ligninous. Greenhouse gas sequestration rates will be evaluated comparatively.

The minimization ratio will be determined according to the treatment of the existing groundwater with the existing biological denitrification process. At the first stage, by using a biological denitrification column reactor, N2O and CO2 emissions from groundwater treatment will be measured and calculated with the newly developed model, then the same process will be performed with biochar adsorption and the minimization amount will be calculated by comparatively evaluation.

At the first stage, N2O emission resulting from the treatment of groundwater will be sampled using a biological denitrification reactor and gas sampling with the Radiello sampling kit. Gas concentration will be found with the help of the model developed by the Radiello gas sampling method (Radiello, 2022). Gas samples will be taken from the top points of the reactors for both systems. CO2 emissions will be calculated using a similar calculation method. The gas sample for CO2 will be taken using the Testo CO2 probe and the concentration will be determined with Testo 440 CO2 analyzer. The global warming potentials (GWP) of CO2 and N2O is 1 and 273, respectively (IPCC, 2022). Each sample will be passed through the adsorption column and denitrification reactor and will be treated simultaneously, and gas samples will be taken after each treatment. The greenhouse gas emission value will be calculated with the help of the model developed in this study proposal based on the IPCC method (1):

$$GHG = C \times GWP \times 1000000 \quad (1)$$

GHG: GHG emission (kg CO2e/d)
C: Gas concentration (mg/m^3)
GWP: Global Warming Potential

3. RESULTS AND DISCUSSION

When the literature is examined, it is seen that the methods to be applied to reduce greenhouse gas emissions from groundwater treatment are limited, with the focus on wastewater treatment within the scope of reducing greenhouse gas emissions from water management (Liu et al., 2017; Jiang et al., 2020). In addition, it has been observed that limited studies on groundwater are generally aimed at determining emissions. On the other hand, it is possible to reduce greenhouse gas emissions from groundwater treatment only by adding different cultures to mixotrophic and microbial denitrification (Liu et al., 2017; Jiang et al., 2020). It is envisaged that this study proposal will fill the gap in this regard. The question of whether the greenhouse gas emission from groundwater treatment, which has no answer in the literature, can be reduced by the application of biochar constitutes the research question of this study proposal. Studies show that it is possible to reduce greenhouse gas emissions from wastewater treatment with biochar (Sun et al., 2018; Zhou et al., 2018; Bock et al., 2018; Guo et al., 2020; Liang et al., 2020; Feng et al., 2020). In the literature review made in WOS and Google Scholar databases, no study was found on the removal of greenhouse gas emissions caused by the biochar adsorption process and groundwater treatment.

Calculation of CO2 emissions from groundwater treatment has generally been associated with emissions from energy consumption using different methodologies (Life cycle assessment, SAM model, etc.) in the literature. Studies on determining CO2 emissions from groundwater treatment are limited (Gilbert et al., (2019); Kyung et al., 2013; Buchary et al., 2020a, 2020b; Senante and Guzman 2018; Biswas and Yek 2016; Alresheedi et al., 2022; Simms et al., 2017). In the reduction of greenhouse gas emissions from groundwater treatment, high amount of N2O accumulation has been observed in some studies in the mixotrophic denitrification method (Liu et al., 2017). In order to control it, a mathematical model was developed, and system optimization was attempted (Liu et al., 2017). Liu et al. (2017) reported that N2O emission value, which is 3% (Emission/Nitrogen load), has been reduced to 1% with system optimization. The other study, N2O accumulation was high because of the microbial denitrification process and different culture experiments were attempted (Jiang et al., 2020). Jiang et al. (2020) reported that there is a reduction in N2O emission at the rate of 8.87 μm/mM-TN. with the addition of Shewanella oneidensis MR-1. This method is both difficult to operate and not an economical method. Biological processes are applications that are difficult to operate and control, and costly. In this study proposal, groundwater will be treated with three biochar types to be produced by solar pyrolysis method, relative to the biological denitrification process, and the measurement of greenhouse gas emissions will be tested, as well as the adsorption of greenhouse gas emissions with this three different biochar. Another study related to Capodici et al. (2018) in this topic. N2O emission from groundwater treatment and denitrification efficiency were correlated in their study. Gibert et al. (2019) has determined of CO2, CH4 and N2O emissions from groundwater treatment with PRB denitrification biological reactor.

4. CONCLUSIONS

Previous studies have generally focused on the determination of greenhouse gas emissions from groundwater treatment. The limited number of studies carried out are for N2O reduction and suggest a known method (Liu et al., 2017; Jiang et al., 2020). This study proposal will be a study in which biochar adsorption, which is an economical method, will reduce N2O and CO2 emissions together. There is no study has been found before, in which the biochar adsorption process has been evaluated as an alternative for minimizing greenhouse gas emissions from groundwater treatment. In addition, studies have focused on the reduction of N2O emissions from groundwater treatment. No recommendation has been found for the reduction of CO2 emissions.

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MACHINE LEARNING-BASED CLASSIFICATION APPROACH FOR IMPROVING RENEWABLE ENERGY MANAGEMENT IN IoT-BASED SMART GRIDS

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ABSTRACT
Nowadays, renewable energy management is an emerging topic within the global warming context. On the other hand, the Internet of Things (IoT) plays an important role in information transmission for the development and efficient management of energy dissipation, renewable energy and smart grids. Evolution of intelligent systems has incorporated optimal solutions like supervised, semi-supervised and un-supervised algorithms. Reducing energy consumption in a stable smart grid system is a key challenge for identifying the stability of renewable energy sources. This study aims to assess and present significant benefits of Ensemble Bagging Trees (EBT) prediction model and Analysis of Variance (ANOVA) feature selection strategy to improve stability and accuracy of existing technical features of renewable energy management in smart grid stability.
Keywords. Smart grids, renewable energy management, machine learning, feature selection, accuracy.

1. INTRODUCTION
The Internet of Things (IoT) provides key aspects of energy management deployment in smart girds based on data transmission with 5G communication technology, intelligent sensors and smart devices. There are several technical challenges in this regard which include lack of policies, storage concerns, security issues in power communication networks. Also, connecting the smart grid and IoT devices is essential to establish the storage of intermittent power generation, saving energy consumption, and power reservation (Altintas & Utlu, 2021). There are two different prediction approaches for evaluating renewable energy management in power generation systems and smart grids. First approach provides machine learning algorithms to detect energy consumption factors like power electricity from power generation stations to end users. In this approach, existing prediction models are applied to enhance accuracy of prediction for renewable energy management factors such as energy consumption and cost. On the other hand, the second prediction approach provides a combined evaluation model to predict frequency and voltage stability based on the smart grid stability (Ucar, 2023). Balancing between cost, voltage stability in generation centers and energy consumption from end user side is a problem for renewable energy management in smart grid stability. For the end user side, prediction of energy management factors and behavior price provisioning is an important challenge that machine learning algorithms can detect and help in overcoming through developing appropriate solutions for this problem (Mirshafiee et al., 2023).
Some recent review papers, like Rangel-Martinez et al. (2021) and Zhang et al. (2018), have categorized renewable energy management strategies according to existing aspects of prediction approaches such as machine learning and deep learning methods in power communication systems (Xu et al., 2022). Recently, Suryadevara et al. (2021) provided an efficient machine learning algorithm that works as a classifier to reduce energy levels by using sensors in an IoT application. Moreover, Yang et al. (2019) presented a fault prediction-based renewable energy generation model based on Convolutional Neural Networks (CNN) to evaluate the type of each existing unexpected fault in the power generation systems. The proposed CNN algorithm is composed of an image layer, several convolutional layers, pooling layers and fully connected layers. At the level of data or applied samples in a dataset, Chen et al. (2019) presented a data segmentation-based ensemble method for energy management approach in smart grid stability. The authors also provided a data sampling approach at the data segmentation level as a major benefit of this approach Based on the above-mentioned literature reviews, feature selection method can be useful to decrease error factor and increase accuracy of energy efficiency prediction based on training and test results in smart grid stability. This research provides a new feature selection strategy for smart grid stability factors to enhance prediction performance based on machine learning methods from smart grid stability environments. Main anticipated contributions of this new methodology are as follows:

•Performing a technical preprocessing method for data cleaning and normalization of information in the smart grid stability dataset.
•Presenting a machine learning-based prediction model and feature selection method to evaluate the stability of the smart grid systems.
•Comparative analysis of the performance of machine learning algorithms implemented on smart grids dataset.

The organization of this paper is shown as follows: In Section 2, a new prediction model with feature selection method for renewable management in smart grids approach is presented. Section 3 shows main simulation results, comparison analysis and discussion on existing data set. Finally, Section 4 shows conclusions and anticipated future work in this area.

2. RESEARCH METHODOLOGY

In smart grids, electricity price is an important factor for the stability of the power communication systems. Sensitivity factor on electricity price and response times for power transmission to end-user is also known as a stability factor. For this reason, there is no foolproof hybrid system to check all power generation factors of smart grid stability in IoT systems. In this research, Analysis of Variation (ANOVA)-based feature selection method is applied for enhancing efficient renewable energy management factors. Then, an Ensemble Bagging Trees (EBT) algorithm as a machine learning-based prediction model is presented to evaluate the renewable energy management in the smart grid stability. Electricity grid datasets from different power generating units are aggregated. First, data gathering is applied to collect existing information from smart metering devices, electric repositories, power stations and power generation systems. Second, data is normalized through data cleaning and removing existing errors and noise. Third, the ANOVA-based feature selection approach is provided to select best and effective attributes related to renewable energy management to realize best performance for renewable energy data prediction in smart grid stability. In addition, the normalized dataset will be updated into a featured attributes that can be provided for prediction approach. In prediction approach, the EBT algorithm is applied on the data with a parallel data sampling and bootstrap aggregation method where all existing classifiers receive training data as a parallel session. The training phase is run for 80% of the data and testing phase is applied for other 20% of data. Final prediction results as “Stable” or “Unstable” are published by system predictor and send to cloud data repository.

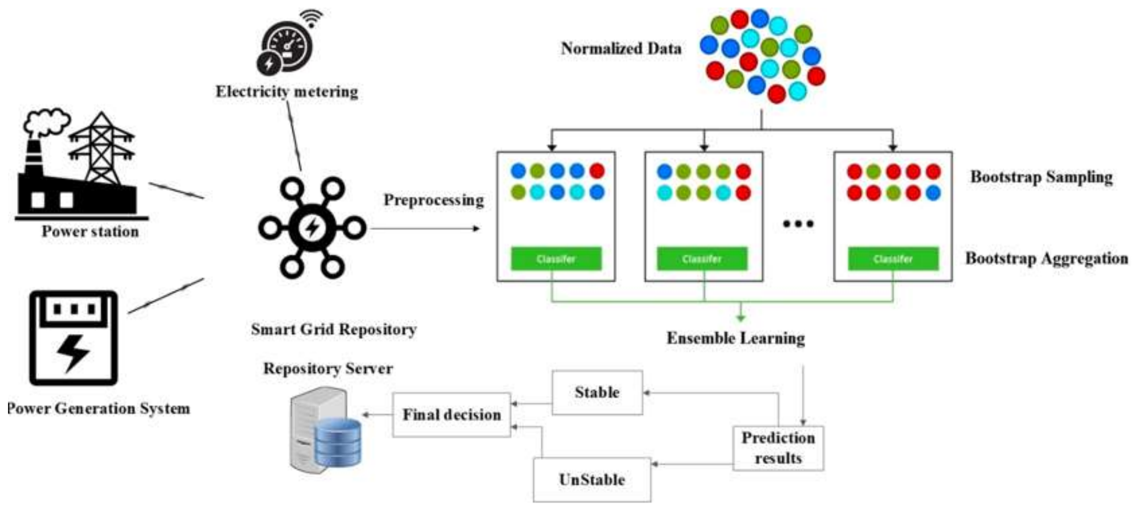

Fig. 1. The proposed prediction-based smart grid stability model.

3. EXPERIMENTAL RESULTS

The dataset used for the evaluation and experimental results comes from the UCI machine learning repository for smart grid stability (Arzamasov et al., 2018). The dataset has 60000 specific instances featuring 14 technical attributes (Schäfer et al., 2016). Existing technical and real-time attributes in the smart grid stability dataset include information related to electricity power generation values, nominal power consumed value, energy produced value, coefficient factor related to price elasticity, maximum and minimum values of the equation root, and final status of smart grid system as stable and unstable modes.

After finalizing feature selection strategy based on ANOVA method, the following important prediction method are defined to evaluate and compare performance of the proposed Ensemble Bagging Trees (EBT) algorithm in smart grid stability.

Accuracy presents the main predictable value for stability factor in Equation (1): Accuracy = $\frac{TP+TN}{TP+TN+FP+FN}$ (1)

Precision shows main value of statistical stability as given in Equation (2): Precision = $\frac{TP}{TP+FP}$ (2)

Recall refers to the quantity of positive result on stability status in Eq. (3): Recall = $\frac{TP}{TP+FN}$ (3)

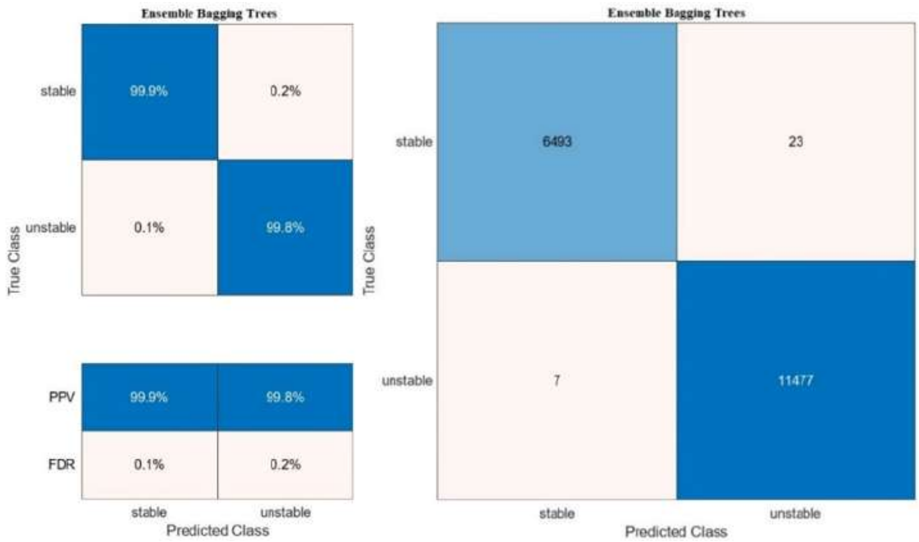

Fig. 3. The confusion matrix for ANOVA-based EBT algorithm in smart grid stability

Then the overall performance metrics of the suggested hybrid machine learning-based prediction model for smart grid stability is compared with other machine learning algorithms. As shown in Table 1, accuracy of the proposed models are as follows: ANOVA-Artificial Neural Networks (ANN) model 99.8%, ANOVA-Support Vector Machine (SVM) algorithm 99.8 %, ANOVA-Naive Bayes (NB) algorithm 97.6%, ANOVA + K-Nearest Neighbors (KNN) algorithm 97.6%, proposed KNN (Hosseinzadeh et al., 2019) model 92.4 %, linear regression 87%, and AdaBoost algorithm 63%. Accuracy of the proposed ANOVA-EBT model, found to be 99.7%, is greater than that of all other machine learning algorithms. Furthermore, recall of the proposed ANOVA-EBT model, found to 99.5%, is higher than that of all other machine learning algorithms.

Table 1. Comparison of prediction factors with existing machine learning algorithms

Technical method	Training Accuracy (%)	Testing Accuracy (%)	Precision (%)	Recall (%)
AdaBoost	63	63.3	60	59.5
Linear Regression	87	88	86	86
KNN	92.4	92	90	90
ANOVA + KNN	94.8	94.2	92.5	90
ANOVA + NB	97.6	85	96	96
ANOVA + SVM	99.8	96.2	96	96
ANOVA+ANN	99.8	99.8	97.8	98
ANOVA + EBT	**99.99**	**99.99**	**99.7**	**99.5**

4. CONCLUSION

This research offered a new machine learning based renewable energy management model for intelligent power devices in smart grids. First, power devices connect together on the IoT environment. Then, a significant number of data transmission factors are provided to collect the efficacy of the energy management factors, power consumption and end-user activities in smart grid systems. By applying the ANOVA feature selection method, the proposed model selects efficient attributes related to renewable energy management. Then, an ensemble bagging trees algorithm is applied to enhance quality of the prediction for smart grid stability. Experimental results proved the high accuracy and performance of the EBT algorithm used for better prediction of smart grid stability. The main performance factors are 99.99% for training accuracy, 99.99% for testing accuracy, 99.7 for precision and 99.5% for recall factor in evaluation of the proposed EBT algorithm with ANOVA feature selection approach. In future work, some other hybrid meta-heuristic algorithms can be applied for enhancing total number of features and optimization of accuracy factor for energy consumption in smart grid stability.

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THECHNICAL ASSESSMET OF CHP SYSTEM INTEGRATED WITH CARBON CAPTURE AND UTILIZATION TECHNOLOGY

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ABSTRACT
With the release of global carbon emission policy, saving energy consumption and reducing CO2 emissions has become essential to sustainable development. Transition from fossil fuels to renewable energy sources facilitates the development of the energy systems. One of the great sources that allows energy to be extracted in various ways is Municipal Solid Waste (MSW). On the other hand, MSW is one of the environmental pollution problems that can be solved through technologies that produce energy from that. Various technologies utilize for converting biomass into useful energy. In this study, two technologies, namely gasification and anaerobic digestion, were investigated using MSW as a feedstock. In both technologies, the applicability of coupled carbon capture and utilization technology (CCU) to the plant was considered and the captured CO2 was utilized in a greenhouse to increase its production rate.
This work evaluates the physical and chemical properties of Tehran's MSW and studies the simultaneous production of electricity and heat (CHP) performance with the specific input of 10 tons of MSW per day as fuel.
The results showed that the electrical power production rate of syngas-based CHP system biogas-based CHP system are 85 kW and 106.3 kW, respectively, and biogas-based system is more environmentally friendly because of its low CO2 emission rate (0.031 kgCO2/h).

Keywords: Combined Heat and Power, CO2 capture and utilization, Energy and Exergy Investigation.

1. INTRODUCTION
The energy production sector is responsible for 70% of greenhouse gas emissions, as reported by the International Energy Agency (IEA outlook 2019). To combat climate change, this sector must lead the way in reducing global warming and carbon intensity while meeting the increasing demand for energy. The Paris Agreement calls for immediate action to limit global warming to less than 2°C and achieve zero net greenhouse gas emissions by the second half of the 21st century (Carnevale et al. 2019). The IEA Renewable Energy Report of 2020 indicates that the renewable energy sector has received three times more investment than coal, natural gas, and nuclear energy combined (Collins et al. 2019). Bioenergy, with modern technologies, contributes 5.1% to the world's total final energy, half of which comes from renewable energy sources (Akrami et al. 2023). Technological change in energy systems, particularly the rapid adoption of low-carbon technologies, is a strategy recommended by the International Energy Agency (IEA) to achieve a low-carbon environment (Gustafsson et al. 2021).

A review by Heiker et al. examined various approaches for modeling biogas production systems and their use in biogas plants. Bottom-up and top-down modeling approaches were used to study energy efficiency, techno-economic performance, and greenhouse gas emissions in large-scale biogas-based energy plants (Heiker et al. 2021). Zhang et al. proposed anaerobic digestion of food waste to produce biogas for a CHP system (Zhang et al. 2021). Holik et al. conducted techno-economic assessments and optimization procedures for a CHP integrated with a biogas-based cogeneration system (Holik et al. 2021). Akkouche et al. utilized a small-scale dual fuel engine in a micro-combined heat and power system (Akkouche et al. 2021). Sund studied a Stirling engine coupled with a gas preheater to use biogas as the primary fuel (Sund et al. 2020). Zang et al. simulated biomass gasification combined cycles and conducted a sensitivity analysis to evaluate adding a CO2 removal section (Zang et al. 2018). Based on the literature survey, CO2 removal is necessary to reduce CO2 emissions. Various technologies, such as absorption, chemical looping, membrane, cryogenic, and adsorption, can be used to capture CO2 from exhaust gases.Peltola et al. proposed the integration of chemical looping combustion with oxygen uncoupling in a biomass-fired CHP system to achieve net-negative emissions, electricity, and district heating (Peltola et al. 2020). Shahbaz et al. considered the Bio-Energy Carbon Capture and Storage/Utilization framework for the storage and utilization of captured CO2 from biomass-based energy systems. They reported that pyrolysis technologies are ready to be commercially deployed and that BECCS technologies are suitable for large-scale energy systems or medium-scale CHP systems (Shahbaz et al 2021).

In another study, Orregioni et al. evaluated a CHP system that utilized a fluidized bed gasifier and implemented two different CO2 capturing processes to minimize environmental impact. The study compared the energy penalties of each process and found that the CHP plant integrated with the Pressure Vacuum Swing Adsorption (PVSA) unit was able to achieve 1.7% higher net electrical output compared to the CHP plant integrated with the amine process (Orregioni et al. 2015). Other researchers, such as (Beiron et al. 2022) and authors, also explored various CO2 capture methods for bio-based energy production systems, such as MEA and HPC. Beiron et al. found that the heat-driven MEA process reduced district heating up to 30% but increased the import of electricity up to 44% compared to a reference scenario. Despite the benefits of bio-based energy production systems coupled with CCS/U technologies in achieving low-carbon energy goals, there are significant drawbacks such as high CO2 storage costs. Therefore, integrating a combined heat and power plant with CCS/U technologies can be a valuable alternative to produce low-emission heat and power simultaneously. To achieve the best system configuration, two integration scenarios have been evaluated for power and heat production. The first scenario involves using biogas produced through anaerobic digestion to utilize in engine-based CHP system. The other scenario utilizes gasification to produce syngas, which is combusted combustion chamber.

This research work provides the following specific contributions:

•Establishing the concept of low-carbon heat and power production and exploring two different scenarios for biomass conversion based on biogas and syngas production. The simulations of these systems were conducted using ASPEN HYSYS.

•The first scenario involves combining a biogas production unit, a CHP (Combined Heat and Power) unit that utilizes an internal combustion engine, and an MEA (Monoethanolamine) CO2 capturing unit. The second scenario involves integrating a downdraft gasification unit for syngas production, the other parts are similar to the first scenario.

•Technical and comparative analyses were carried out under identical operating conditions.

2. MATERIAL AND METHODS

The proposed system functions as a combined heat and power (CHP) plant that generates power and hot water, as illustrated in Fig. 1. The system is comprised of three primary sections: 1) power and hot water production based on biogas or syngas, 2) MEA-based post-combustion CO2 capture, and 3) greenhouse units.The biogas/syngas energy conversion unit consists of a set of biomass digesters or downdraft gasification. In this unit, combustible gas and air are combusted, and the resulting high-temperature flue gas produces electrical power. The turbine off-gas still contains a significant amount of available energy, which can be recovered using heat exchangers to provide hot water for heating applications and generate steam for the stripper boiler in the CO2 capture section. Also, based on Fig. 1, the CO2 separation unit is situated downstream of the CHP system, and it consists of a direct-contact cooler that reduces the temperature of the exhaust stream. The cooled exhaust gas then flows into the absorber, where it comes into contact with a falling stream of lean solvent. The flue gas, which contains low levels of CO2, is cleaned in a water washing stage before being released into the atmosphere. Meanwhile, the CO2-rich solvent at the bottom of the absorber is sent to the stripper unit to generate pure CO2, which is then directed to the greenhouse units for enhanced plant growth. Additionally, a heat exchanger is employed to warm up the low-CO2 solution to enhance CO2 release, while the lean solvent is recirculated back to the absorber.
This investigation employs Aspen HYSYS software to simulate the proposed system. To create the system simulation model, the following simplifications and assumptions were made:

•Steady-state conditions are maintained in the system.
•The potential and kinetic energy of the fluid are negligible.
•Heat loss and pressure drop during the cycle are disregarded.
•All fluid temperatures are considered as overall or average temperature at that location.
•Gas mixtures are in chemical equilibrium at all points.
•Air composition is N2 (77.48%), O2 (20.59%), CO2 (0.03%), and H2O (1.9%).
•The ambient conditions are 101.3 kPa and 25°C.
•The proposed system's energy efficiency is calculated by considering each component as a control volume with an inlet and outlet, and utilizing the following equations to maintain mass and energy balance:

$$\sum \dot{m}_i = \sum \dot{m}_e \quad (1)$$

$$\sum \dot{m}_i h_i + \dot{Q} = \sum \dot{m}_e h_e + \dot{W} \quad (2)$$

The subscripts "in" and "out" indicate the inlet and outlet streams of the component, respectively. The energy efficiency of the system for both scenarios are described as:

where W(net,CHP)represents the net power output of CHP unit, W(CO2,capturing) is the energy penalty of the CO2 capturing unit, Q_heating is the recovered heat from the CHP's exhaust unit, and LHV_biomass is the lower heating value of the biomass.

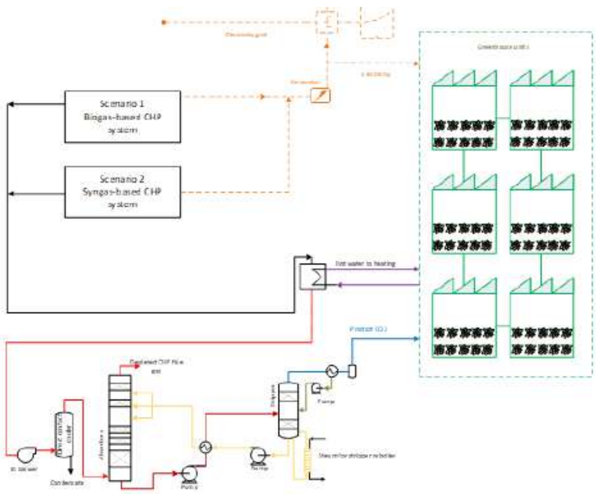

Fig. 1. The layout of the proposed energy system for two scenario configurations.

3. RESULTS AND DISCUSSION

Table 1 provides a detailed analysis of the performance of the systems, both scenarios in terms of thermodynamics and environmental impact. The results indicate that incorporating a CO2 capture section in the proposed systems leads to a 62.4% and 70.9% reduction in CO2 emissions, respectively for biogas-based and syngas-based system, but imposes a 15.52% and 21.32% power penalty. To enhance the photosynthesis process in the greenhouses, CO2 utilization methods can be employed. Adding 0.50-0.60 kg of CO2/hr./100m2 can maintain the desired CO2 level of 1300 ppm, regardless of solar radiation levels. The captured CO2 flow from the scenarios can cover approximately 3250 and 4851 square meters of greenhouses with a proper distribution system. However, the addition of the CO2 capture section also decreases the overall energy efficiency by 000% and 000%, respectively, and utilizes a significant portion of the heating capacity in the stripper reboiler section of CO2 capturing.

Table 1
Provided comparison data from thermodynamic performance point of view

	Net power production [kW]	$\dot{Q}_{heating}$ [kW]	CO_2 emissions [ton/yr.]	Specific CO_2 emissions [kg_{CO_2}/kWh]	CO_2 capture efficiency [%]	Overall energy efficiency [%]
Proposed system with biogas-based CHP system	106.3	128	270	37.96	62.4%	81.5
Proposed system with syngas-based CHP system	85	113	403	47.41	70.9	85.6

4. CONCLUSIONS

The objective of this study is to design and simulate a combined heat and power (CHP) system that uses biomass as its primary fuel source, and incorporates a post-combustion CO2 capturing unit to produce low-carbon heat and power. The system's thermodynamic performance is evaluated. The simulation results are presented for the integrated system units, with key results including an overall energy efficiency of 81.5% and 85.9%, a net power production of 106.3 and 85 kW, and a CO2 emission rate of 37.96 and 47.41 kgCO2/kWh, respectively for biogas based and syngas-based CHP system. The study's findings provide valuable insights into the relationship between energy and environment and support the development of better energy policies by utilizing renewable energies at various system scales.

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LIFE CYCLE ASSESSMENT OF DIFFERENT ENERGY SOURCES FOR MUNICIPAL GASIFICATION SYSTEM

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ABSTRACT
The transition to low-carbon economy has accelerated the need for alternative energy sources and hydrogen production emerging as a promising option. Due to its potential for large-scale hydrogen production, gasification process has gained attention. Moreover, life cycle assessment has emerged as an significant tool for evaluation of environmental impact of product, services and systems. In this study, life cycle assessment of different energy sources based integrated municipal gasification system is performed. The proposed integrated municipal gasification system produces electricity, hydrogen, and provides heat to community. Life cycle assessment of concentrated solar based gasification, wood chips-based gasification and coal-based gasification are performed and compared by using the SimaPro software package. Furthermore, for the analysis, ReCiPe 2016 Midpoint (H) method is used. The life cycle assessment is performed in six categories: global warming potential, stratospheric ozone depletion, ozone formation-human health, terrestrial acidification, land use and water consumption. The highest global warming potential observed in coal-based gasification while the least global warming potential is observed in solar based gasification.
Keywords: Global warming potential, Sustainability, Gasification, Renewable, Solar, Energy

INTRODUCTION
As a consequence of rapidly increasing CO2 emissions, high CO2 concentrations of 414 ppm have a significant impact on global warming and climate change. In 1950, total CO2 emissions were 6 billion tons and they reached 22 billion in 1990. However, currently, CO2 emissions are greater than 34 billion tons per year [1]. That increase in CO2 emissions accelerated the necessity of renewable energy sources and hydrogen is one of the promising options. Gasification process has a potential for large-scale hydrogen production. Gasification is kind of indirect combustion. During the gasification process, syngas is produced from solid waste via gas foaming reactions with less oxygen concentration than stoichiometric combustion. Life cycle assessment is a systematic methodology used to evaluate the environmental impacts of a product, process or service. In this study, life cycle assessment of different energy sources based integrated municipal gasification system is performed. Life cycle assessment of concentrated solar based gasification, wood chips-based gasification and coal-based gasification are performed and compared by using the Sima Pro software package. Global warming potential, stratospheric ozone depletion, ozone formation-human health, terrestrial acidification, land use and water consumption of the processes are analyzed and compared. A life cycle assessment of this system is performed through ReCiPe 2016 Midpoint (H) method.

SYSTEM DESCRIPTION AND EVALUATION
The proposed system contains a municipal gasification system, water-gas shift reactor, Rankine and Brayton cycles and CO2 capture system. In this system, fluidized bed gasification is used. The operating temperature and pressure of gasifier is determined as 700 °C and 2750 kPa. Required heat for gasification system is provided from the steam and combustion chamber. Half of the syngas is transferred to the water-gas shift reactor for hydrogen production. The other half is sent to the combustion chamber and used in Brayton-Rankine combined cycle. The syngas and compressed air are combined and burned in the combustion chamber. The produced exhaust gas is sent to the turbine for generating power. Then exhaust gas is sent to the CO2 capture unit. The Rankine and Brayton cycles are utilized for producing electricity, and the excess heat is utilized to provide heat to the district heating system for a sustainable community. In addition to this, the water-gas shift reactor is used to produce hydrogen. Required energy for the gasification system is supplied in 3 cases: with concentrated solar tower, coal and wood chips.

RESULTS AND DISCUSSION
In this paper, the life cycle assessment studies of concentrated solar based gasification, wood chips-based gasification and coal-based gasification are performed and compared. The highest global warming potential observed in coal-based gasification while the least global warming potential is observed in solar based gasification as shown in Figure 2. In addition to this, as shown in figure 3 below, solar tower has the highest land use area compared to the coal and wood chips based energy systems. For the developed system, electricity generation and amount of heating are calculated 39.1 MW and 4.9 MW respectively. In addition to this, the amount of produced hydrogen is 0.5 kg/s.

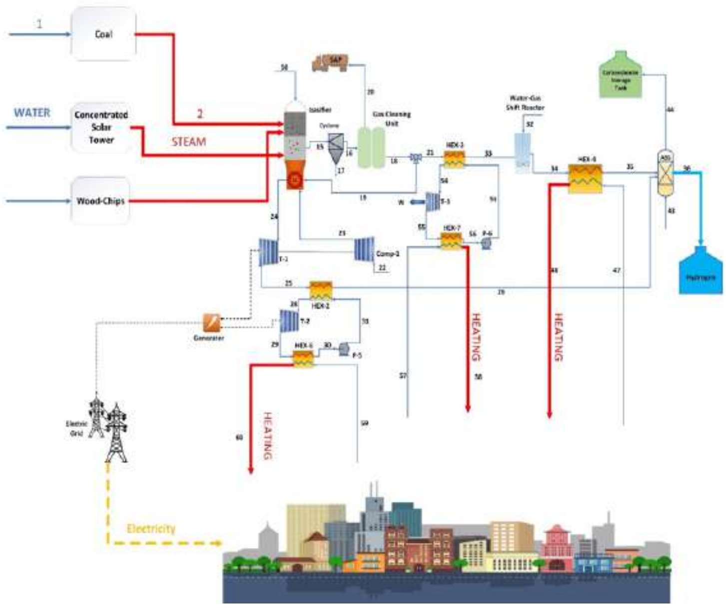

Figure 1: Municipal Gasification System

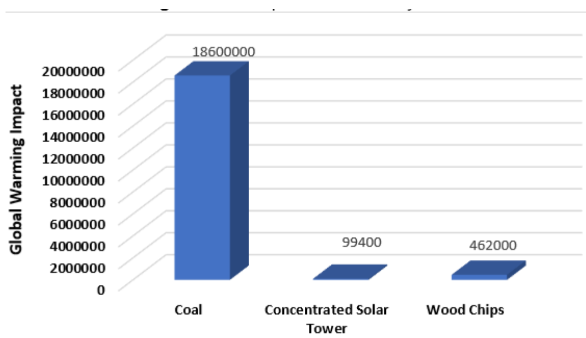

Figure 2: Global Warming Impact of Energy Sources

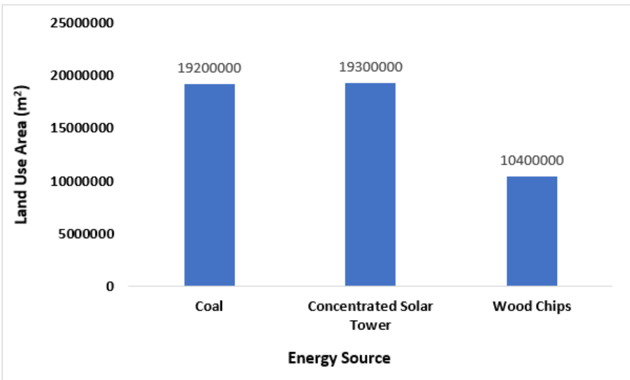

Figure 3: Land Use Area

CONCLUSIONS

In this study, the environmental impacts of concentrated solar based gasification, wood chips-based gasification and coal-based gasification are analyzed through life cycle assessment by using the Sima Pro software package. This study shows that the solar energy-based system is most environment friendly compared to the coal based and wood chips based gasification systems.

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REDUCTION OF ENERGY COSTS FROM GROUNDWATER TREATMENT USING BIOCHAR APPLICATION IN TERMS OF WATER-ENERGY NEXUS: DEVELOPMENT OF ENERGY COST INDICATOR

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ABSTRACT
This study has aimed to mitigate the energy costs using carob (Ceratonia siliqua) seeds, pomegranate (Punica Granatum) peels and Turkish Coffee (Coffea Turkish) residues derived biochar application for groundwater treatment. Indirect greenhouse gas emissions from groundwater treatment have originated from the water-energy nexus. Energy consumption is a constituent of the indirect emissions. In this context, an energy cost indicator (ECI) will be developed applying a new quantitative approximation based on greenhouse gas (GHG) emissions, water quality parameters and energy consumption. Solar pyrolysis method will be applied for biochar production as a renewable energy resource to mitigate the electricity consumption. As an innovative technique, biochar adsorption could be considered as one of the most economical and effective methods that can be applied for groundwater treatment. Energy costs will be correlated with GHG emissions and groundwater quality parameters. Also, the possible impacts of water quality parameters on greenhouse gas emissions will be determined by the analytical hierarchy process (AHP) method. In this study, variables have been defined, and a hypothesis has been developed in order to formulate this research question, which we could not find an answer to in the literature. This study shows an overview and develops a model to present the potential of biochar application on the reduction of energy costs of groundwater treatment.
Keywords: Biochar, GHG emissions, groundwater treatment, ECI, reduction.

1. INTRODUCTION
Water and energy resources are corresponded with a complicated correlation describing as the water-energy nexus (Yapıcıoğlu & Yeşilnacar 2023a, Castellet & Molinos-Senante 2016; Ji et al., 2020). The water cycle contains two main constituents which are drinking water and wastewater collection, treatment, and distribution. Previous studies have presented that several researchers have majorly focused on wastewater treatment as energy issues related to drinking water were less investigated (Molinos-Senante & Guzman 2018). Several researchers have ignored energy consumption of water treatment technologies in terms of water-energy nexus and concentrated on water consumption in the energy plants. Energy consumption is need in large amounts to treat groundwater adequately. Also, huge amounts of energy are needed to treat groundwater for obtaining the drinking water standards. Furthermore, raw water and potable water pumping processes have caused to large amounts of energy consumption.

There are several energy costs mitigation techniques for water treatment. One of these techniques are process modifications and renewable energy. Generally, renewable energy technologies such as solar panels, photovoltaic systems and biomass energy have been used to reduce the energy consumptions and the greenhouse gas emissions at drinking water treatment plants (Bukhary et al. 2020a, 2020b). It could be said that using biomass energy is not only a treatment technique but also is an energy consumption minimization method for water treatment. From this perspective, biochar is one of the types of biomass energy could be applied for this purpose. Furthermore, biomass energy could be an efficient greenhouse gas and electricity consumption mitigation way due to many advantages. These advantages could be considered that biomass energy is cheaper and feasible for application in the water and wastewater treatment plants (Liang et al. 2020, Feng et al. 2020). It is generally carried out since biochar application is known also a water and wastewater treatment technique (Vithanage et al. 2017; Vithanage et al. 2014). Biochar is a porous carbonaceous substance with large specific surface area, and it is generated with the help pyrolysis of biomass in sealed containers, under limited oxygen environment (Qambrani et al. 2017). Biochar is generated by pyrolysis of biomass such as agricultural crops, fertilizers, and solid wastes (Yapıcıoğlu & Yeşilanacar 2022a; Sadhu et al. 2021). In the literature, in water management, biochar has been generally used for wastewater treatment. In recent years, many researchers have focused on the use of adsorbents such as biomass energy sources for groundwater treatment (Yapıcıoğlu and Yeşilnacar 2023b). Biochar is one of the biomass energy sources. It could adsorb the contaminants from water immediately and uses less energy to carry out the treatment (Zhang et al. 2022). So, biochar could be an alternative treatment technique instead of conventional treatment systems because of several advantages.

2. MATERIAL AND METHODS

The study area is Bolatlar, Yaygılı and Uğraklı wells located in the Harran Plain located at southeastern of Turkey. Solar pyrolysis method, which is an example of original and renewable energy, will be used for biochar production. In this study proposal, biochar will be produced from carob (Ceratonia Siliqua) seeds, pomegranate (Punica Granatum) peels and Turkish Coffee (Coffea Turkish) residues by solar pyrolysis method. The schematic diagram of study recommended is given in Figure 1.

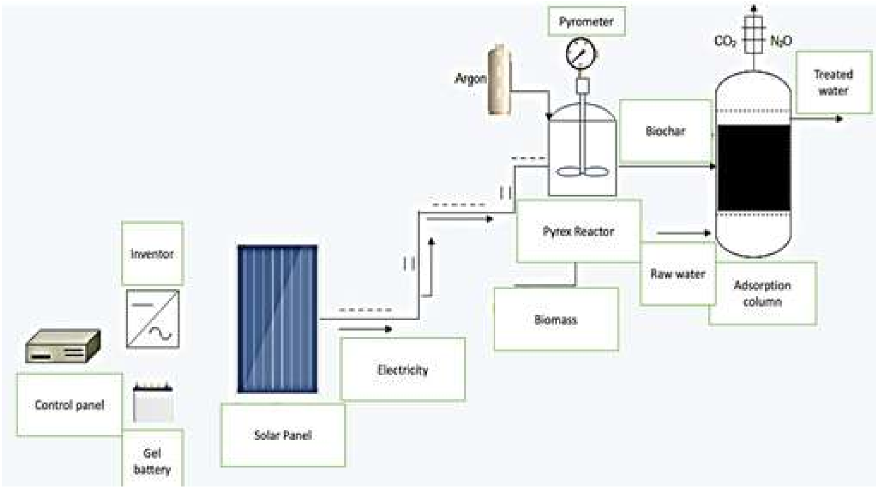

Fig. 1. Biochar Production and Adsorption Configuration with Solar Assisted Pyrolysis Process

Three types of biochar (0.10 g) will be mixed with 10 mL of CO_2 (H_2CO_3) and N_2O (NO_3^-) aqueous solutions in a glass column. The mixture will be shaken for 24 hours at 30 rpm using a rotary shaker. The mixture will then be separated using a 0.45 µm syringe filter. Final concentrations of N_2O will be determined using the Radiello gas measurement and sampling kit (Radiello 2022). The final concentration of CO_2 will be determined with the help of the Testo 440 analyzer and the Testo 440 CO_2 probe. The amount of CO_2 and N_2O (mmol g^{-1}) adsorbed to the biochar removed, is determined using the Eq. 1. (Metcalf and Eddy, 2014).

$$q_e = ((A_o - A_e) V)/W \quad (1)$$

In Eq.1., A_o is the initial gas concentrations (mM), A_e is the equilibrium gas concentrations (mM), V is the solution volume (L), and W is the biochar dose (g).

The process that is planned to be compared with the biochar adsorption process in terms of energy costs is the biological denitrification process. Carbon dioxide (CO_2) and nitrous oxide (N_2O) emissions from groundwater treatment has been monitored for each process. The possible effects of water quality parameters on greenhouse gas emissions will be determined by the analytical hierarchy process (AHP) method. It is aimed to reveal the relationship between greenhouse gas emissions from groundwater treatment and water quality parameters (Ammonium (NH_4-N), Nitrate (NO_3^-), pH, Total Organic Carbon (TOC), Arsenic (As), Fluoride (F)). The specified water quality parameters will be analyzed in Harran University Central Laboratory and Environmental Engineering Department Laboratory by applying Standard Methods (APHA, 1998). Ammonium, nitrate and fluoride analyzes will be determined by ion chromatography, arsenic analysis will be determined by inductively coupled plasma-optical emission spectrometry (ICP-OES) technique, TOC analysis will be determined by the TOC device in the department laboratory, and pH measurements will be determined by the pH meter in the department laboratory. The energy cost indicator will be developed based on the basic calculation tool for wastewater treatment plants developed by Castellet-Viciano et al. (2018) (2).

$$EC = AVbe^{(\sum \alpha_i \cdot x_i)} \quad (2)$$

3. RESULTS AND DISCUSSION

A new model will be developed within the scope of water-energy nexus by associating the energy costs arising from groundwater treatment with greenhouse gas emissions and the most effective water quality parameters. The model validation will be provided by applying the Statistical Anova test method (using the Statistica version 7.1. program), and it is aimed to minimize the energy costs with the use of renewable energy (biochar biomass energy). Studies in the literature are generally on energy efficiency and economic performance evaluation of the plants (Landa-Cansigno et al., 2020). This study proposal will be a guide study made by associating greenhouse gas emissions and economic performance evaluation within the scope of groundwater treatment. The variables of the study proposal are greenhouse gas emissions, energy consumption and water quality parameters.

Energy cost indicator (ECI), energy consumption (kWh) (EC), water flow (Q) and greenhouse gas emission (GHG) and the most effective water quality parameters (WQP) determined by AHP will be calculated with the help of a model to be developed (3). Coefficients (a,b,c) will be determined by sensitivity and regression analysis. The model validation will be provided by applying the Statistical Anova test method (using the Statistica version 7.1. program), and it is aimed to minimize the energy costs with the use of renewable energy (biochar biomass energy).

ECI= a. bEC. Qc e (dGHG±eWQP) (3)

In this model proposal, the dependent variable is the energy cost indicator. The independent variables are CO_2 and N_2O emissions, biochar derived pomegranate peel, carob seed, Turkish coffee residue and water quality parameters ((NH_4-N), (NO_3^-), pH, (TOC), (As), and (F)), energy consumption and greenhouse gas concentrations.

4. CONCLUSIONS

Previous studies have generally focused on the determination of energy efficiency of wastewater treatment plants. This study proposal will be a study in which biochar adsorption, which is an economical method, will reduce GHG emissions and energy costs together. There is no study has been found before, in which the biochar adsorption process has been evaluated as an alternative for minimizing energy costs from groundwater treatment. Whether the biochar adsorption process is a more economical method for groundwater treatment will be determined by calculating the energy cost indicator. Greenhouse gas emission and water quality parameters will be correlated. Theoretically, it is known that N_2O emission is mostly related to NO_3^- parameter and CO_2 emission is related to TOC parameter. As a measure of success, this relationship will be investigated.

Acknowledgement

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AN ENVIRONMENTAL IMPACT COMPARISON OF THERMOCHEMICAL CYCLES AND STEAM METHANE REFORMING FOR HYDROGEN PRODUCTION PROCESSES

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ABSTRACT
To address rising energy demand, hydrogen generation through environmentally friendly sources are extensively explored, and new technologies are being developed on daily basis. Hydrogen can be produced using renewable energy, nuclear energy, or fossil fuels. Today, most amount of the hydrogen is still produced using fossil fuels, which increases the amount of greenhouse gases. The development of novel hydrogen production technologies, such as thermochemical water splitting cycles, is a promising technology that will ultimately substitute for fossil-fuel-based hydrogen generation. The environmental impacts of hydrogen production systems such as solar-based thermochemical hybrid sulfur (HyS), nuclear-based thermochemical HyS, and steam methane reforming have been investigated in this study. In regard to abiotic depletion, global warming, and human toxicity, this study finds that steam methane reforming has the greatest overall negative impact, while nuclear-based hydrogen synthesis has a greater impact than solar-based production.
Keywords: HyS cycle, Hydrogen, Environmental Impact, Life Cycle Assessment, Solar Power, Nuclear Power

1. INTRODUCTION
Hydrogen is an essential industrial ingredient and potentially environmentally fuel. One of the most prevalent approaches is the direct electrolysis of water to produce hydrogen. To produce hydrogen from water, an initial source of energy like renewable energy, nuclear power or fossil fuel is required (Takai et al., 2011). Alternative energy sources need to be discovered to secure a sustainable energy market and avoid excessive global warming. Thermochemical water splitting techniques could be used to produce hydrogen using nuclear power plants or concentrated solar power techniques (Monnerie et al., 2011). A simple flowchart of the HyS thermochemical cycle is shown in Figure 1. The decomposition of H2SO4 in the cycle requires high temperature. This temperature can be provided by solar energy or by using nuclear energy, as shown in the figure 1. Detailed calculations of solar driven HyS thermochemical cycle were performed in Engineering Equation Solver (EES). The obtained data were used in life cycle impact analysis. The solar-based HyS cycle is compared to the nuclear-based HyS cycle and the steam methane reforming technology. Life Cycle Assessment (LCA) is an immensely popular topic that has been the subject of numerous studies in the literature. Ozbilen et al. (Ozbilen et al., 2011)used the LCA method to compare some thermochemical water separation cycles with various hydrogen production methods. LCA results for hydrogen production processes show that thermochemical cycles have lower environmental impacts, while steam reforming of natural gas has the highest environmental impact. Cetinkaya et al. (Cetinkaya et al., 2012) present a LCA for five ways of hydrogen production: water electrolysis via wind and solar electrolysis, natural gas steam reforming, coal gasification, and thermochemical water splitting with a Cu-Cl cycle. In terms of CO2 equivalent emissions, they discovered that thermochemical water separation using the Cu-Cl cycle outperformed other approaches, followed by wind and solar electrolysis. The scope of this study is essentially to compare the effects of global warming, human toxicity, and abiotic depletion on solar-based hybrid sulfur cycle, nuclear-based hybrid sulfur cycle and steam methane reforming hydrogen production methods.

2. MATERIAL AND METHODS
In this study, SimaPro software was used to analyse the life cycle impacts of three different hydrogen production methods. As a method, two methods were studied: CML-IA baseline and Eco-Indicator 95. In addition, The EES software package was used to perform energy and exergy analyses on the proposed system. It is the first thermochemical water splitting technique with only two reactions that has been demonstrated. The hybrid process gets its name from the combination of sulfuric acid thermal degradation and electrochemistry. Cycle reactions are as follows:

- Sulfuric acid decomposition reaction: $H_2SO_{4(aq)} \rightarrow H_2O_{(g)} + SO_{3(g)}$ (T=450 °C, ΔH°(kJ/mol) = + 176.5)
- SO_3 splitting reaction: $SO_{3(g)} \rightarrow SO_{2(g)} + ½\, O_{2(g)}$ (T=800 °C, ΔH°=+ 99kJ/mol)

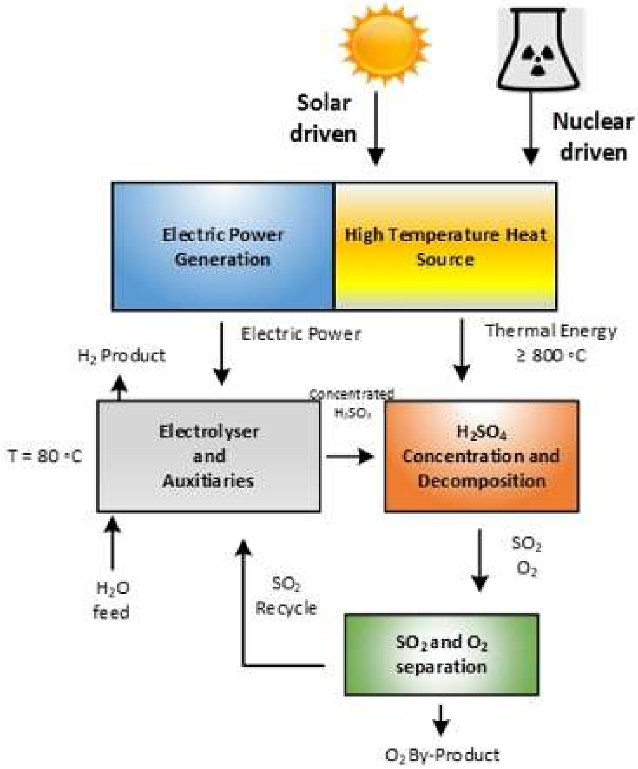

Fig.1. Solar or nuclear based hydrogen production from the HyS cycle diagram.

The GWP, or global warming potential, is connected to the temperature increase on Earth caused by human emissions, often referred to as the greenhouse effect. The abiotic resource depletion potential (ADP) considers a product's or process's impact on non-living natural resources. The adverse effects of hazardous compounds on human health and the environment are referred to as human toxicity (Karaca et al., 2020).

Table 1. Some of the impact categories used in the assessment study.

Impact categories	Indicators
HTP (Human toxicity potential)	kg 1,4 DB-equivalents
ADP (Abiotic depletion potential)	kg Sb equivalents
GWP (Global warming potential)	kg CO_2 equivalents

3. RESULTS AND DISCUSSION

In terms of CO2 emissions, the LCA results in Fig. 2 show that hydrogen production via solar-based thermochemical HyS processes is the most environmentally friendly of the techniques evaluated for hydrogen production. Furthermore, steam methane reforming is thought to be the most hazardous. In addition, the hydrogen production method with steam methane reforming shows the most negative environmental impact in terms of human toxicity, which is shown in Fig. 3, and abiotic depletion, which is shown in Fig. 4.

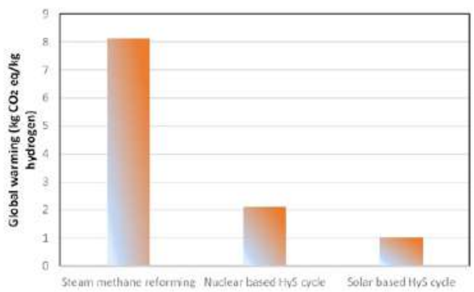

Fig. 2. GWP for three hydrogen production processes.

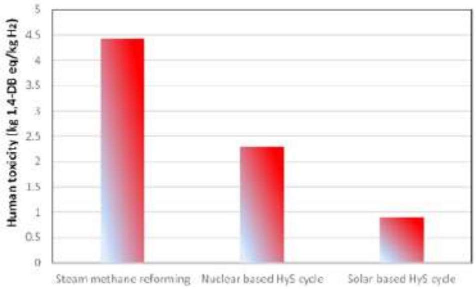

Fig.3. HTP for three hydrogen production processes.

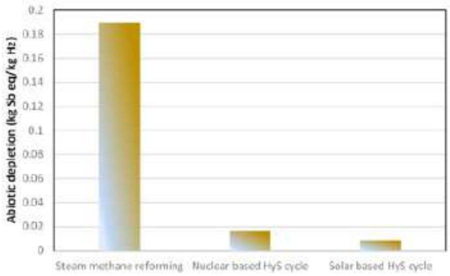

Fig.4. ADP for three hydrogen production processes.

4. CONCLUSIONS

The environmental impacts of several hydrogen manufacturing procedures are compared in this study, which takes into account diverse energy sources. To study these implications, a life cycle assessment (LCA) approach is used. According to the LCA results, hydrogen manufacturing using a solar-driven HyS thermochemical cycle might be preferable over standard steam methane reforming and have lower environmental implications than high-temperature electrolysis and renewable hydrogen production. Furthermore, it has low GWP, HTP, and ADP that these values 1.04 kg CO2 eq/kg H2, 0.91 kg 1,4-DB eq/kg H2, and 0.008 kg Sb eq/kg H2, respectively.

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ECOSPACE PROGRAM AS THE TRANSITION OF CIVILIZATION TO THE NATURAL PATH OF TECHNOCRATIC DEVELOPMENT

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ABSTRACT
The key goal of the EcoSpace program is to eliminate the harmful anthropogenic oppression of the Earth's biosphere by the technosphere. However, this will be possible only if there is an energy-efficient, environmentally friendly and safe geocosmic transport system that will be able to provide industrial-scale cargo and passenger transportation, which is millions of tons of cargo and millions of passengers per year, while reducing the cost of transportation compared to rockets by at least a thousand times. Thus, the implementation of the EcoSpace program: "The Earth - for Life. Space - for Industry." is possible only if there is a general planetary vehicle (GPV).

Keywords: GENERAL PLANETARY VEHICLE (GPV), GEOCOSMIC TRANSPORT SYSTEM, USPACE, ORBIT SPACE INDUSTRIAL NECKLACE (SIN ORBIT)

INTRODUCTION
Man chose the technological path of civilizational development about 2 million years ago, when he created his first engineering technologies, including lighting the first bonfire and cooking food on a bonfire. Primitive people died of lung cancer at the age of 20, until they guessed to take fire and other simple industrial technologies out of the cave, their home, into the environment – into the big biosphere house Earth. Today we fully feel the result of the subsequent technological development and the creation of a global industry (technosphere) – the biosphere of our planet is filled with technological smog, threatening not only man, but all life on Earth.
The total energy efficiency of a carrier-rocket running on solid or liquid fuel is about 1%. Geocosmic transportation by means of rockets will always remain extremely dangerous from the point of view of ecology, and their cost will exceed 1 million USD for each ton of cargo delivered to space (or back). And, most importantly, the ozone layer that protects our planet from harsh cosmic radiation (ultraviolet) is destroyed in colossal volumes – millions of tons per each launch of a heavy rocket.

It is a common knowledge that ozone is produced from the air, being passed through an ozonizer. Cost of the ozone production depends on the electricity prices, as this process has high-energy consumption. The best industrial ozonizers consume about 10 kWh of energy to produce 1 kg of ozone [1]. With an average world cost of electricity of about 0.1 USD/kWh, the cost of electricity consumed to obtain 1 ton of ozone will be approximately 1,000 USD in energy. Considering the cost of equipment and the overheads, the cost will be significantly higher for the largescale application.
The EcoSpace program proposes the most efficient approach to solving this problem by combining private, public and government initiatives. The program is based on the synthesis of the cosmic worldview and specific astroengineering technologies implemented in the foreseeable future.

The geocosmic transport system optimal for the industrialization of space must meet the fundamental laws of nature. These include four physical conservation laws: energy, momentum, angular momentum and the motion of the center of mass of the system. At the same time, the design and principle of operation of the cosmic transportation system should be integrated into the environment with a minimal impact on the biosphere, harmoniously fit into the landscape and not contradict the ongoing natural processes. To date, only one engineering solution meets the specified conditions and meets a number of additional geocosmic transport and logistics requirements subject to the tasks of space industrialization – this is a general planetary vehicle (GPV) developed by engineer Anatoli Unitsky.

MODELING AND METHODOLOGY
To implement the EcoSpace program, the authors used the methods of deduction and analysis:

1.Preparatory stage.
Implementation period: 20-25 years (from 2020 to 2045).
Goals and objectives: conducting research, development and technological work (R&D), construction of an Equatorial Linear City (including an equatorial launch overpass), production of GPV, organizational preparation and logistics support of GPV flights.

2.Basic industrialization of space.

Implementation period: 10-15 years (from 2040 to 2055).

Goals and objectives: creation and rapid capacity expanding of the basic branches of the cosmic industry, which will allow the competitive displacement and smooth, industry by industry, reconstruction of the existing dirty technosphere of the Earth. In parallel, it is planned to carry out the installation of the transport and infrastructure part of the SIN Orbit, construction of the first residential and industrial orbital clusters using materials of terrestrial origin. Further, mass industrial development of equatorial orbits using space materials is envisaged.

3.Large-scale industrialization of space.

Indefinite, starting from 2055.

Goals and objectives: expanding the range of high-quality consumer and industrial cosmic goods and services, setting up a competitive geocosmic market.

This article discusses the model of a general planetary vehicle (GPV), a constructive version of which is shown in Fig. 1 using finite element analysis, which is a modern advanced technique for calculating all possible structures and processes occurring in them. The essence of the finite element calculation is that the model or process is discretized by elements or by time, respectively and the results are on Fig.4.

RESULTS AND DISCUSSION

A general planetary vehicle is an eco-oriented reusable geospace transport that allows exploration of near space without the use of rockets. It is presented in a form of a self-supporting aircraft (Fig. 1), covering the planet within the equatorial plane [2].

The uniqueness of the GPV operation is seen in the way of reaching the outer space. It happens by the increasing in the diameter of the ring (by 1.57 % when lifting every 100 km) and reaching at the calculated altitude (with passengers and cargo) the peripheral velocity of the body, which should be equal to the first cosmic velocity up to 10−12 km/s. The GPV has a glow of a hybrid magnetic suspension of flywheels (Fig. 1). The design includes a system of power limiting magnets, a system of stabilizing emissions and a linear electric motor, the issuance of acceleration of flywheels, as well as power take-off in the process of admitting GPV. At the same time, the position of the centre of mass of the GPV does not change in the elevation process and it always coincides with the centre of mass of the planet. The resulting force acting on the rotor from the side of the magnetic system is determined, provided that there are no external influences, except for gravity, it is equal to 30 N and is directed from the center of mass of the earth.

Therefore, the movement (rising to altitude and receiving the first cosmic velocity at a given altitude) can be carried out relying on the internal forces of the system, without significant interaction with the environment.

Fig.1 – GPV design: 1.1 and 1.2 – belt flywheels;
2.1 and 2.2 – magnetic suspension systems and linear electric motor;
3 – body; 4.1 and 4.2 – containers with cargo (visualisation)

The mode of ascent and docking in orbit sets so that at any operating speed the GPV takes place to turn off the speed, takes place stabilizable and is determined in acute (stretched) equilibrium. When delivering a cargo mass m_c to a circular orbit r with direction R from the center of the Earth, work A [3] is performed to as Eq. (1):

$$A = \frac{\mu_3 m_c}{R}\left(1 - \frac{R}{2r}\right), \qquad (1)$$

here μ_3 -is the gravitational parameter of the Earth.
To do this, the body near the surface of the Earth must have a characteristic velocity *Vx* to as Eq:

$$V_x^2 = \frac{2\mu_3}{R}\left(1-\frac{R}{2r}\right) = V_2^2\left(1-\frac{R}{2r}\right), \qquad (2)$$

V_2^2 is the second cosmic velocity.
The total energy E_n, which should be spent to bring the body into space to as Eq. (3):

$$E_n = \frac{A_n}{\eta_E} = \frac{K_g}{\eta_E} = \frac{m_c V_x^2}{2\eta_E} = \frac{m_c \mu_3}{\eta R}\left(1-\frac{R}{2r}\right), \qquad (3)$$

here ηE is the energy efficiency of the GPV, taking into account all pre-flight and flight energy losses; Kg is the kinetic energy of a body with a speed Vx. The total power N developed by the GPV during the launch of cargoes into orbit to as Eq. (4):

$$N_n = \frac{E_n}{t} = \frac{m_c \mu_3}{\eta R t}\left(1-\frac{R}{2r}\right) = \frac{m_c V_2^2}{\eta t}\left(1-\frac{R}{2r}\right), \qquad (4)$$

here t is the operating time of the GPV (the time of supplying energy to the load). On Fig.2 and Fig.3 show the energy consumption and the power of the GPV when launching a cargo into orbit [3].

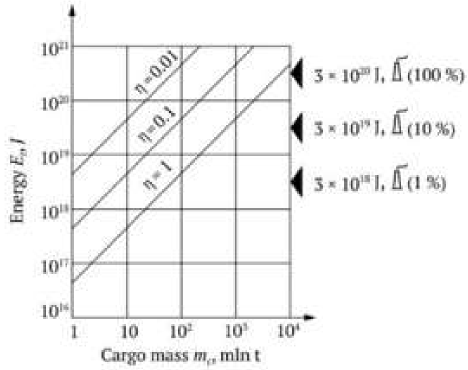

Fig.2. Energy consumption required to take cargo to the orbit, Vx = 104 m/s

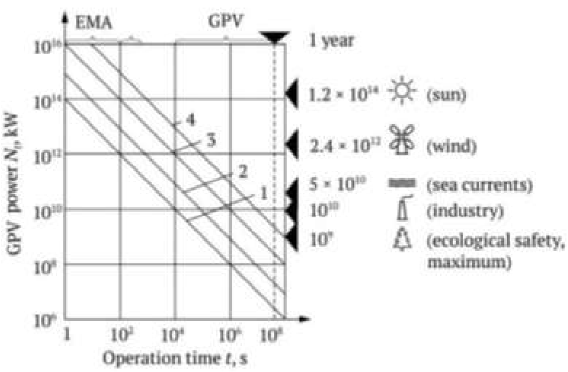

Fig.3. GPV generated during taking cargo to the orbit at Vx = 10^4 m/s η= 0.5 and mc equals:
1-1 mln t; 2- 10mln t; 3 – 100 mln t; 4 – 1bln t.

The specific load capacity of the system is 12,330 N/m or 1,257 kgf/m. With the specific mass of flywheels and shell equal to 250, 225 and 200 kg/m, respectively, the maximum payload mass was 582 kg/m. The actual load capacity is 500 kg/m.

We have made calculations on the impact of forces acting on the GPV during takeoff. The results are presented in Fig. 4

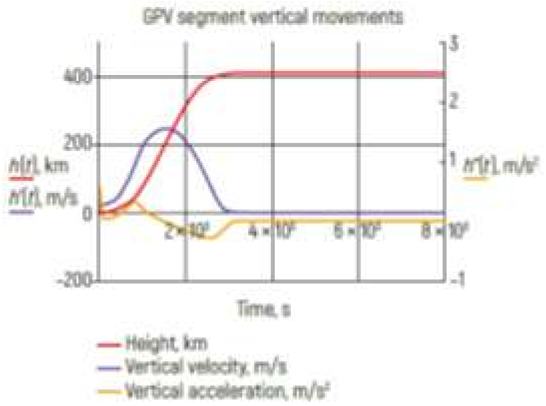

Fig.4 – Diagram of abscend, vertical velocity and vertical acceleration with time

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OPTIMAL DESIGN AND PERFORMANCE EVALUATION OF AN OFF-GRID PV SYSTEM: A Case Study in Babel, Iraq

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ABSTRACT
The current study investigates solar energy potential of Iraq, which is characterized by its high solar insolation and longer sun hours. The paper aims to optimize an off-grid photovoltaic system to supply a domestic home electrical load of 20 kW/day, located at Babel, Iraq.

HOMER and MATLAB software are used for the analysis.

The results show that a system consisting of 11.6 kW PV panels, 34 Li-ion batteries, one kW each, and 4.7 kW converter would be the optimum selection for the considered system.

The net positive cost (NPC) of this system is approximately US $ 62,082 and the cost of energy (COE) is 0.74 2USD/kWh. MATLAB simulations confirm that the proposed system sustains permanent electrical supply at all conditions, and that applying Maximum power point tracking (MPPT) algorithm ensures the high performance of the system.

The proper design of photovoltaic systems and the effective energy management, considerably contribute toward improving the overall performance of solar systems and reduce their costs.

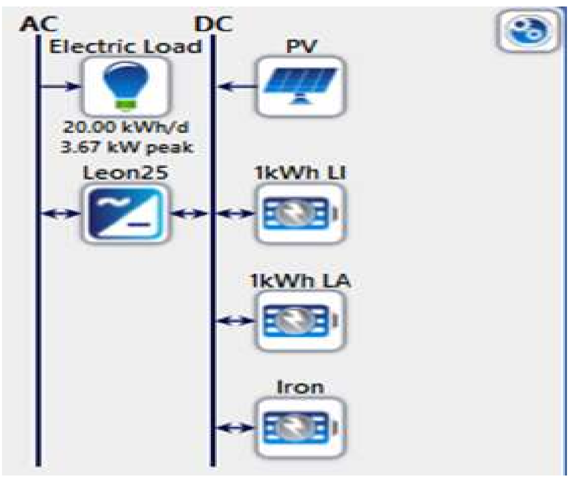
INTRODUCTION
Residential sector consumes about 40% of the total produced energy over the world, according to World Watch Institute. In Iraq, the residential buildings consume 48%,29% industrial, 13% offices, 6% commercial and 4% agricultural of the annual electricity production in Baghdad (It is one of the largest Iraqi cities in terms of area and population density); most consumption is for heating and cooling purposes [1].

The city of Babel, the selected location of the current study, is located about 50 miles south of Baghdad, the capital of Iraq.

It has an average global solar irradiation of about 5.16 kWh/m2/day, and the sun shining hours is over 3000 hours per year.

The main idea of this research is to design an optimal rooftop off-grid PV solar system of a specific capacity to meet the electrical load of a residential house in Iraq, instead of using conventional source.

The optimization is performed using HOMER and MATLAB software.



METHODOLOGY

The required electrical load of the house is estimated to be 20 kW.

The PV system will be modelled, its components will be selected, and the economic and technical performance of the system will be analysed and optimized using HOMER software.

The (MPPT) in a photovoltaic (PV) power conversion system is to continually adjust the system so that it draws maximum power from the solar array regardless of weather or load conditions.

In order to make an optimal use of the solar panel, MPPT tracking algorithms are used.

There are several MPPT algorithms proposed in scientific literature, some of these algorithms are based on tracking power peak pursuit like Observe and Perturb (P&O) and INCremental CONductance (INC-CON) algorithms, while some others are based on panel voltage regulation or panel current as well as weighting control and neural networks [7,8]. In this study, different MPPT algorithms are included in the simulation.

FINDINGS

In the current study, an off-grid PV system to feed a small house of electrical load of 20 kW, is designed and optimized using HOMER and MATLAB software. The main findings of the current study are as follow:

For pure solar energy system case, a system composed of 11.6 kW PV panels, 34 batteries (1 kW LI), and 4.7 kW converter represents an optimal design. The net positive cost (NPC) of this PV system is 62,082 USD, and the levelized cost of energy (LCOE) is 0.742 USD/kWh. The total annual electricity production of the system has reached 17,084 kWh/year, with no electricity shortage at any time.

Using solar energy has a significant positive effect related to both economic and environmental issues.

MATLAB simulations results showed that the proposed power system achieves effective and highly efficient performance, as the maximum power point is pursued despite the presence of changes in temperature or solar radiation, and an almost constant value of the dc-link voltage is maintained.

Architecture						Cost			
PV (kW)	1kWh LI (#)	1kWh LA (#)	Iron (#)	Leon25 (kW)	Dispatch	CAPEX ($)	Operating cost ($/yr)	LCOE ($/kWh)	NPC ($)
11.6	34			4.70	CC	$50,512	$1,009	$0.742	$62,082
12.9			26	3.92	CC	$60,508	$384.77	$0.776	$64,921
11.7		51		5.08	CC	$47,577	$1,588	$0.786	$65,789

EXERGOENVIRONMENTAL ASSESSMENT OF A HIGH-TEMPERATURE BASED GEOTHERMAL SYSTEM: A CASE STUDY

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ABSTRACT
This study focuses on the development of an integrated high temperature geothermal energy-based system for the synthesis of green hydrogen with freshwater and electricity as well as the exergoenvironmental assessment of the system for a specifically selected location in Menengai, Kenya. The designed system consists of an alkaline electrolyzer, an organic rankine cycle, a multi-effect desalination system, and a high temperature geothermal system. The component with the highest sustainability and minimal environmental impact was obtained as electrolyzer subsystem in terms of exergo environmental analyses with an exergo environmental effect factor of 1.607.
Keywords: Hydrogen, Geothermal, Exergoenvironmental analysis

1. INTRODUCTION
Over the past, mankind has used a variety of energy resources as answers to critical issues. Multiple techniques can be used to extract beneficial energy sources, fuels, or outcomes from underground thermal energy (Temiz and Dincer, 2021). The planet's primary boundaries of plates are recognized for having a high geothermal potential. In 2011, the Menengai geothermal field's steam potential was investigated. Since then, a number of production and exploratory wells have been drilled, with highest reported temperatures reaching 390°C.(Montegrossi et al., 2015). This clearly indicates the potential for power generation of Menengai. Zhang et al. (2020) evaluated high temperature geothermal source potential resulting in the development of a superior geothermal system in the northeastern Tibetan Plateau. Carlino et al. (2016) examined high temperature volcanic resevoirs of Southern Italy and provides development of zero emission power plant. A new method is used for producing green hydrogen by high temperature geothermal source and to produce freshwater and power, geothermal is also integrated with a multi-effect desalination (MED) unit and an Organic Rankine cycle. The objectives are developing new system with clean energy source such as geothermal source, modeling the system and analyzing environmental effect of the system. The exergoenvironmental analyses of the subsystems of the system designed for the high-temperature geothermal reservoir in Menegai were performed on the EES

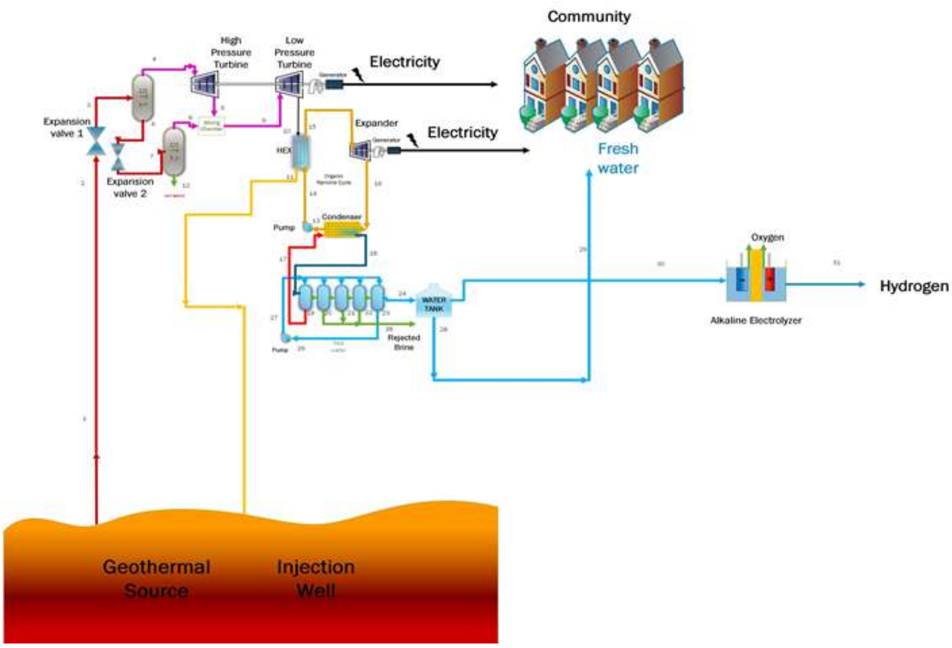


Fig. 1: A schematic layout of the developed system.

2. SYSTEM MODELING

Fig. 1 illustrates the developed binary geothermal based system for high temperature geothermal reservoir which produces electricity, freshwater and hydrogen in Menengai, Kenya. The design is investigated from an exergoenvironmental point of view. Moreover, electrolysis is used to produce the H2 that is generated by the procedure. The chemical reaction at the anode, cathode as follows:

$$Cathode: 2H_2O + 2e^{-1} \rightarrow H_2 + OH \quad (1)$$

$$Anode: 2OH^- \rightarrow \frac{1}{2}O_2 + H_2O + 2e^{-1} \quad (2)$$

Also, the overall energy and exergy efficiencies are defined as

$$\eta_{Overall} = \frac{\dot{W}_{net} + \dot{m}_{28}h_{28} + \dot{m}_{30}LHV_{H_2}}{\dot{Q}_{geothermal}} \quad (3)$$

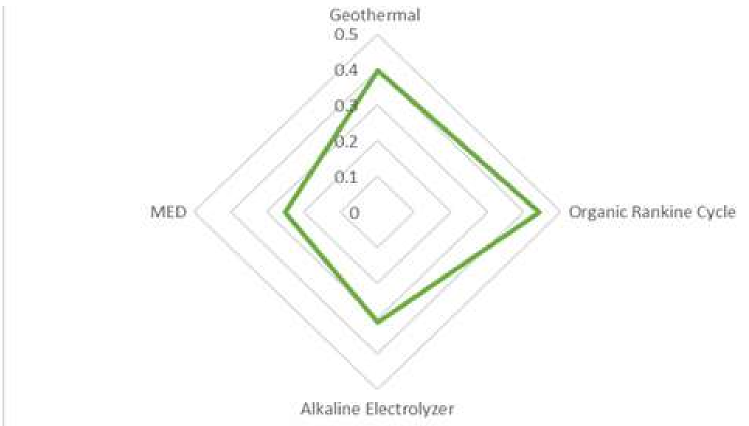
and

$$= \quad \Psi_{Overall} \quad \frac{\dot{W}_{net} + \dot{m}_{28}ex_{28} + \dot{m}_{30}(ex_{30} + ex^{ch}_{H_2})}{\dot{Q}_{geothermal}(1 - \frac{T_0}{T_1})} \quad (4)$$

3. RESULTS AND DISCUSSION

Exergo environment factor , environmental damage effectiveness factor , exergo environmental impact coefficient , exergo environmental impact values were found for each subsystem. The exergo environmental analyses that applied in the system's essential subsystems are shown in Fig. 2. The subsystem with the highest exergo environmental factor is the organic rankine cycle with a value of 0.44. The subsystem with the lowest exergo environmental factor value is multi effect desalination with a value of 0.25.

It may be claimed that components with higher exergoenvironment factors are more detrimental to the environment since the exergoenvironmental factor is directly proportional to the exergy destruction rate values.



The exergo environmental analyses of the subsystems are demonstrated in Fig. 3. In the analysis for the exergo environmental impact coefficient , it is observed that this parameter is inversely proportional to the exergy efficiency. In other words the component's environmental impact will be decreased the more exergy-efficient it is. The electrolyzer appears to have the lowest component with an exergoenvironmental effect factor of 1.607.

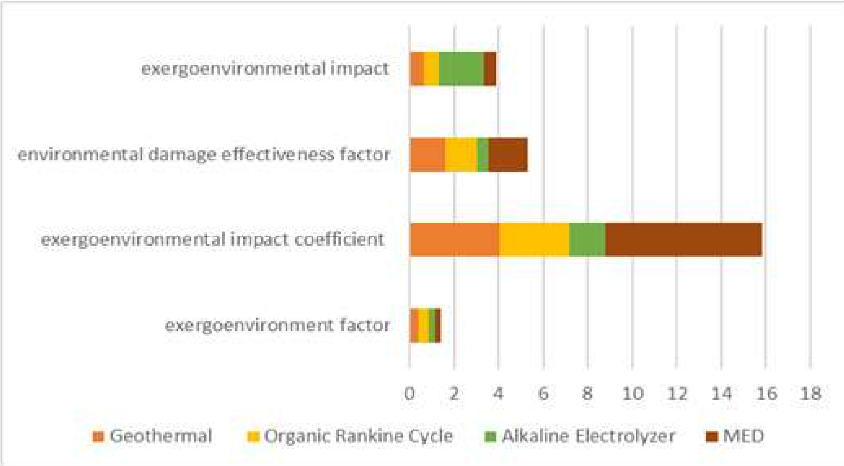


Fig. 3: Exergoenvironmental impact assessment results of the subsystems

4. CONCLUSIONS

The results of the exergoenvironmental impact assessment studies have been found to tend not to grow rapidly. In view of this, it has been proven that renewable energy methods are more beneficial for the environment. The electrolyzer component was found to be the most sustainable and environmentally friendly component in all exergo environmental analyzes.

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ASSESSMENT OF ENVIRONMENTAL PROTECTION COSTS WITHIN THE FRAMEWORK OF GLOBAL WARMING

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ABSTRACT
Expenditures regarding the global environmental protection are made in different areas such as the management of water utilization, air and noise waste, and radioactive waste. In addition, the investments which enterprises make to protect the environment in terms of their fields of activity draw attention to sectors such as agriculture and food, consumer goods, and automotive. In this context, our study will focus on the expenditures and investments made by the countries to prevent the detrimental effects of global warming.

In the second part of the research, the carbon costs within the related elements that the enterprises bear in the fields of carbon management and cost accounting will be examined with the purpose of examining the environmental protection costs at the enterprise level. Both traditional and modern cost methods, techniques, and applications will be compared accordingly. The relation between carbon costs and the other cost factors incurred in protecting the environment will be discussed in detail.

Keywords: Global Warming, EU Green Deal, Carbon Cost Management, Carbon Accounting

1. INTRODUCTION
Global warming and its detrimental affects are one of the hot topics on global agenda. Corporate accounting practices and policies have also been affected by global warming. In addition to the social and environmental reporting, the effects of global warming require reporting of both financial and non-financial information reporting. The European Union's Green Deal is among the developments that draw a great deal of attention in this regard. In addition, issues such as energy crises, biodiversity, land use, deforestation, and air and water pollution have come to the fore front in parallel to these issues. It is unfortunate that traditional cost systems exclude the costs incurred to prevent these problems and environmental effects. However, current studies in the field of accounting and the increasing importance of sustainability show that both areas should be considered together in business processes, and therefore traditional methods should be developed by taking into account environmental costs.
James R. Aldrich (1996) explained the concept of externality in terms of microeconomics and expressed that the consumer's actions in the marketplace are involuntarily dependent on the actions of the other. This commitment can result in either cost or benefit. Aldrich stated that environmental pollution is a good example of a negative externality. If negative externalities are not included in the cost of products and services, it will lead to underpricing and overproduction. "The polluter pays" principle states that the social and environmental costs arising from the polluters should be determined. Businesses have to directly allocate these costs to their goods and services (Dascalu et al., 2009). Internalization of positive externalities refers to the introduction of an incentive system for companies that carry out protective activities for environmental and social benefits such as research and development, environmental protection, education, and regional development. It can be thought of as a positive case model of the polluter pays principle.
Estes (1972) expressed the importance of socio-economic issues in accounting with topics such as national income accounting, evaluation of social programs, the role of accounting in economic development, and the creation of a social development index. However, when it comes to today, it is seen that the research areas that attract attention are different.

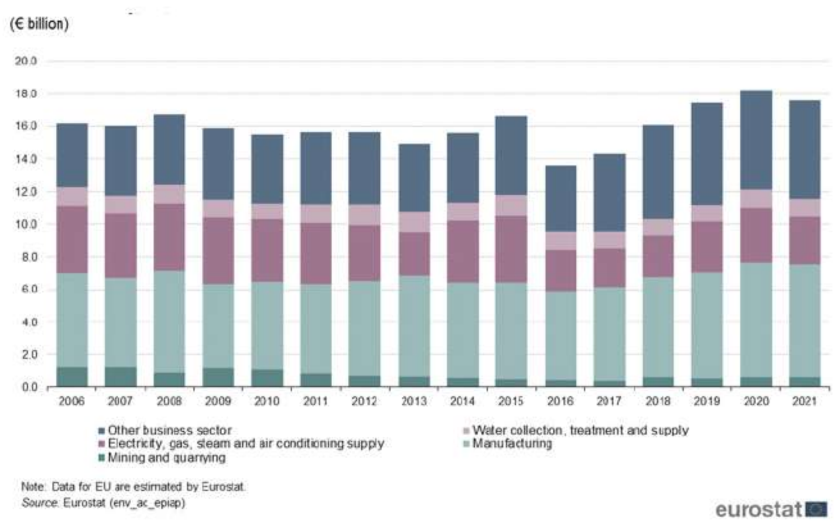
An overview of the environmental protection investments by corporations in the European Union (EU) and Canada is provided in the first section. In the second section, studies on traditional cost models and ecological costing models and the increasing importance of carbon management accounting are discussed.

2. ENVIRONMENTAL PROTECTION INVESTMENTS

The European Commission has adopted a package of recommendations that will enable the EU to reduce net greenhouse gas emissions by at least 55% by 2030 when compared to 1990 levels in the areas of climate, energy, transport, and tax. On December 11, 2019, the EU Commission introduced the European Green Deal in Brussels, aiming to achieve climate neutrality by 2050 (European Commission, 2019).

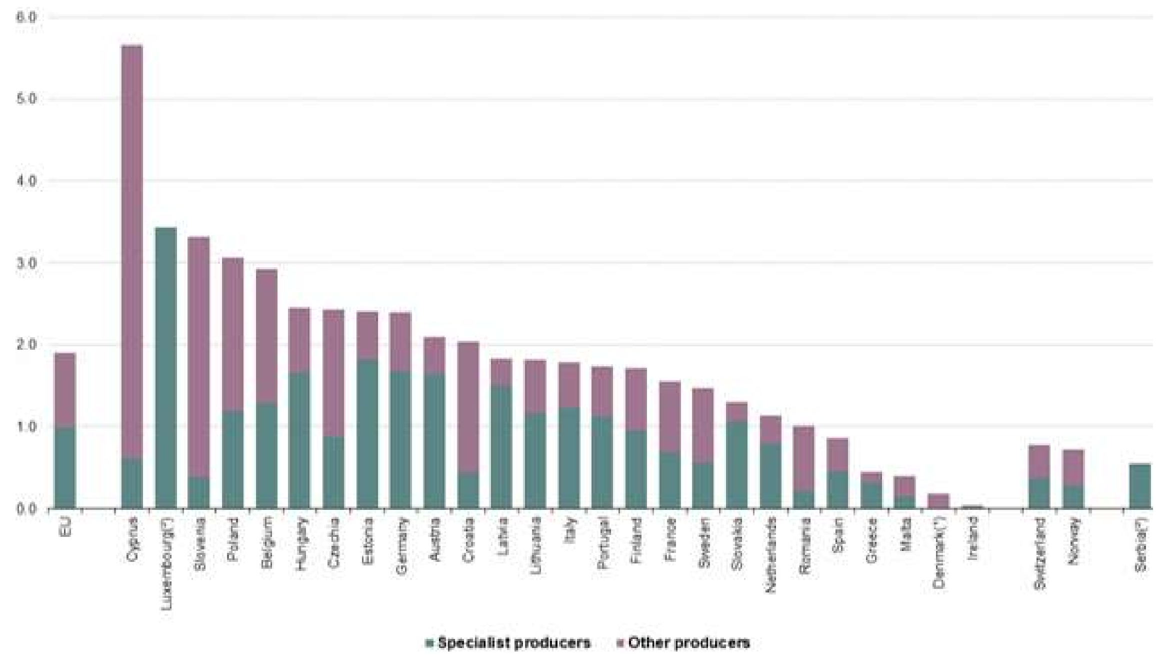
In Figure 1, representing the period from 2006 to 2021, we can observe that the highest percentages of the total Environmental Protection Expenditure Accounts (EPEA) investments made by corporations, other than specialist producers to mitigate the environmental harm caused by current production technologies, belong to the manufacturing sector (39%) and other business sectors (34%) in 2021. About 23% of the total is made up of utility company investments, while 4% is derived from mining and quarrying (Eurostat, 2022a).

Figure 1. Environmental protection expenditures of corporations other than specialist producers by economic activity, EU, 2006-2021



According to data from European Union member states shown in Figure 2, the share of investments in environmental protection in total investments differ among countries in 2019 and vary from 0.1% to 5.6% of total investments (Eurostat, 2022b).

Figure 2. Investments for environmental protection by corporations, 2019



We also examine the data from Canada (Statistics Canada, 2022). Almost 9 out of 10 Canadian businesses reported that investments were made in the field of environmental protection in 2019. It is pointed out that 87% of Canadian businesses reported their environmental protection expenditure in the related year. Environmental protection activities and resource management activities are the two main categories that are recognized under environmental protection expenditures. Environmental protection activities reduce the negative effects on the environment and the intensity of resource consumption. The prevention, reduction, or elimination of pollution are all parts of resource management activities. The majority (60%) of companies in the paper manufacturing sector made high-volume investments in technology to enhance resource management. They were followed by companies in the production, transmission, and distribution of electric power (58%) and companies in the distribution of natural gas (44%).

3. CARBON MANAGEMENT AND COST ACCOUNTING

Drawing attention to the importance of collecting, managing, and reporting carbon-related information, the study explained the reasons why businesses focus on this issue under three main headings. These include the increase in emission trading systems, the need for standardized measurement of carbon emissions for use in corporate reports, and the growing public interest in carbon management with the increasing global warming (Burritt et. al 2011).

Hu et al. (2022), on the other hand, listed the increase in the need for energy demand and the increase in this demand causing environmental problems among the important reasons in this regard. The study classified carbon emission costs into prevention, governance, maintenance, loss, and contingency costs. While prevention costs include research and development expenses to reduce carbon emissions, governance costs include recycling related expenditure and contingency cost includes the expenses such as carbon emission quotas, carbon taxes, and transaction expenditure. He also counted material flow cost accounting and life cycle assessment methods among the methods used in the measurement of carbon emission costs.

Dascalu et al. (2009) developed the traditional full-cost accounting model in their study and revealed the eco-costing model which was included in the costs of sustainable developments and environmental reporting. Ratnatunga et al. (2009), on the other hand, explained carbon allowances, low-carbon dioxide emission technologies, and the calculation of carbon costs resulting from increased carbon emissions and climate change

Traditional Overhead Expenses	Environmental Overhead
Electricity, Rental, Transportation	Regulatory Costs (Regulations on carbon emissions)
Administration, Marketing	Waste management
Depreciation of Machinery	Amortization of Design Costs
After-sale Service Costs	Carbon Credits

According to Ratnatunga et al. (2009) and reprinted

Ratnatunga et al., (2009) stated that carbon costs throughout the life cycle of products and services in Table 1 should be analyzed with the help of strategic cost management systems. Direct and indirect costs are evaluated in traditional cost systems (Hacırüstemoğlu, 2001; Basık et al., 2006). In carbon cost accounting, environmental costs should be evaluated in terms of raw materials, labor, overhead, waste management, and recycling.

4. CONCLUSIONS

Pollution prevention is advocated by both environmental and legal authorities. In addition, the basic principle in this matter is that the problem should be prevented at the source even before the environment starts to be polluted. Therefore, investments in environmental protection and carbon costs accounting should be developed and implemented with modern tools and methods. Within the scope of the study, both the investments made by Canada and the European Union countries to protect the environment and carbon cost accounting methods are included. In further research, we will examine environmental protection investments in Turkey and some other countries.

Acknowledgment
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EXERGY ANALYSIS OF DIFFERENT FUEL BLENDS POWERED COMPRESSION IGNITION ENGINE – A REVIEW

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ABSTRACT
The degrading environmental concerns and depletion of fossil fuels gain momentum for using alternative fuels in compression ignition engines. The effective way to determine the fuel efficiency and effectiveness of a compression ignition engine could be the exergy analysis quantifying the fuel to available energy. Exergy can be the basis to gauge the energy quality for the yielded maximum work of a system that interacted with its environment or the required minimum work obtained for a given state from the environmental conditions. The blending of WPO with pure diesel significantly increased the fuel exergy while a reverse trend was observed for exergetic efficiency. 'D35E15B50' (35%diesel + 15%ethanol + 50% PPME) showed an increase of 25.64% in exergetic efficiency. Thermodynamic irreversibilities which is considered mainly responsible for the lowered exergy efficiency are found to be decrease with the enhancement of oxygen content in the fuel blends. Exergy efficiency for ethanol blends and biodiesel blends are observed to be lower than the thermal efficiency.
Keywords: Exergy, Diesel, Biodiesel, Exergetic Efficiency

1. INTRODUCTION
The continuous increase of energy exigence in the world is propelled by the surge in the populace amalgated with economy that projected 48% of energy growth between 2012 and 2040 forecasting to meet nearly three-fourths (3/4) of the overall demand for energy by fossil fuels in 2040 [1]. Besides, the use of diesel engines in the agricultural, industrial and transportation sectors has been increasing due to the factors like better economy in its usage, durability, reliability and specific power output thereby amplifying the consumption of diesel fuel derived from fossil fuels which in turn increases the oxides of nitrogen (NOx) and emissions of particulate in the atmosphere [2,3]. However, this growth in consumption of diesel fuel is not favourable because of the fast depletion of non-renewable 'fossil fuel' reserves, flare-up of global warming in the environment and the combustion products from fossil fuels leading to environmental pollution. So, this issue has become inalienable from the mind of mankind and gives thought to resolving these issues through the utilization of state-of-the-art pristine burning fuels that become an attraction to 'internal combustion' (IC) engines [4]. Generally, biofuels which are considered renewable fuels are derived from edible feedstocks like groundnut, cottonseed, palm nut, etc. and non-edible feedstocks viz., calophullum inophullum, jatropha curcas, algae, bael, etc. [5]. Diesel engines can be operated with vegetable oils that are obtained from plant seeds and operating diesel engines with substitute fuels derived from biomass, vegetable oils and alcohols could be imperative to curtail fossil fuels consumption which in turn controls the damage to the environment [6]. The lower exhaust emissions from alcohol and vegetable oils grounded the interest in renewable energy sources owing to their oxygen content and synthetic structure [7]. Apart from the renewability, vegetable oils bear excellent flash point, lubricity, lower sulfur content with aromatic values and are biodegradable making them promising fuels as compared to fossil fuels [8]. The use of 100% neat vegetable oil in replacement of diesel fuel experienced operational problems like high deposition of carbon, stickings in the piston rings, coking of injector and thickening of lubrication oil through polymerization [9].

Energy saving, efficiency and sustainability through the use of biofuels in internal combustion engines could play a vital role in the impending global energy scenario. Considering its essentiality, 'energy-exergy' and 'sustainability index' (SI) analyses seemed to be quite significant in respect of performances and emission values of biofuels in engines. Moreover, engine performances were evaluated based on 'brake power' (BP), 'brake thermal efficiency' (BTE), 'brake-specific fuel consumption' (BSFC) and emission analysis considering the 1st law of thermodynamics (energy analysis) that quantitatively evaluated the 'energy' for diesel and biofuels operated diesel engines so far available in the literature. In doing so, the real performance of engines that are analysed through the 2nd law of thermodynamics which considers the thermal aspect through exergy is overlooked. However, system inefficiencies can be achieved through the 2nd law of thermodynamics (exergy analysis).

The involvement of exergy concepts, balances and efficiencies make the exergy analysis evaluate and improve the system thereby determining the qualitative and quantitative losses in the system and locations that occurred due to irreversibilities which provided the engine efficiencies information more accurately [10,11]. In addition, the 1st law of thermodynamics (energy analysis) is limited to the performance evaluation of the engine and is not able to account for some energy degradation features that lead to restoring the interest in the second law of thermodynamics (exergy analysis) [12,13]. 'Exergy' not a conserved property in an isolated system can be generated, destroyed and stored while it was mostly destroyed as low-temperature heat transfer during chemical reactions interacting the unutilized exergy with surroundings that cause environmental harm through undesirable environmental processes occurred in non-equilibrium processes. The quality of energy was found to be more suitably described through the method of exergy analysis compared to energy analysis because of its indicative useful work potential of energy. Exergy analysis through economic and sustainability assessments could feature the thermal system's actual performance [14]. Some studies have been analysed to better understand the sensitivity of various operating parameters in performance analysis using energy and exergy for biofuels-operated internal combustion engines.

2. EXERGY ANALYSIS FOR DIFFERENT FUEL BLENDS

Sarıkoç, et al. [15] recorded the maximum "energetic – exergetic" and 'SI' values at 1400 rpm with 'biodiesel' (waste cooking oil biodiesel) converting the "exergy" of 'biodiesel' to exergy brake power of approximately 29.77%, exhaust exergy by about 12.29%, cooling water exergy estimated to about 7.33% and 'exergy destruction rate' nearly 50.60% respectively because of higher cetane number and improved combustion quality of biodiesel in presence of oxygen. Thermodynamic irreversibilities are accounted to be the main reason for the lowered 'exergy efficiency' than the 'energy efficiency' of engine. Besides, the "exergy efficiency" intensely depends on the speed of the engine, frictional effects, reactions of the chemicals and heat transfer to the cylinder wall. Slightly lower energy and exergy efficiency than euro diesel was noticed for butanol blends attributing to lower heating value (LHV), lower cetane number and high vaporization but improved slightly owing to the improved combustion process of the oxygen-rich fuel blend. Compared to euro diesel, butanol fuel blends showed no significant change in energy and exergy efficiency while it is higher for biodiesel than euro diesel. The presence of higher oxygen atoms in combination with better cetane number, lowered viscosity and density lead to easier vaporization that improved the combustion which in turn decreased the thermodynamic irreversibilities resulting in improvement of energy and exergy analysis through fuel properties. The ternary blend of diesel - biodiesel - butanol blend inferred almost similar "energy-exergy" efficiency, 'SI' value and drop in emissions of exhaust to euro diesel. The D75B20But5 fuel blend showed nearly identical "energy-exergy" efficiency performance and SI value recording inferior "energy-exergy" losses, destruction rate of exergy and emissions of CO than diesel. Nazzal and AlDoury [16] reported increase in fuel exergy as well as exergy destruction with the rising speed of engines for both 'diesel' and 'diesel–corn' oil fuel blends. 'CB8' (8% corn oil + 92% diesel) and 'CB15' (15% corn oil + 85% diesel) fuel recorded losses in exergy and energy transfer through exhaust gases to be lowered than diesel fuel while higher exergy destruction was observed for 'CB8' and 'CB15' than diesel at different engine speeds. The influence of engine speeds on exergy destruction, thermal efficiency and exergetic efficiency is indicated by the decreasing trend of brake power for diesel-corn oil blends having LHV than diesel. Diesel fuel obtained the highest values of "exergetic efficiency" and 'thermal efficiency' with lower exergetic efficiency than thermal efficiency under the same conditions that are explained through the exergy destruction, i.e., conversion of work exergy from small amounts of fuel exergy which is in consistent with [17,18]. Elimination of exergy destruction reasons through exergy destruction in the form of exergy loss with major fraction of fuel exergy is required for higher efficiency. The second reason to improve exergetic efficiency through the minimization of the exergy losses in the exhaust gases can be achieved by recycling the exhaust gases. 'CB8' and 'CB15' offered similar exergetic and thermal efficiency to that of 'diesel' fuel. Nabi et al. [19] demonstrated higher exergy than energy for all the tested fuels. The three biodiesel blends viz. MD (30 %Macadamia Biodiesel + 70%Diesel), WD (30%Waste Cooking Biodiesel + 70%Diesel) and MWD (20%Waste Cooking Biodiesel + 10%Macadamia Biodiesel + 70%Diesel) recorded lower energy and exergy compared to diesel because of the lesser LHV of the biodiesel blends. Gokalp et al. [20] identified increase in engine performance with biodiesel as fuel and an enhancement in emissions of exhaust as equated to 'diesel'. The addition of 'biodiesel' in several ratios to diesel fuel increases the exergy efficiency. However, irreversibilities in the system cause exergy destruction through the exhaust gas and heat transfer resulting in the decrease of system efficiency. Gogoi [21] reported higher fuel exergy for 'KSOME' (Koroch seed oil methyl ester) fuel blends than 'NRL diesel' at diversified loads which attributes to more atoms of C (Carbon), H (Hydrogen) and O (Oxygen) in combination with higher flow rate of fuel for the blends. . 'KSOME' blends observed lesser exergy losses with heat transfer compared to 'NRL diesel'. 'KSOME' fuel blends observed more total heat loss that consisted the heat losses responsible for engine cooling as well as unaccounted heat loss with lower exergy heat transfer because of lower cylinder temperature for the fuel blends.

. 'Exergy' loss through the transport of heat was observed very smaller in comparison to input exergy of fuel recording minimum loss in exergy with heat transfer for B20 (80%KSOME + 20%Diesel) blend than other blends at all engine loading conditions. Losses through exhaust exergy for 'KSOME' blends were observed marginally higher at loads in comparison to 'NRL diesel' due to the combined effects of elevated EGT, molar coefficients with slightly more values in addition to higher molar fuel flow rate. At all engine loads, exergy destroyed was greater for 'KSOME' blends compared to 'NRL diesel' fuel with B10 (90%KSOME + 10%Diesel) showing a slight reduction at 25% load. Notably, B40 (60%KSOME + 40%Diesel) showed the maximum rate of exergy destroyed at all loading conditions due to irreversibility allied with mixing of air-fuel and combustion. Lower combustion efficiency for B40 ensured incomplete combustion. 'KSOME' blends observed lower exergetic efficiencies and B40 in particular at all loads compared to diesel fuel operation. Das et al. [22] recorded higher fuel exergy rate for blended fuels (waste plastic oil) compared to diesel fuel and exergetic efficiency showed an increasing trend for blended fuels with increasing load while it decreases with rise in concentration over diesel conforming to the thermodynamic viewpoint with irreversibilities leading exergy destroyed that caused in blended fuels. Paul et al. [23] stated consistently lower exergy efficiencies than engine brake thermal efficiency for different percentages of ethanol owing to the reason that thermodynamic irreversibilities resulted in the loss of a portion of input energy in the processes like burning of fuel, comprehensive chemical reactions, rigorous heat transfers and mechanical friction etc [24]. 'D35E15B50' blend with 15% ethanol in it showed the highest "exergy efficiency" and "brake thermal efficiency" of the engine with its significant improvement in exergy efficiency and brake thermal efficiency paving the way to utilize the energy from chemicals of fuel and converting that energy into work effectively. Tiwari et al. [25] identified a similar pattern for the engine's exergy efficiency and thermal efficiency of the fuel blends tested noticing lower exergy efficiency than thermal efficiency with a difference of 3-6% under identical conditions. Inlet exergy rate which is the obliteration of most of the fuel exergy fed the transformation of a small quantity of work exergy into low energy effectiveness by the fuel [24,26]. Higher values of both efficiencies were observed for diesel fuel compared to other types of test fuels due to its higher calorific value. However, exergy flow was slightly decreased with the more quantity of biodiesel in the mixture resulting from the increase in fuel consumption because of lower calorific value and fuel's chemical makeup. The exergy for diesel was found to be 31.06%, 18.35%, 46.14% and 4.43% for brake power, exhaust rate, destruction rate and heat transfer rate respectively. However, a declining trend in 'brake power' was observed for other tested fuels with 'SBF20' (20%Spirulina microalgae biodiesel + 80% Diesel), 'SBF40' (40%Spirulina microalgae biodiesel + 60% Diesel), 'SBF60' (60%Spirulina microalgae biodiesel + 40% Diesel), 'SBF80' (80%Spirulina microalgae biodiesel + 20% Diesel), and 'SBF100' (100%Spirulina microalgae biodiesel) with its decreased value obtained as 30.79%, 30.57%, 30.35%, 30.09%, and 29.75% respectively that resulted a fall in power output owing to the lower calorific value of the biodiesel blends [27]. An increasing trend was observed for the exergy through the exhaust and heat transfer due to the intensifying flow rate of exergy exhaust gas resulting from fuel mixture consequent to incomplete combustion of hydrocarbons with more long chain in the fuel that exhibited an increase of exergy exhaust rate by 18.35%, 18.4%, 18.46%, 18.54%, 18.7% and 18.86% and exergy transfer rate by 4.43%, 4.5%, 4.56%,4.62%, 4.69% and 4.77% for 'SBF20', 'SBF40', 'SBF60,' 'SBF80', and 'SBF100' respectively. During combustion, major portion of the energy input was reported to be lost in transforming a tiny portion of it into exergetic work during an engine cycle and exergy destruction accounts for the main segment of the 'input exergy' lost [28,29] with an increasing trend for increased blend ratio being observed for 'SBF20', 'SBF40', 'SBF60', 'SBF80', and 'SBF100' that 46.14%, 46.29%, 46.39%, 46.47%, 46.51%, and 46.61% respectively.

3. CONCLUSIONS

Exergy analysis conducted on compression ignition engines powered by different fuels revealed improvement in exergy-energy with improved combustion from enhanced oxygen content thereby reducing the thermodynamic irreversibilities which in turn minimizes the energy-exergy losses and exergy destruction rate. An increasing trend in fuel exergy and exergy destruction rate was found for increased engine speeds. Higher efficiency can be achieved through the elimination of exergy loss through the major fraction of fuel exergy and the recycling of exhaust gases.

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ECONOMIC GROWTH AND SUSTAINABILITY: DEBATING THE PROS AND CONS OF DEGROWTH AND GREEN GROWTH

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ABSTRACT
"Degrowth" and "Green Growth" are two contrasting concepts that propose various approaches to addressing the environmental and social problems of the modern world. As a viable alternative to the standard growth-based economic paradigm, the concept of degrowth has gained traction in recent years. To achieve ecological sustainability and social equality, this strategy advocates reducing economic activity and consumption. Simultaneously, green growth has also come into existence as a plan for attaining sustainability through technical development and innovation. By focusing on the role of technology, this essay examines how different methods work together and where there are conflicts in the context of a sustainable economy.
Keywords: Degrowth, Green Growth, Sustainable Economy

INTRODUCTION
The existing economic system is predicated on the idea that wealth and social advancement can only be attained via sustained economic growth. However, environmental deterioration, climate change, and resource depletion are also connected to economic expansion. Alternative approaches, such degrowth and green growth, have emerged as a result of the necessity to solve these environmental issues. Green growth tries to reconcile economic development with environmental sustainability through the adoption of greener technology and policies, whereas degrowth opposes the dominant growth-centric paradigm by pushing for a decrease in economic output. Both the degrowth and green growth storylines depend heavily on technical development, with proponents claiming that these developments may boost productivity, resource conservation, and environmental protection.

According to the premise that economic growth and environmental sustainability can be achieved simultaneously through the use of technology, innovation, and market-based mechanisms, United Nations Environment launched the Green Economy Initiative (GEI) in 2008, and the green economy in the context of sustainable development and poverty eradication was placed on the 2012 Rio+20 agenda and was acknowledged as a tool for achieving sustainable development.

It promoted green growth as a strategy for achieving sustainable development. Investments in renewable energy, energy efficiency, and environmentally friendly transportation were among the policies and investments that were encouraged by the project. Green growth gained popularity in the years that followed, and other governments and international organizations adopted the idea as the foundation for their sustainability plans. The success of green development policies in reaching sustainability objectives, however, is still up for discussion. Some detractors claim that they fall short in addressing the underlying causes of environmental problems.
The idea of degrowth was developed in reaction to the perceived limitations of economic growth as a barometer of sustainability for both the environment and human well-being. Its foundation is the idea that pursuing economic growth is inimical to ecological sustainability and that, in order to secure a sustainable future, economic activity must be reduced.

Both the degrowth and green growth storylines rely heavily on advances in technology. Technological development has the potential to encourage renewable energy sources, improve resource efficiency, and lessen pollution. Technology is considered from a degrowth viewpoint as a way to facilitate sufficiency-oriented actions and support sustainable living. Instead, advocates of green growth see technology advancement as a catalyst for eco-efficiency and decoupling, seeking to balance economic growth with environmental sustainability.
This paper provides a critical review of the of degrowth and green growth concepts and the role of technology embedded in those concepts for achieving sustainability goals. The complicated interactions between degrowth, green growth, and technological advancement are analyzed. A qualitative methodology; critical analysis is adopted for evaluation and interpretation.

DEGROWTH

Theoretical Foundations

The core principle of the degrowth concept is typically stated as follows: ‘’an equitable downscaling of production and consumption that increases human well-being and enhances ecological conditions at the local and global level, in the short and long-term’’ (Kerschner, 2010).

Degrowth has theoretical foundations in a variety of fields, such as social ecology, post-development theory, and ecological economics. These pillars offer the theoretical framework for challenging the preeminent growth-based economic paradigm and putting forth substitute theories of sustainable societies. Ecological economics emphasizes the necessity to take into consideration the planet's ecological boundaries by higlighting the interconnectedness of the economy and the environment. By contesting the notion that ongoing economic expansion and ecological sustainability are compatible, degrowth builds on this viewpoint. It contends that ongoing growth in both production and consumption can result in social inequality and permanent environmental deterioration.
Degrowth emphasizes the necessity for fundamental societal changes to address ecological and social crises, which is consistent with social ecology. It calls into question the exploitative and hierarchical structures that are part of the current growth-oriented economy and promotes more inclusive and democratic forms of government.

Degrowth's foundational tenets and presumptions serve as the cornerstone for its vision of a sustainable society:
a) Redefining Well-Being: Degrowth questions the prevailing emphasis on material acquisition and economic growth as indicators of well-being. It promotes the use of alternative metrics that place a higher priority on livability, equality, and environmental health.
b) Sufficiency and Post-Growth: Degrowth encourages a transition away from excess and toward sufficiency. To promote an equitable allocation of resources and reduce negative environmental effects, it argues for lowering excessive consumption and production levels. This requires reassessing society ideals and objectives beyond monetary gain, as well as challenging the dominant consumerist culture.
d) Ecological Limits and the Need for a Steady-State Economy: Degrowth acknowledges the limited nature of Earth's resources and the necessity of maintaining ecological boundaries. It suggests a changeover to a steady-state economy that runs within the range of ecosystems' carrying capacities.

Criticisms and Problems

Degrowth, although having the potential to be a transformational paradigm, is subject to several criticisms and difficulties:
a) Political Feasibility: Degrowth plans would encounter considerable political and social obstacles.Deeply ingrained in society, the growth-oriented mindset may be resistant to systemic adjustments. Without addressing political power structures and creating social agreement, it may be difficult to win widespread support for degrowth policies and make the switch to alternative economic models.
b) Distributional Concerns: Degrowth, according to critics, might make inequality worse if it isn't implemented with due consideration of these issues. Reducing consumption and production might have a particularly negative impact on marginalized groups, who depend on economic expansion to raise their standard of living. Social justice and equality are emphasized by proponents of degrowth as essential elements of the transition.
c) Technological Innovation: Skeptics doubt that degrowth will be sufficient to overcome environmental issues.

GREEN GROWTH

Theoretical Foundations

In academic and policy discourse, green growth is the preeminent anticipatory-utopian idea for how to attain environmental sustainability. (Kenis and Lievens, 2015). By fostering resource efficiency, low-carbon technology, and ecosystem preservation, the notion of "green growth" aims to bring economic growth and environmental sustainability into harmony. It highlights the possibility of economic expansion while limiting environmental damage and attaining sustainable development objectives. The idea that environmental preservation and economic development may coexist and create a positive feedback loop is sometimes linked to "green growth."
The idea of "green growth" acknowledges the need for innovation and economic transformation to solve environmental issues. It places a strong emphasis on using greener technology, resource-wise manufacturing methods, and behaviors. Green growth seeks to break the link between economic growth and environmental deterioration by incorporating environmental concerns into economic policies and decision-making.

a) The Wellbeing Principle: The green economy is people-centred and focuses on growing wealth to support wellbeing, with opportunities for green livelihoods, enterprises and jobs.
b)The Justice Principle: The green economy promotes equity within and between generations by sharing decision-making, benefits and costs fairly, avoiding elite capture, and supporting women's empowerment. It takes a long-term perspective and is based on solidarity and social justice, strengthening trust and social ties, and supporting human rights.
c)The Planetary Boundaries Principle: The green economy recognizes and nurtures nature's diverse values, employs the precautionary principle to avoid loss of natural capital, and invests in protecting, growing and restoring biodiversity, soil, water, air, and natural systems.
d)The Efficiency and Sufficiency Principle: The Efficiency and Sufficiency Principle of the green economy focuses on sustainable consumption and production, limiting resource consumption to physically sustainable levels, and creating a social floor of basic goods and services. It also aligns prices, subsidies and incentives with true costs to society and benefits those who deliver inclusive green outcomes.
f)The Good Governance Principle: The green economy is guided by integrated, accountable and resilient institutions that are evidence-based, deploying both sound science and economics along with local knowledge. It requires public participation, prior informed consent, transparency, social dialogue, democratic accountability, and freedom from vested interests in all institutions. It promotes devolved decision-making for local economies and management of natural systems while maintaining strong common, centralized standards, procedures and compliance systems.

Limitations and Criticisms
Despite the fact that it has the potential to be a paradigm shifter, green growth has been met with a number of objections and challenges, including the following:
Economic expansion, even when it is "green," can nevertheless result in overconsumption, ecological overshoot, and social inequality.
a) Insufficient Systemic Change: Green growth strategies frequently concentrate on enhancing current economic systems' technical and operational efficiency without addressing underlying structural problems. But besides technology advancements, real sustainability necessitates radical adjustments to economic institutions, consumer habits, and cultural values.
b) Concerns about fairness and distribution: Green growth plans could not effectively address equity and distributional issues. The advantages of green growth could not be equally spread, leaving disadvantaged populations and marginalized areas behind. To prevent escalating inequality, it is crucial to make sure that green growth policies place a priority on social justice and inclusion.
c) Ecological constraints: Planetary boundaries and ecological constraints may not be properly taken into consideration by green growth. Despite technological advancements, the level of economic activity may still be greater than the planet's carrying capacity.

SYNERGIES BETWEEN DEGROWTH AND GREEN GROWTH AND THE ROLE OF TECHNOLOGY
Although their theoretical underpinnings and methods of operation are distinct from one another, degrowth and green growth do have some goals in common and can complement one another. Although they do so in different ways, each of these goals hope to advance sustainable development and provide solutions to environmental problems. The following are some potential areas of overlap between degrowth and green growth, as well as synergies between the two:

a) Resource Efficiency: Both degrowth and green growth stress the significance of resource efficiency in terms of its role in mitigating the effects of human activity on the environment. Both of these strategies have the potential to lessen the impact that economic activities have on the environment by cutting down on resource use and waste.
b) Localism and Community Resilience: Degrowth promotes locally-based economies that are decentralized, whereas green growth places an emphasis on the significance of community resilience and empowerment. Both strategies acknowledge the potential advantages that may be gained through community-based initiatives and other types of economic models.
c) Low-Carbon Technologies and Renewable Energy Sources: Both degrowth and green growth place a high priority on the implementation of low-carbon technologies and renewable energy sources in order to curb greenhouse gas emissions and slow the progression of climate change.
d) Ecosystem conservation and Restoration: Both degrowth and green growth acknowledge that the conservation and restoration of ecosystems is an essential component of sustainable growth. Both of these techniques have the potential to strengthen the resilience of ecosystems and to preserve biodiversity if natural capital is valued and given priority.

In this context, technological advancements might act as a link between the degrowth and growth-oriented perspectives on sustainability. Degrowth approaches promote lowering resource use and placing a higher priority on well-being and ecological balance, in contrast to growth-oriented approaches, which are concerned with growing economic production and consumption. Both approaches might potentially benefit from the following technological advancements:

Efficiency and resource optimization: Technological developments can allow for a more effective use of resources, decreasing waste and adverse effects on the environment. For instance, advancements in smart grids, renewable energy systems, and energy-efficient technologies support sustainable energy production and consumption, fitting with both degrowth and growth objectives.

Circular economy: Technology is essential in the move from the linear "take-make-dispose" paradigm to the circular economy, which maximizes resource utilization. Innovations like 3D printing, sophisticated recycling techniques, and materials science can make it possible to reuse, repair, and remanufacture things, hence eliminating waste and the need for ongoing resource extraction.

Digitalization and the Sharing Economy: The development of the sharing economy has been aided by the development of digital technology. By emphasizing access over ownership, platforms for ride-sharing, home-sharing, and collaborative consumption allow for the more effective use of resources. Sharing economy models can increase economic possibilities while lowering overall demand for products and services.

Sustainable Infrastructure: Infrastructure that is sustainable may be built with the help of technological developments in urban design, transportation, and construction. For instance, smart city projects incorporate data and technology to improve waste management, transportation, and energy consumption. Such infrastructure encourages economic development while reducing the negative effects of urbanization on the environment.

Information and communication technologies (ICT): Information and communication technologies have advanced to the point that they now allow for teleconferencing, digital communication, and remote work, which reduces the need for physical travel and the carbon emissions it produces. Technology may promote degrowth goals by lessening the need for ongoing economic expansion based on physical production and consumption by enabling virtual cooperation and distant access to services.

Innovation and Research: Technological advancement frequently results from research and invention. Promoting research in clean energy, environmental solutions, and sustainable technology may boost economic growth and further sustainability objectives. This involves financial investments in fields like eco-friendly chemistry, sustainable agriculture, and renewable energy.

It's crucial to remember that, even if technical development might offer useful instruments for sustainability, it also necessitates systemic adjustments and changes in society values. A comprehensive strategy that integrates technical innovation with social, economic, and cultural developments is essential to achieving long-term sustainability.

CONCLUSIONS

The methods of degrowth and green growth may, despite the possibility of synergies, also confront the possibility of competing agendas and trade-offs. Green growth highlights the possibility for sustainable economic expansion, whereas degrowth emphasizes the necessity for total economic activity to be reduced to remain within ecological boundaries. Degrowth and green growth are both aspects of the same concept. This basic difference in goals may rise to conflicts and discussions over the optimal approach to sustainability, which can be quite frustrating for everyone involved.

In addition, measures that promote green growth may place a higher priority on economic growth than on other social and environmental goals, which might result in possible trade-offs and disputes.
In a similar vein, degrowth programs could run into problems when trying to strike a balance between their environmental goals and the requirements of society and the economy, particularly in developing nations where issues of poverty and inequality continue to be serious problems. It is necessary to provide thorough analysis and use a holistic approach while pursuing sustainability in order to prevent unforeseen consequences and strike a balance between conflicting agendas.

Findings of theoretical underpinnings, key concepts, criticisms can be summarized as follows;

- Degrowth and green growth aim for sustainability but use different methods. Green growth uses technology and efficiency to support economic development, whereas degrowth reduces economic activity to keep within ecological boundaries.

- Technological advancement can reconcile degrowth and green growth, enabling more sustainable production and consumption. But technological development alone is insufficient and requires systemic adjustments.

- Degrowth and green growth may work together in ways like resource efficiency, localism, and the use of renewable energy. The recognition of these synergies and their use can improve sustainability initiatives.

- Management of degrowth-green growth conflicts and trade-offs is required. Equity, distribution, and growth paradigm constraints must be considered while balancing economic, social, and environmental goals.

By making it possible to adopt production methods and consumption habits that are less harmful to the environment, advances in technology have the potential to play a pivotal part in bridging the gap between degrowth and green growth. The development of new technologies has the potential to cut down on resource use, boost energy efficiency, and encourage the use of renewable energy sources. In addition to this, it can make the transition to a circular economy easier, which is one in which waste is reduced as much as possible and resources are recycled and reused.

Additionally, technology advancement has the potential to assist in mediating the conflicts that exist between degrowth and green growth. It has the potential to enable more sustainable economic growth while simultaneously decreasing the consequences on the environment. Nevertheless, the advancement of technology by itself might not be enough to solve the systemic problems that exist in regard to sustainability. Transformational shifts are required in the ways that economic institutions, consumer habits, and society values operate concurrently with this shift.

As technical advancement and innovation are presumed to be the primary drivers of green development, the topic of technology will continue to be at the center of the argument between green growth and degrowth. As a result, it is of the utmost importance to analyze technology in terms of the potential it possesses to accomplish sustainable progress. How the capacity of technology to maintain long-term green growth and build a sustainable society can be objectively evaluated is an important topic that needs to be answered, and it is one that has not yet gotten adequate attention from the scientific community. This is a vital subject that both proponents of green growth and degrowth need to address.

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PLASTIC RECYCLING IN A R&D OFFICE: RECYCLING OF PLASTIC WASTE AS GRANULES AND FIBRE

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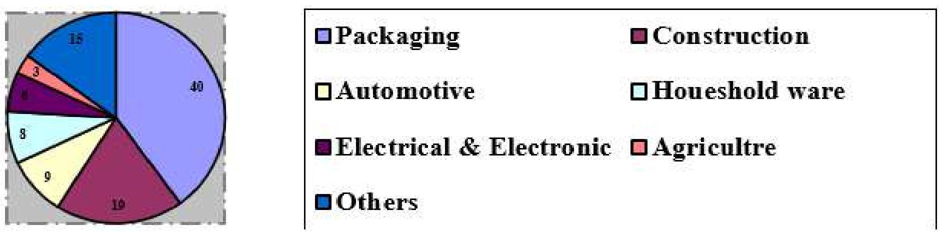
ABSTRACT

As of 21st century, humanity reached the maximum amount of plastic consumption of all time. Those plastic products that used by us are not biodegradable products, so, they aren't dissolve in nature. Therefore, plastic wastes are causing global plastic pollution. In recent years, plastic pollution has exceedingly come into question. Wherefore, scientific community is getting more related to plastic pollution and waste management subjects. Along with recent studies and researches it has put forth that waste management could efficiently realise in daily life, with a set of actions. As one of the places where the most plastic consumption concerned, in office mediums could realise efficient plastic waste management. In this study, a project that running by Formfleks R&D Leadership has explained. R&D centre has successfully realised recycling of plastic wastes as granules and fibre for processing in mass production systems. The investment necessities of R&D centre for plastic recycling have determined initially. Subsequently, with a decision-making process which performed with integrated usage of NPV and maximum regret value methods the optimum investment has selected and realised. Afterwards, the obtaining of granules and fibres process has carried out. With this study, Formfleks R&D Leadership has started to contribute to ecology and economy by plastic recycling.
Keywords: Plastic recycling, green technology, plastic granules, plastic fibre, plastic waste

1. INTRODUCTION

Monomers are simple structures which formed by petrochemicals alike carbon, hydrogen, oxygen, nitrogen, and other organic or inorganic elements. And plastic is a name that given to the materials which synthesized by breaking the bond from monomers and transforming them into long and chained structured called polymer (Harper, 2006). Since the invention of first plastic polymer in early decades of the 20th century, the development and increment of the plastic polymer varieties has continued (Worrell & Reuter, 2014). Nowadays, the early 21st century, plastics have a plenty of key use. The following table shows the industries' ratio of the plastic usage.

Table 1. Key applications of plastics



Plastic products have a big number of species. The most common plastic products in the world might queue up respect to their usage proportion among other species as: PP (polypropylene) by ratio of 19 %, LD&LLD-PE (Low-density and linear-low-density polyethylene) by ratio of 17 %, PVC (polyvinyl chloride) by ratio of 13 %, HD-PE (high-density polyethylene) by ratio of 12 %, PETE (polyethylene terephthalate) by ratio of 7 %, PS & EPS (polystyrene and expanded-polystyrene) by ratio of 7 %, PUR (polyurethane) by ratio of 6 % and other plastics such as PC (polycarbonate), PMMA (polymethyl methacrylate) etc. by ratio of 19 % (Andrady & Neal, 2009). It might be said that the number of plastic products varieties is noticeably much. This caused by the society's specific demands.

As a consequence of the plenty usage of plastic products, the global plastic pollution has increased dramatically. Plastic pollution is the accumulation of the plastic products in micro-, meso- or macro- dimensions as some sub-branches of them (such as microbeads, clippings, spalls etc.) which adversely affect the entire taxons of the ecosystem (Parker, 2018) (Hester & Harrison, 2011). In a global perspective, it might clearly be said that plastic pollution has many effects. Those adverse affection might come to an end by efficient integration of instructions and actions. In context of this study a process which has aimed to realise an efficient recycling of plastics products in office medium and transforming them into a ready-to-use situation.

The recycling of plastic products might perform both chemical and physical methods. Chemical recycling of plastic products might contains some kind of chemical processes such as hydrolysis, methanolysis, aminolysis, glycolysis for the purpose of total depolymerisation into monomers or partial depolymerisation into oligomers and other products (Chen, Chen, Lo, Mao, & Liao, 2001)(Guclu, Yalcinyuva, Ozgumus, & Orbay, 2003) (Ikladious, 2000) (Jankauskaite, Macijauskas, & Lygaitis, 2008) (Karayannidis & Achilias, 2007) (Kurokawa, Ohshima, Sugiyama, & Miura, 2003) (Spychaj, Fabrycy, Spychaj, & Kacperski, 2001) (Shukla & Harad, 2006). Therewithal some kind of chemical recycling techniques which depends on high temperature and high pressure has put forward such as pyrolysis, hydrogenation, and gasification (Goodship, 2007). On the other hand, physical recycling is the most common recycling type of plastics products in literature and in industry. Physical recycling has a specific pathway to perform: Collecting, pre-treatment, and re-extrusion (Ulcay, 2004). Those steps may adapt in various processes according to the recycling aims.

Collecting the plastic wastes is the first step in a physical recycling process. Following step, pre-treatment, may has various sub-steps in itself. Such as sorting, classification, climatization, cleansing, pelletising etc. These sub-steps might augment and enhanced, depending on necessaries and main goal (Worrell & Reuter, 2014). Finally, the last step is re-extrusion which contains extrusion of plastic agglomers. This re-extrusion might perform in diverse machining procedure in order to re-product different ultimate products, such as granules, fibres, felts, non-wovens etc.

In office medium, there are a big number of plastic wastes for instance plastic jugs, bottles, covering films, disposable drinkware, straws, cutlery, etc. Therewithal, parallel to the plastic waste amount, the potential of recycling and regaining arise. There is sort of actions would take in office medium to recycle of plastic for sustainability and green technology. Yet, it is known that all companies have their own mechanisms while running. Therefore, all companies shall develop their idiosyncratic sustainability actions. This study has aimed to put forth a new point of view for efficient plastic recycling.

Formfleks Co. is a company that run their productions in the NVH sector, in automotive industry, as a subsidiary organisation of Erkurt Holding Incorporation. For adaptation to green technology, Formfleks Co. has initiated several projects, for a while. R&D Leadership is one of the most critical units in Formfleks Co. The leadership aims to adding value to sustainability and development. So, this study has performed in R&D Leadership in Formfleks Co. for the purpose of set an example for other companies.

2.THEORETICAL METHOD

Theoretical method of this study has determined by the R&D researchers' consensus. Researchers has formed a crew with a view to transform their R&D office into a new office that adds value to science and production, in a green perspective. And in this section, it would explain that the ideal recycling system and its operations that has put forward by the crew to be applied in Formfleks R&D Leadership.

The ideal recycling system has determined as "a system which transforms the collected plastic rejectamenta from office into the material for mass-production with low energy consumption". Therefore, the main structure of the system has determined alike in the literature as collecting, pre-treatment, and re-extrusion (Ulcay, 2004). And sub-steps of ideal recycling system have determined as collection of rejectamenta, sorting by kinds, washing to cleanse impurities, drying, shredding and agglomeration, re-extrusion (Worrell & Reuter, 2014) (Goodship, 2007). By those steps, the recycling system that going to be formed in office has designed. But system will be sustained by production-feeding by the shipping of materials that has re-produced and the utilisation of them in mass-production. Theoretical contributions which expected from system, in perspective of green technology and cost analysis, has forecasted. Net present value (NPV) and maximum regret value approach has utilised for forecasting calculations. Following equation has used:

$$NPV(i,N) = \sum_{t=0}^{N} \frac{R_t}{(1+i)^t}$$

Equation 1. Net present value formula

3.EXPERIMENTAL METHOD

3.1. Collection of The Rejectamenta

Initially, sundry of instructions that inform people about plastic pollution and the recycling potential of office has hung on walls, desks, panels, boards, and other stuff which are in-use. Especially, the ones that placed in which R&D members might be situated together and may use plastics most such as meeting rooms, lounge, terrace, parlour, etc. And it has observed that R&D members gotten more conscious about the plastic wastes. And then a set of awareness classes has held about plastic pollution and plastic recycling. The main purpose of these actions was making all R&D member attended to recycling process. Thus, the collection of the plastic rejectamenta has realised by all of the members and the mass of obtained waste has increased.

3.2. Pre-treatment

In pre-treatment process, there are 3 sub-operations. Those operations are sorting the wastes by type, washing them to cleanse impurities and drying them. The sorting of the plastic wastes has a critical effect in recycling system because all type of plastic has idiosyncratic re-processing conditions. Such as, while it is appropriate to dry polyethylene terephthalate in 70 oC the drying process of low-density polyethylene has to been limited in 50 oC, maximum. Therewithal, while PET is suitable to extrude as fibre, cellophane is suitable for granulation. Hence, the sorting of the wastes has made by their type. Then entire plastic wastes which have sorted, washed with 96 % pure isopropanol. Isopropanol treatment has applied as antimicrobial and antiviral. After that, wastes have placed into drying ovens. Afterwards, plastics products have washed with sodium hypochlorite solution that contains circa 11% active chlorine. This application has aimed to cleanse rejectamenta from other impurities. Then, rejectamenta have washed by pure water to neutralise the pH. And the last drying process has realised in a drying oven for special condition of each plastic type. The conditions have shared in following table. Subsequently, the plastic wastes have sheared in a shredder to made them easy to process. Finally wastes have agglomerated as determined weights by melting for re-extrusion process.

Table 2. Drying conditions of each plastic type

Plastic Type	Climatization Conditions (°C, % relative humidity(rh.))	Drying Time (h)
Polyethylene terephthalate (PET)	70 °C, 50 % rh.	1 h
High-density polyethylene (HDPE)	60 °C, 50 % rh.	1 h
Polyvinyl chloride	40 °C, 50 % rh.	1 h
Low-density/linear-low-density polyethylene (LD/LLD-PE)	50 °C, 50 % rh.	1 h
Polypropylene (PP)	60 °C, 50 % rh.	1 h
Polystyrene (PS)	70 °C, 50 % rh.	1 h
Cellophane	40 °C, 50 % rh.	1 h

3.3. Re-extrusion

There are two types of re-extrusion methods in this study's context: granulation and fibre extrusion. Re-extrusion process has started with the classification of materials by their suitable re-extrusion method and the classification has shared in Table 3. Re-extrusion processes has performed by melted plastic agglomers. The melting point of each plastic type would seen in following table, as well.

Table 3. Suitable re-extrusion methods and melting points of each plastic type

Plastic Type	Suitable Re-extrusion Method	Melting Point (°C)
Polyethylene terephthalate (PET)	Fibre extrusion	260 °C
High-density polyethylene (HDPE)	Fibre extrusion	~125 °C
Polyvinyl chloride	Granulation	~180 °C
Low-density/linear-low-density polyethylene (LD/LLD-PE)	Granulation	~130 °C
Polypropylene (PP)	Fibre extrusion, granulation	~160 °C
Polystyrene (PS)	Granulation	~230 °C
Cellophane	Granulation	~175 °C

Melting the plastic agglomers has performed circa their melting points with upper tolerances. Afterwards the melting process, extrusion process has performed by granulator or fibre-extruder. Granules' dimensions have determined respect to mass production's needing. For example, granules which utilised for lamination in production system has structured smaller than others, circa 1mm diameter. Contrary, granules which utilised for sheet-making, structured greater than others, circa 3mm diameter. Similarly, fibre extruder has set-up for the demands of production responsible. For instance, fibres' which will been utilised as additive for other products, has structured with less l/d (length/diameter) ratio than others. On the other hand, the fibres' which will been utilised as raw material of felts structured respect to production's instructions. At the end of the re-extrusion process, fibres and granules which has obtained, has shipped to the production site.

4. RESULT AND DISCUSSION

In theoretical method, it has said that NPV and maximum regret value approach has applied to find the optimal investment for the recycling process. The optimal decision which means alternative that has the optimal integration of greatest NPV, and smallest maximum regret value has determined as realising the investment of granulator and fibre extruder. The optimal investment result might change for company by company. Hence, the result that shared in this study is a subjective investment advice. Therewithal, plastic rejectamenta have re-produced respect to the mass production's demands, successfully. And these recycled products have utilised in mass production featly. Some of recycled products might be seen in following figures. The chemicals that used in washing processes are optional. Hence, the chemicals might change according to facilities opportunity and expectations. For instance, hydrogen peroxide might use instead of sodium hypochlorite. But the results could be affected adversely or affirmatively by the various chemicals.

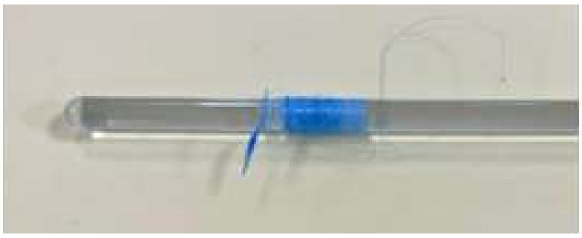


Figure 2. HDPE fibre

5. CONCLUSIONS

The best investment determined as the procurement of the granulator and fibre extruder for Formfleks R&D Leadership. Beyond this, the study has put forth that it is possible to form a recycling system upon plastic office rejectamenta with a number of investments. Therewithal, the study has shown that plastic recycling would be suitable for a R&D centre. Hence, it is clear that study has contributed to literature and industry by the recycling of the plastics. Also, study has also contributed to plastic washing and drying method by suggesting chemicals which is hard to seen in similar studies.

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PLANNING PORTS IN CHANGING CLIMATE - SEA LEVEL RISE AND FLOATING PORTS

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ABSTRACT
Most studies on ports, seen as an important greenhouse gas emissions source, focus on options to mitigate emissions from port operations. In parallel with this, effective implementation of port energy management, technical and operational solutions to increase the energy efficiency of the port, and environmentally friendly new technologies come to the fore. However, predictions of the scale, timing, and location of the consequences of climate change caused by greenhouse gas emissions are often uncertain. Therefore, although global warming and climate change are tried to be slowed down by reducing emissions, climate change threats continue to be at our doorstep as long as greenhouse gas emissions cannot be reduced to zero. Sea level rise is an indicator of climate change that will have an impact on port facilities over this century and potentially beyond. The rate of future sea level rise will vary according to emission scenarios and is regionally and locally affected by physical and magnetic changes in the earth. The rate of sea level rise is vital at the planning and design stages of conventional port facilities when both mean and extreme sea level changes are considered. The floating port designs highlighted in this study promise significant advantages over conventional port designs in terms of economic, environmental, and sustainability. In addition, the opportunity to optimize methods such as maintenance/upgrade/adaptation to enable appropriate security and operational levels with floating port structures will significantly contribute to the operational sustainability of ports. In summary, rising sea levels triggered by greenhouse gas emissions and climate change, which is today's hot topic, may cause conventional port infrastructures to be flooded and lose their function. This study applies an in-depth analysis of floating port alternatives so that maritime transport will be less affected by this situation and presents preliminary results.
Keywords: Port Planning, Sea Level Rise, Floating Ports, Climate Change

1. INTRODUCTION
The construction of a port is a challenging process, starting with the resolution to start planning, calculating the environmental forces of the construction area, and determining its technical and operational characteristics (Thoresen, 2010). Of course, the economic and financial dimensions of the project cannot be ignored. In this complicated planning and construction phase, it is becoming more important today that technical analyzes are carried out more sensitively and as far from assumptions as possible, together with climate change. However, the uncertainty of the consequences of climate change in terms of scale, timing and location particularly causes hypothetical forecast thresholds to be considered high.

Although the mean and extreme sea level in the port area is calculated and predicted for the future within the scope of environmental forces, the effect of sea level rise (SLR) on the port facilities is expected to be felt more severely with climate change. In fact, SLR due to climate change may cause some existing ports to be flooded or lose some of their functions. To prevent these ports from being affected by SLR, scheduled maintenance/upgrade/adaptation should be done by maintaining the desired security and operation standards in scenarios with varying risk levels. On the other hand, a future-view in-depth examination of the mean and extreme sea-level changes during the planning and design phase of new ports can prevent those ports from being submerged. In addition, alternative port structures that can adapt to SLR caused by climate change can help to ensure the sustainability of maritime transport. The general approach to these alternative port structures is floating ports that can show flexibility to adapt to SLR.

Most studies in the field of floating ports have only focused on increasing the capacity or operational flexibility of existing conventional ports. In other words, the use of floating ports as an alternative to conventional ports to cope with SLR has not been investigated. Therefore, it is still not known whether floating ports can actually cope with the SRL that is predicted to occur with climate change. Therefore, this paper attempts to show the general technical features of floating ports and analysis the pros and cons of floating port alternatives for SLR that can impact maritime transport sustainability.

2. SEA LEVEL RISE PROJECTION

Due to their location, the first units to face the SLR threat are the ports. Although ports are not permanently affected by the increase in sea level today, ports in various parts of the world have been flooded as a result of natural disasters such as hurricanes, floods, earthquakes and tsunamis, and their operations have been disrupted (Barbier, 2015; Binder et al., 2015; Tomita et al., 2013; Wadey et al., 2015). SLRs of about 20 cm in the 20th century and more than 1 meter in the 21st century have been observed (Church et al., 2013). In addition, according to the SLR projection, this increase is expected to continue, as in Figure 1 (Stocker et al., 2014). Changes in sea level from past to present and future SLR forecasts clearly reveal the threat facing ports. Therefore, the threat of SLR forces ports to review their current operational strategies to reduce emissions and contribute to slowing global warming. Also, ports have to revise their existing and planned infrastructures against possible future floods.

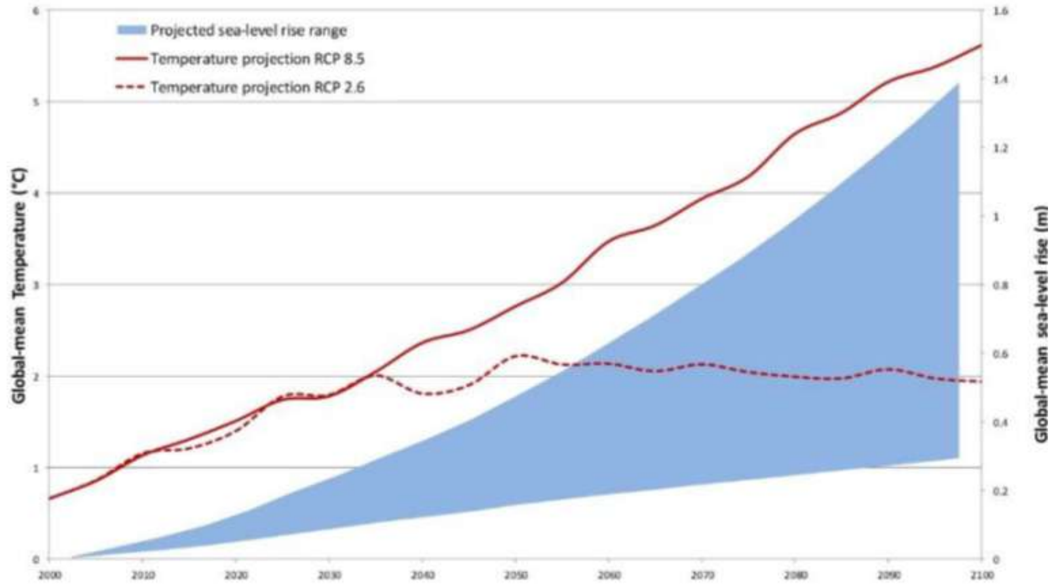

Fig.1. Projected global-mean temperature and corresponding global-mean sea-level rise (RCP2.6 and RCP8.5 scenarios)

The default limits in Figure 1 represent the Intergovernmental Panel on Climate Change's (IPCC) lower and upper emission scenarios. These lower and upper limits represent a scenario in which the global average temperature rise is limited to 2°C (RCP 2.6) and a scenario where emission control is not performed and global average temperatures increase rapidly (RCP 8.5), respectively. The uncertainty of the effects of climate change makes it impossible to say which temperature trajectory will have a greater impact on our lives in the future. Therefore, ports need to consider the range from lowest to highest when planning, paying particular attention to the upper limit of the SLR to minimize risks.

Since SLR represents the mean change on earth, the effects of SLR spatially will also differ. This is because each region's geographic characteristics and vertical land ratios differ, which can exacerbate or offset SLR effects. Also, Church et al. (2013) states that future SLR will vary regionally due to atmospheric and oceanic factors and the extent of glacial melting. This introduces yet another complexity for port planning. This introduces yet another complexity for port planning. Relative (or local) sea level rise (RSLR) is a key element associated with climatic and non-climatic factors.

In the light of all this, it is inevitable that ports as connection points of maritime transport to land will be affected by SLR. To be prepared for the impact of SLR on ports, the criterion that should be referenced by port planners is RSLR, which includes the atmospheric, oceanic, and geographical advantages and disadvantages of the port region. In the study of Hanson & Nicholls (2015), the ports where the changes in their lands will be greatest with the effect of RSLR are determined. Accordingly, the ports that will be exposed to the maximum RSLR (according to RCP8.5) in the projection for the years 2050 and 2100 are shown in the table below.

Table 1. Top ports with high RSRL in RCP8.5 scenario – 2050 and 2100 projections

Maximum RSLR (RCP8.5) in 2050		Maximum RSLR (RCP8.5) in 2100	
Port	(m)	Port	(m)
Calcutta (India)	0.88	Calcutta (India)	2.25
New Orleans (USA)	0.60	New Orleans (USA)	1.67
Alexandria, Port Said, Damietta (Egypt)	0.60	Mobile (USA)	1.65
Mobile (USA)	0.60	Toyohashi, Honshu (Japan)	1.65
Novorossiysk (Russia)	0.60	Alexandria, Damietta (Egypt)	1.62
Samsun (Turkey)	0.58	Port Said (Egypt)	1.61
Odesa, Illichivsk, Sevastopol (Ukraine)	0.57	Tianjin (China)	1.59
Istanbul (Turkey)	0.57	Hampton Roads, Norfolk (USA)	1.53
Varna (Bulgaria)	0.57	Brooklyn, New York (USA)	1.50
Gdansk, Gdynia (Poland)	0.53	Halifax (Canada)	1.50
Toyohashi, Honshu (Japan)	0.53	Baltimore (USA)	1.50
Rotterdam, Amsterdam (Netherlands)	0.51	Chester (USA)	1.49
London (UK)	0.51	Philadelphia (USA)	1.49
Tianjin (China)	0.50	Shanghai (China)	1.49
Immingham (UK)	0.49	Boston (USA)	1.48

When the ports at risk are evaluated based on the RSRL, it is seen that there are significant changes in the ranking of the top 15 ports in the period from 2050 to 2100. Ports where the RSRL exacerbates due to coastal subsidence in 2050 will be replaced by port areas on the East American coast that are likely to be exposed to major ocean currents in 2100. The global distribution of the top 15 ports with high RSRL index for 2050 and 2100 is shown in Fig. 2.

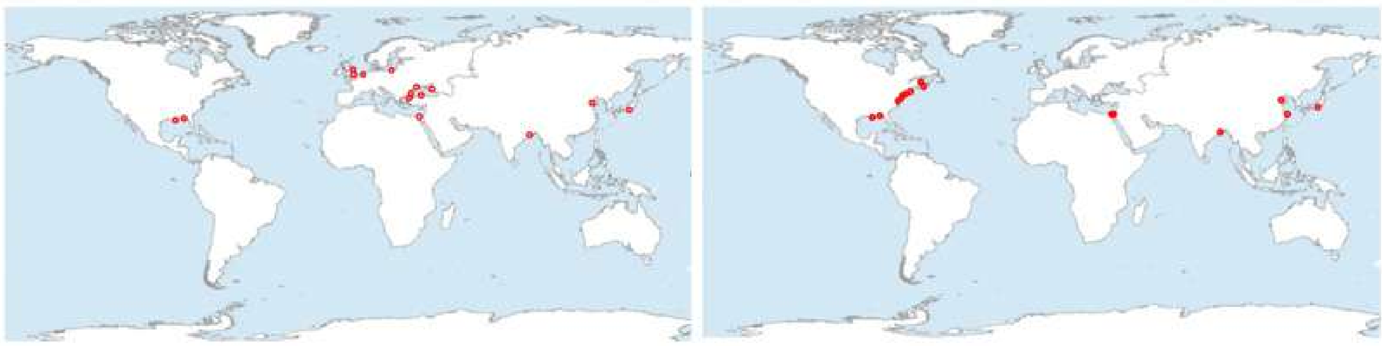

Fig. 2. Global distribution comparison of top ports with high RSRL – 2050 and 2100 projection

The IPCC's lower and upper limit scenarios, the range of RSRL projection, and RSRL changes over time demonstrate the degree of flexibility of ports for new planning and adaptations. On the other hand, floating ports, which have the potential to show more flexible behavior against RSRL changes compared to conventional ports, can have an important place in future planning.

3. FLOATING PORTS

Floating port structures are used for various purposes in maritime transport modes. Many floating port projects have been put into use to provide operational flexibility thanks to its technical advantage over the existing traditional port (Kim & Morrison, 2012). Kurt et al. (2021) presented offshore container port systems as an alternative to existing ports to be able to handle mega ships, and at the same time, capacity increase will be possible in the existing port area. Venice Offshore-Onshore Port System (VOOPS), another important offshore port project, is proposed both to increase the port capacity of the region and as an alternative port structure for historic Venice, which will be affected by SLR (Pachakis et al., 2017).

While floating port designs offer tailored solutions with simple designs, they can also have complex designs that can be considered as an alternative to conventional ports (Ali, 2005; Lau & Ng, 2017). At the same time, floating ports are advantageous in terms of the lack of land purchase costs and operational costs (Baird & Rother, 2013; Kurt et al., 2015). With the increase in land scarcity with SLR, land costs for traditional ports investments are expected to increase.

Existing studies show that no previous study has investigated floating ports to deal with the SLR potential impacts of shipping. Therefore, floating ports highlighted in this study can be considered as an important alternative in terms of providing technical advantages and operational sustainability in case conventional ports are flooded with SLR. Conventional ports often involve raising the structure heights to adapt SLR. However, it is not technically possible to raise the structure in which the RSLR intensity is observed excessively. Thus, floating ports that can automatically adapt to the RSLR due to their floating structure are highly likely to come to the fore in the future.

5. CONCLUSIONS

All ports are expected to be affected by sea level rise caused by climate change. However, the analyzes show that ports in some regions will be more affected by the relative or local sea level rise (RSLR). Factors that will increase and decrease this effect are coastal structures, atmospheric and oceanic effects, and the level of glacial melting. In terms of coastal structures, port areas with coastal subsidence will be more affected in the early periods. Next, the effectiveness of emission reduction solutions will be decisive for the affected port areas. The inefficiency of emission reduction solutions presents a negative scenario, with the impacts of atmospheric, oceanic, and glacial melting going to be more pronounced, and port areas such as the Eastern Americas that will be exposed to major ocean currents will be more affected.

While the methods used for conventional ports to adapt to sea-level rise are to increase the height of the structures, floating ports proposed as an alternative will be able to adapt to sea-level rise more easily with the advantage of being physically buoyant

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TRANSFORMATION OF A TOURISTIC FACILITY TO COGENERATION SYSTEM AND THERMOECONOMIC ANALYSIS

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ABSTRACT

Cogeneration is a process where electrical and thermal energy is produced simultaneously. In this study, economical analysis of the current system to be built in a 88 bed capacity private otel that occupies a 3.200 m2 of covered area in Istanbul. Unlike other studies, this hotel which does not have a cogeneration system, has been designed anew with electricity and gas cost analysis to transform electricity and natural gas into a cogeneration system for heating and electricity. Alternative case, recovery time and energy saving are calculated with real consumption, not estimated. For this purpose, it is aimed to reach exact results in feasibility and investment costs.

Uses that are important in terms of energy have been evaluated by explaining them up-to-date. In addition, the frequency of use of cogeneration systems in Turkey and the world, technical components and the thermo-economic evaluation of the selected system was made by researching the frequently used types. As a result of the study, it was found appropriate to choose a system with a thermal power of 109 kW, which can produce 71 kWe of energy for the hotel. The overall investment costs have been determined as 140,000 USD and it has been concluded that the cogeneration system will pay for itself in approximately 5 years by starting to earn.

Keywords: Energy consumption, Cost-benefit analysis, Cogeneration, Thermo-economic.

1. INTRODUCTION

Electricity and heating needs constitute the primary need group worldwide. In addition to conventional power plants, cogeneration systems are combined heat and power systems that product not only electricity but also hot water and steam.The systems used for district heating mostly consist of two circuits. The circuit in which the heat generated in the heat center is transported to the blocks is the primary (primary) circuit. The circuits that distribute heat within each of the blocks are called secondary circuits. Two solutions were used for heat transfer. In the first method, heat transfer is provided through the heat exchanger designed between the primary circuit and the secondary circuit. In the second method, called direct system, the primary circuit fluid is circulated in the secondary circuit with the help of a pump (Işık, E., & İnallı, M. 2005).

The rate of economic growth and energy consumption are directly proportional to each other. The need for energy consumption, the rapid increase in energy prices and foreign dependency in energy supply affect the continuity and cost of production. Since plants with cogeneration systems can produce their own energy, their dependence on foreign energy is only necessary during periodic maintenance and repair. Since waste exhaust gas is utilized according to the working principle of cogeneration systems, they are both economical and environmentally friendly investments considering energy recovery and CO2 emissions.

2. MATERIAL AND ANALYSIS

Since gas engine cogeneration systems provide waste heat at lower temperature and mass than gas turbine systems, they stand out as the optimum solution considering energy and economy, especially in applications where electricity demand is higher than heat demand.

Approximately 1/3 of the waste heat recovered in gas engines is recovered from the exhaust gas, while 2/3 is recovered from the cooling systems of the engine (Ebrahimi, M. et al., 2012). Internal combustion engines are generally suitable for low and medium power cogeneration systems.

In gas engines, waste heat is obtained through the lubrication circuit of the gas engine, the exhaust gases and charge air generated by combustion and the cylinder block cooling water circuit.

In cogeneration systems using gas engines, the total cycle efficiency reaches 85-91% in total due to the fact that users need electricity and domestic hot water (Muccillo, M., Gimelli, A. 2014).

2.1 Electricity Consumption Analysis of The Hotel

In order to determine a thermoeconomically appropriate cogeneration system selection, the values consumed in annual time periods, if possible, or monthly or weekly time periods, if not, should be determined and graphically interpreted (İnallı, M. et al., 2002). It is planned that the cogeneration system to be selected for the touristic facility, which is the subject of the study, will operate under operating conditions for a maximum of 690 hours per month for oil changes, electrical and installation connection controls and maintenance, and the electrical energy required for the remaining 30 hours will be supplied from the grid according to the periodic maintenance needs of the facility and the cogeneration system.

Table 2.1: 12 Monthly Electricity Consumption According to 3-Time Tariff (kWh)

Energy Consumption kWh / Month	Daytime Consumption kWh(06:00-17:00)	Peak Demand Consumption kWh(17:00-22:00)	Night Consumption kWh(22:00-06:00)	Monthly Total Energy Consumption (kWh / Month)
January	22,142.21	10,835.55	14,133.33	47,111.09
February	21,834.28	10,684.86	13,936.78	46,455.92
March	22,859.12	11,186.38	14,590.93	48,636.42
April	23,556.77	11,527.78	15,036.24	50,120.80
May	24,177.45	11,831.52	15,432.41	51,441.38
June	24,523.87	12,001.04	15,653.54	52,178.45
July	25,370.69	12,415.44	16,194.05	53,980.18
August	25,086.81	12,276.52	16,012.86	53,376.19
September	24,350.66	11,916.28	15,542.98	51,809.92
October	23,431.68	11,466.57	14,956.39	49,854.63
November	22,796.57	11,155.77	14,551.00	48,503.34
December	23,109.31	11,308.81	14,750.62	49,168.75

Annual average cogeneration electrical energy requirement for the daytime (E1), peak demand (E2), night (E3) consumption values determined in Table 2.1; E1 = 74.69 kW, E2 = 80.77 kW, E3 = 65.22 kW.
Average total power consumption needed per year (for 690 hours, excluding periodic maintenance and breakdown hours): 72.78 kW. According to EPDK law, the operating efficiency of natural gas-fired cogeneration plants must be at least 80% in order to generate electricity without a license (EPDK, 2021).

2.2 Hotel Hot Water Energy Consumption Analysis

It is planned to save the amount of fuel to be used for the heating system by using the calculated thermal energy of the cogeneration system to be selected in preheating. According to the calculations made, the amount of hot water energy needed and its usage areas are analyzed in Table 2.2.

Table 2.2: Heating Requirement Table for Hot Water Systems of the Hotel

Consumption/ Month	Natural Gas Consumption (kWh/Month)	Natural Gas Thermal Power	Water Heat Requirement (m^3/Month)	Natural Gas Consumption (TL/Month)
January	122,914.61	170.01	11,552.14	26,155.00 TL
February	117,745.19	163.53	11,066.29	25,055.00 TL
March	112,575.78	156.36	10,580.44	23,955.00 TL
April	105,056.63	145.91	9,873.76	25,355.00 TL
May	97,537.48	135.47	9,167.07	20,755.00 TL
June	92,368.06	128.29	8,681.22	19,655.00 TL
July	86,728.70	120.46	8,151.20	18,455.00 TL
August	84,378.97	117.19	7,930.36	17,955.00 TL
September	95,751.68	132.99	8,999.23	20,375.00 TL
October	106,635.65	148.11	10,022.16	22,691.00 TL
November	116,340.05	161.58	10,934.23	24,756.00 TL
December	131,373.65	182.46	10,077.50	27,955.00 TL

2.3 Thermodynamic Analysis of Gas Engine Cogeneration System

2.3.1 Cogeneration system exhaust gas thermodynamic analysis

For the cogeneration system exhaust gas waste heat gain power calculation, the inlet and outlet temperatures of the exhaust gas during full load and the exhaust gas flow rate are utilized. In order for the flue gas to be discharged from the chimney to the external environment in a healthy way, waste heat can be utilized to a certain extent (Kılıç, B. et al., 2011).
QB exhaust gas energy is determined by utilizing the exhaust gas flow rate and outlet temperatures according to the type of facility to be utilized and the capacity of the selected cogeneration system (QB 42,42 kW).

2.3.2 Cogeneration system cooling water circuit thermodynamic analysis

The jacket water (QC) recovered from the cogeneration system cylinder block cooling water circuit has an energy of 45.29 kW. The engine jacket water primary circuit operates in the average 80 ˚C - 95 ˚C range. In order to get 100% efficiency from the engine, heat transfer from the engine jacket water to the cooling water heat exchanger is important. The heat recovery from the lubrication circuit (QY) and after cooler heat exchanger is included in the calculations as 21,29 kW.

2.4 Electrical and Thermodynamic Efficiency of Gas Engine Cogeneration System

In order to analyse the electrical and thermal efficiency correctly, it is necessary to calculate the fuel requirement of the cogeneration system according to the lower heating value of natural gas. The maximum amount of energy that can be obtained from the total amount of natural gas required for the cogeneration system can be calculated as follows:
•21,27 m^3/h(Cogeneration system hourly natural gas consumption,%100 capacity) * 8250 kcal/Nm3(Lower calorific value of natural gas) = 175.477 kcal/h = 204,5 kW

2.4.1 Electrical efficiency of cogeneration system

The electrical efficiency of the gas engine cogeneration system can be calculated as Eq. (1) follows with the ratio of the electrical power to be obtained from the selected cogeneration system to the total amount of fuel consumed (Wilkinson, B.W., Barnes, R.W. 1980).

$$\eta_e = P/H \quad (1)$$

$$\eta_e = (71 \text{ kW}/ 204{,}5 \text{ kW}) * 100 = 0{,}347 * 100 = \%34{,}70$$

2.4.2 Waste heat boiler (exhaust) efficiency of cogeneration system

The exhaust gas heat leaving the system at high temperature from the cogeneration system is brought to the domestic water heating circuit by the exhaust gas heat exchanger. The efficiency of the waste heat boiler can be calculated as Eq. (2) follows with the ratio of the heat gain to the total amount of fuel to be obtained;

$$\eta_b = Q_B / H \quad (2)$$

$$\eta_b = 42{,}42 \text{ kW} / 204{,}5 \text{ kW} * 100 = 0{,}225 * 100 = \%20{,}74$$

2.4.3 Cooling water efficiency of cogeneration system

The cooling water heat recovery Qs value obtained from the engine jacket water cooling heat exchanger, lubrication circuit high temperature heat exchanger and aftercooler was calculated as 66.58 kW. The efficiency of hot water production can be calculated as Eq. (3) follows;

$$\eta_s = Q_S / H \quad (3)$$

$$\eta_s = 66{,}58 \text{ kW} / 204{,}5 \text{ kW} * 100 = 0{,}325 * 100 = \%32{,}55$$

2.5 The Total Efficiency

The total efficiency obtained per unit time from the cogeneration system can be calculated as Eq. (4) the sum of hot water efficiency, waste heat boiler efficiency and gas engine efficiency used in electricity generation (Kılıç, B. et al., 2011). If Equations 1 - 2 and 3 are used, the total efficiency of the cogeneration system;

$$\eta_{chp} = \eta_e + \eta_b + \eta_s \quad (4)$$

$$\eta_{chp} = \%34,70 + \%20,74 + \%32,55 = \%88.00$$

2.6 Payback Period Accounting and System Projection
2.6.1 Unit price for electricity and natural gas consumption
Excluding taxes and other deductions, the price of unit electricity as of 11.10.2021 is 0.9421 TL for 1 kWh. Cost incl. taxes; 0.9937 TL/kWh (TEDAS, 2021). Current natural gas unit costs were calculated as received by İGDAŞ (İGDAS, 2021). Volume unit cost; TL / m3: 2.26409 TL.

2.6.2 Part replacement and general periodic maintenance expenses
Periodic maintenance is important in terms of prolonging the working life of the cogeneration system and meeting the investment costs and making profit for the investor. Monthly maintenance and repair costs calculated 4.830 TL/month and included in the accounts. With the commissioning of the cogeneration system, the lubrication circuit oil must be changed in certain periods in order for the engine circuit to operate properly. Monthly oil change cost calculated 2300 TL/month and included in the accounts.

2.6.3 Cogeneration system internal electricity consumption
During the operation of the cogeneration system, the internal consumption costs of the internal units such as cooling water pump, fan, battery charger, etc., which need to be supplied from the network during the operation of the cogeneration system, are fixed on average, but 1.0 kWh energy consumption occurs in the selected system. Monthly system internal electricity consumption cost calculated 685.65 TL/month and included in the accounts.

3. RESULTS AND DISCUSSION
The calculation and analysis of the economic viability of the thermodynamically analyzed system is important in terms of seeing the gain of the initial investment cost of the system. The first investment cost of the cogeneration system selected for the depreciation period calculation is included in the calculation as 100.000 USD. During the installation phase of the system, mechanical installation and ventilation works, electrical panel projects of the cogeneration system are included in the first investment cost as 40.000 USD.

Table 3.1: 71 kWe Gas Engine Cogeneration System Depreciation Period

Cogeneration System Total Investment Cost (USD)	140,000.00 USD	Cogeneration System Total Investment Cost (TL)	1,334,018.00 TL
Cogeneration System Total Annual Net Gain (USD)	29,579.30 USD	Cogeneration System Total Annual Net Gain (TL)	281,852.25 TL
Depreciation Period (Year)	4.73		

As can be seen in Table 3.1, with the inclusion of the investment cost, the depreciation period of the cogeneration system, electromechanical installation projects and other consumption materials planned and selected to be installed in the touristic facility was calculated. In the calculations made, the amount to be profited in case of producing electricity from the system and getting hot water with the heat recovery of the engine, jacket water, waste heat boiler heat exchangers is calculated as 281,852.25 TL (exchange rate TCMB, 2021).

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GENERAL PLANETARY TRANSPORT SYSTEM IS THE TOOL OF NON-ROCKET SPACE INDUSTRIALIZATION TO PREVENT PLANETARY ECOLOGICAL-RESOURCES CATASTROPHE AND TO ENSURE THE FURTHER TECHNOCRATIC DEVELOPMENT

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ABSTRACT
An ecological-resource catastrophe is inevitable, since the Earth civilization has chosen a technocratic path of development and objectively cannot refuse it. The basic industries of the Earth's technosphere, which has the most harmful anthropogenic impact on the Earth's biosphere, must be eliminated by newly build-up space industries. Boundless outer space, inexhaustibility of energy resources, as well as fundamentally new and unique technological conditions (weightlessness, deep vacuum, absolute purity, etc.) - determine the absolute price & quality competitive superiority of the upcoming space industry over the Earth's technosphere. So, we are talking about the ordinary market competitive mechanism of reindustrialization.
As for the multibillion civilization of people, it should stay to live in its biospheric home Earth, since the human body, as one of the systems of a complex biospheric complex, has been ideally "adapted" to earthly conditions over billions of years of evolution of living matter.
The feasibility of space vector of industrialization depends on many newly developed technologies, but the principal of them is geospace transport system, which should be distinguished by energy efficiency close to 100% efficiency, absolute environmental friendliness, cleanliness and safety, as well as the ability to develop the scale of cargo and passenger transportation, estimated at millions of tons of cargo and cargo. million passengers a year when the challenge of global reindustrialization is set.

Keywords: BIOSPHERE OF THE EARTH, SPACE VECTOR OF INDUSTRIAL DEVELOPMENT, GENERAL PLANETARY TRANSPORT SYSTEM (GPTS) OF ENGINEER A.E. UNITSKY, FEASIBILITY STUDY, TECHNOSPHERE OF THE EARTH.

1.INTRODUCTION
Anatoly Unitsky, author creator and general designer of General Planetary Transport System, devoted his entire life to saving Earth civilization from an impending environmental catastrophe, seeing the solution to all environmental and resource problems in the space vector of industrialization, the essence of which is "Earth is for Life, Space is for Industry".
An ecological-resource catastrophe is inevitable, since the Earth civilization has chosen a technocratic path of development and objectively cannot refuse it. The basic industries of the Earth's technosphere, which has the most harmful anthropogenic impact on the Earth's biosphere, must be eliminated by newly build-up space industries. Boundless of outer space, inexhaustibility of energy resources, as well as fundamentally new and unique technological conditions (weightlessness, deep vacuum, absolute purity, etc.) - determine the absolute price & quality competitive superiority of the upcoming space industry over the Earth's technosphere. So, we are talking about the ordinary market competitive mechanism of reindustrialization.
As for the multibillion civilization of people, it should stay to live in its biospheric home Earth, since the human body, as one of the systems of a complex biospheric complex, has been ideally "adapted" to earthly conditions over billions of years of evolution of living matter [1].
The feasibility of space vector of industrialization depends on many newly developed technologies, but the principal of them is geospace transport system, which should be distinguished by energy efficiency close to 100% efficiency, absolute environmental friendliness, cleanliness and safety, as well as the ability to develop the scale of cargo and passenger transportation, estimated at millions of tons of cargo and cargo. million passengers a year when the challenge of global reindustrialization is set.
The space-rocket transport complex of the Earth does not correspond and will never be able to correspond that task. Today, no more than 500 tons of cargo per year are delivered to space from Earth, and nothing (except astronauts and some scrap metal) is returned to earth. The results of the more modest transport activities of the global rocket and space industry, the efficiency of which does not exceed 3%, already have a tangible ecological ecology, and any consequences increase the volume of cargo transportation of the Earth's rocket and space biosphere simply cannot stand it.

2.GENERAL PLANETARY TRANSPORT SYSTEM DEVELOPED BY ENGINEER ANATOLY UNITSKY.

It is difficult to predict how technology will develop in the future, including space technology. The only thing that can be said with complete certainty is that whatever this technique may be, it will obey the fundamental laws of physics of our world. Such natural laws, repeatedly verified by practice, will remain valid at all times. In the field of mechanics, these include four conservation laws, to which all other particular conservation laws can be reduced, namely, energy, momentum, angular momentum, and motion of the center of mass of the system. [2].

In addition to the fundamental laws of physics, the geospace transport system must also meet a number of additional conditions and requirements: – should be made not as a stationary structure, but as an aircraft; - use only the internal forces of the system, minimizing any interaction with the environment, including excluding linear support on the earth's surface; - its efficiency should be close to 100%, the productivity should be millions, and in the future - even billions of tons per year; - during descent, it is capable of recuperating the potential and kinetic energy of space cargo and its own design; - must consume electrical energy, and the power of the drives of the geospace transport system in terms of a ton of cargo should not exceed 100 kW (for example, like a passenger electric car); - the acceleration and deceleration during geospace transportation should be comfortable for passengers and acceptable for cargo (no more than 1.5 m/s2), while the time to enter orbit and accelerate to the first cosmic velocity should be calculated in hours, not in days.

All the above conditions and requirements have been formulated and the only one engineering solution - General planet transport system (GPTS) have been developed by engineer Anatoly Unitsky more than 40 years ago and during this time it has been repeatedly studied and verified by calculation methods, which are described in detail in the author's popular scientific publications and in his monographs.

The GPTS is a toroidal structure with a cross section of several meters, encircling the planet in the plane of the equator and having belt flywheels in its core. Flywheels, accelerated by linear electric motors to cosmic speeds (about 10 km / sec.), due to centrifugal forces provide the necessary lifting force. Switching thrust from one flywheel to another causes the body of the GPTS to rotate around the planet, up to obtaining the first space velocity in a given equatorial circular orbit. When rising for every 100 km above the Earth's surface, the GPTS ring diameter increases symmetrically in all directions relative to the center by 1.57%, while the position of the GPV center of mass always remains unchanged and coincides with the center of mass of the planet.

GPTS is the only technical solution in which the transport system is capable of launching cargo into various circular equatorial orbits without the use of jet engines, using only the internal forces of the system, without any energy, mechanical, chemical and other types of interaction with the environment, i.e. the ultimate environmentally friendly solution for geospace logistics. For one flight, the GPTS is capable of putting into orbit about 10 million tons of cargo and 10 million passengers, who will be involved in the creation and operation of the near-Earth space industry. In one year, GPTS will be able to go into space up to 100 times. At the same time, the cost of delivering each ton of payload into orbit will be thousands of times lower than that of modern launch vehicles, and will amount to less than 1000 USD/t. That is, the cost of a passenger ticket to orbit will be within 100 USD with travel comfort exceeding the convenience of modern trains.

3.FEASIBILITY STUDY OF GPV GEOSPACE TRANSPORTATION

The cost price of GPTS geospace transportation consists of three main components: 1) the cost of electrical energy; 2) wages with taxes and deductions; 3) amortization deductions for the GPTS and for the equatorial transport-infrastructure complex serving it with a runway.

The total supply of energy required to lift the GPTS with a total mass of 40 million tons (one ton per linear meter) into near space, including the payload delivered into orbit with a mass of 10 million tons (250 kg / m), and return to Earth (already without payload) is approximately 4.2 × 1011 kWh. To provide the GPTS with starting electrical energy, it is more expedient to have its own power plants, which will allow it to be distributed within the geospace system at a cost of about 0.05 USD/(kWh). In addition, additional energy can be taken from the network of countries in the equatorial belt of the planet, through whose territory the launch overpass of the GPTS will pass. It is most profitable to do this at night, since nighttime tariffs are 2–2.5 times lower than daytime ones. The cost of the total energy Eo required for the first launch of the GPTS will be: 420 billion kWh × 0.05 USD/(kWh) = 21 billion USD, and the unit cost is 2100 USD/t.

Moreover, once accelerated flywheels can rotate inside the vacuum channels for years, because the magnetic cushion on permanent magnets, like vacuum, will not create resistance when they move at cosmic speeds. This means that the energy costs for the second and subsequent flights of the GPTS will be associated only with a part of the total energy proportional to the transported cargo, as well as with internal energy losses estimated not to exceed 10%. Although theoretically they can be reduced to 5% and even lower, to 1-2%. When the GPTS begins to rise, it will transfer energy to the terrestrial cargo, and when descending, by analogy with the falling water of a hydroelectric power station, on the contrary, the cargo from space will transfer its potential and kinetic energy to the GPTS. Considering that after the creation of the space industry in equatorial circular orbits, the main cargo flow will be carried out from space to Earth, the GPTS will begin to generate electricity, also operating as a giant dynamo with a total capacity of about 100 million kW.

From this it follows that the main specific energy component of the cost only for lifting a ton of cargo: E1 = 2100 USD/t × (25% of the GPTS gross weight + 10% losses in the Efficiency coefficient) = 735 USD/t. The main specific energy component of the cost only for lowering a ton of cargo will be equal to a negative value: E2 = 2100 USD/t × (-25% of GPTS gross weight + 10% of losses in Efficiency coefficient)) = -315 USD/t, since the descent cargo does not consume, but transfers its cosmic potential and kinetic energy to the GPTS. The main specific energy component of the cost of a round-trip flight with a full load: E3 = 2100 USD/t × (10% losses in Efficiency coefficient)) /two cargo transportations = 105 USD/t.

The GPTS and the equatorial airstrip will operate in automatic mode. However, keeping them running will require the creation of at least 200,000 jobs at an average wage, along with taxes of $50,000/year and annual total wage costs of $10 billion. The component of the unit self-cost (CUSC) in terms of wages with 50 flights per year with a full load of 10 million tons of cargo along the Earth-Orbit route (characteristic of the stage of the beginning of the industrialization of near space): CUSC = 10 billion USD/year / 50 flights/year / 10 million tons/flight = 20 USD/ton.
In terms of the complexity of equipment and the composition of components, an GPTS is generally equivalent to an electric vehicle (for example, a Tesla brand worth USD 50,000−75,000 and weighing 2−3 tons), the cost of a ton of construction of which does not exceed USD 25,000/t. Since the mass of the equipped GPTS (without payload) will reach 30 million tons, the capital costs for its creation (design and construction) will be equal to: 30,000,000 tons × 25,000 USD/t = 750 billion USD.
Once the space industry is fully operational and the exploration of asteroids and the moon as sources of raw materials begins, the need to deliver equipment and materials from Earth will decrease significantly. At the same time, the reverse descending cargo flow from orbit to the planet will significantly exceed the direct ascending cargo flow, since the main part of industrial products for earthlings is planned to be delivered from space. The GPTS will put less payload into orbit (the estimated load of one flight on the ascending route will be only 20%) and, first of all, will begin to rise into space precisely for the products produced there.

Therefore, subject to the operating conditions for the GPTS (50 years of operation with 50 flights per year; carrying capacity - 10 million tons; loading of the GPTS on the route up - 20%, on the route down - 100%), the gross volume of cargo transported in both directions for the entire the period of operation (depreciation) of the GPTS will be about 30 billion tons. Thus, amortization deductions per ton of cargo from capital investments in GPTS will be equal to: GPTS-ad = 750 billion USD / 30 billion tons = 25 USD/t.The length of the equatorial take-off and landing overpass complex (ETOLOC), including the equatorial string transportation and logistics, will be 40,076 km, of which approximately 20% of the length is land sections, 80% - sea. Since the GPTS is intended not only for spacewalking, but primarily for launching cargo and passengers into orbit, string transport and infrastructure communicators will appear along the equator on the planet and along the equatorial orbit in space, created according to the “5 in 1” principle. They will include complexes of urban, high-speed, high-speed and hyper-speed transport, energy and information communications and communication lines. Power plants, cargo-passenger logistics hubs, industrial and residential clusters will also be built, in which millions of people will live and work[3].

The cost of such a complex (including string transportation) built on planet Earth can be estimated at 1,320 billion USD, based on the fact that it will average 25 million USD/km on land and 35 million USD/km on offshore areas. Taking into account the total volume of cargo transported by the GPTS for the entire period of operation, amortization deductions per ton of cargo from capital investments in the string transport and communication part of the ground equatorial runway complex will be equal to: ETOLOC-ad = 1320 billion USD / 30 billion tons = 44 USD/t.
Thus, the full amortization deductions are made up of the costs of restoring the GPTS and the equatorial

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4. CONCLUSIONS

An analysis of the data given in the Table 1 allows us to draw the following conclusions: the highest cost of geospace transportation (775 USD / t) in the first year of operation is associated mainly with the upward cargo-passenger flow. This, in turn, led to the absence of compensatory income from the generation of the descent, as well as the low volume of transported goods and passengers, which led to a high specific value of wage costs. Nevertheless, such figures will be more than 1000 times lower than those of launch vehicles in the most optimistic forecasts. As the volume of transportation, both direct and return, grows, their cost will begin to decline. In the tenth year of operation, when the cargo flow from orbit to the planet will significantly exceed the cargo flow from the planet to orbit, the unit cost of transportation will turn out to be negative. This means that the GPTS geospace complex will bring profit not only as a transport, but also as a giant linear kinetic power plant with a length of more than 40,000 km, with belt flywheels with a total mass of 20 million tons, capable of recuperating the potential and kinetic energy of space cargo into electrical energy.

Table 1. The cost of geospace transportation in the first year of GPST operation.

Years since GPTS firs launch	Annual cargo transporatation, mln.t		Components of operationg costs per geocosmic cargo unit, USD/t					Self-costs per cargo unit, USD/t, (-)-means profit
	Lifting to Orbit	Landing on Earth	Lifting energy	Lost energy	Wages	Amortization	etc.	
1	100	10	429,55	190,91	90,91	55,2	7,5	774,06
2	200	50	315,00	168,00	40,00	55,2	7,5	585,70
3	300	100	262,50	157,50	25,00	55,2	7,5	507,70
4	400	150	238,64	152,73	18,18	55,2	7,5	472,25
5	500	200	225,00	150,00	14,29	55,2	7,5	451,99
6	500	250	175,00	140,00	13,33	55,2	7,5	391,03
7	400	300	75,00	120,00	14,29	55,2	7,5	271,99
8	300	350	- 40,38	113,08	15,38	55,2	7,5	150,78
9	200	400	- 175,00	140,00	16,67	55,2	7,5	44,37
10	100	500	- 350,00	175,00	16,67	55,2	7,5	- 95,63
11	100	500	- 350,00	175,00	16,67	55,2	7,5	- 95,63
12	100	500	- 350,00	175,00	16,67	55,2	7,5	- 95,63
13	100	500	- 350,00	175,00	16,67	55,2	7,5	- 95,63
14	100	500	- 350,00	175,00	16,67	55,2	7,5	- 95,63
15	100	500	- 350,00	175,00	16,67	55,2	7,5	- 95,63
16	100	500	- 350,00	175,00	16,67	55,2	7,5	- 95,63
17	100	500	- 350,00	175,00	16,67	55,2	7,5	- 95,63
18	100	500	- 350,00	175,00	16,67	55,2	7,5	- 95,63
19	100	500	- 350,00	175,00	16,67	55,2	7,5	- 95,63
20	100	500	- 350,00	175,00	16,67	55,2	7,5	- 95,63
total	4000	7310						

GPST with such incredibly high efficiency and performance characteristics is the tool of non-rocket space industrialization to prevent planetary ecological-resources catastrophe and to ensure the further technocratic development.

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CHARACTERIZATION OF CARBON NANOTUBE ENHANCED COMPOSITE PHASE CHANGE MATERIAL DERIVED FROM WASTE LDPE

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ABSTRACT
Thermal energy storage (TES) technologies using phase change materials (PCM) have gained importance as a sustainable and efficient energy method. The thermal properties of PCMs must be enhanced to improve the overall performance of the TES system. In this context, in this study, the potential of using wax (PE-wax) obtained by the pyrolysis of waste Low-Density Polyethylene (LDPE) as a low-cost and environmentally friendly material as an alternative to conventionally used PCMs. Furthermore, the potential to make composite PCM with improved thermal properties with carbon nanotube (CNT) was investigated. PE-wax as PCM, waste LDPE as supporting material, and CNT as thermal properties improver was used. The composites were prepared in a twin-screw extruder. Thermal Gravimetric Analysis (TGA), Fourier transform infrared spectrometer (FT-IR), Differential Scanning Calorimetry (DSC) analyses of the obtained composite PCMs were performed.

Keywords: CNT, LDPE, PARAFFIN, PCM

1. INTRODUCTION
Renewable energy sources such as solar and wind power are becoming increasingly popular due to their potential to reduce greenhouse gas emissions and mitigate climate change. However, one of the challenges with these energy sources is their intermittent nature, which means that energy is not always available when it is needed. Thermal energy storage (TES) systems can help to address this challenge by storing energy when it is available and releasing it when it is needed. TES systems work by storing thermal energy in a material such as water, ice, or a phase change material (PCM) such as paraffin wax or salt hydrates, which can store large amounts of energy in a small volume. PCM-based thermal energy storage has recently become an important research topic with advantages such as high latent heat and constant phase change temperature (Gao et al., 2022). However, conventional PCM materials have limitations such as low thermal conductivity and low heat transfer rates, which can lead to slow charging and discharging rates, reduced energy storage capacity, and reduced overall performance of the TES system.

To solve the problems associated with conventional PCM, work is underway on the development of composite PCM (C-PCM) to improve the properties, efficiency and performance of PCMs. Depending on the desired properties and application of the C-PCM, materials for a heterogeneous mixture of two or more homogeneous phases can be selected from a wide variety of materials such as metals, polymers, ceramics, carbons and liquids. Although C-PCMs prepared with conventional materials generally have good performance, they are not economically viable. Waste materials such as industrial by-products, agricultural residues, and municipal solid waste can be used as fillers in C-PCM, providing an environmentally friendly solution for waste management. Several studies have investigated the use of waste materials in C-PCM and have shown that these materials can improve the thermal properties and performance of the TES system while also reducing costs and environmental impacts (Almousa et al., 2021; Ghani et al., 2021; Harmen et al., 2020).

A tremendous amount of waste is generated every year on a global basis, making it a problem that needs to be addressed in terms of waste management, cost, and pollution. Waste low-density polyethylene (LDPE) is a type of plastic commonly found in packaging materials, such as plastic bags, shrink wrap, and bubble wrap (Gebre et al., 2021). There are several ways to recycle waste LDPE, including mechanical recycling, which involves shredding the plastic into small pieces and melting it down to create new products.

Another option is to convert LDPE through pyrolysis, where the plastic is heated in the absence of oxygen to break the polymer chains into smaller molecules that can be used as a source for new products (Ragaert et al., 2017). It is possible to control the yield and process parameters of the products obtained in the pyrolysis process (Gaidhani and Mahanwar, 2023). As a result of the studies, it has been seen that the appropriate conditions to produce wax from waste LDPEs are the operating temperature range of 400-500 °C (Gebre et al 2021). Waxes obtained from the pyrolysis of LDPE have similar properties with commercial paraffin waxes used in PCMs in terms of their long chain molecular structure, melting temperature and latent heat value (Akgun et al., 2021).

The thermal energy storage capability of the PCM depends on the phase change temperature, melting and solidification enthalpies, and thermal cycling behavior (Shi et al., 2021). The heat transfer capacity of PCMs is mainly evaluated by the charge/discharge ratio during phase transformation. Paraffin waxes used as PCM may have disadvantages such as subcooling, low stability during thermal cycling and low thermal conductivity, which limits their use in TES systems. Supporting materials are needed to overcome these disadvantages (Shahid and Abdala, 2021). Creating composite PCMs by adding supporting materials to paraffins is one of these approaches. In general, the thermal conductivity of supporting materials is higher than PCMs (Chen et al., 2020; Zhang et al., 2021). Studies have shown that the use of nanotechnology can improve the heat transfer of materials with low thermal conductivity. To improve the shortcomings of organic PCMs, such as thermal and physical problem, to achieve commercial applications in thermal management, it is necessary to composite and use carbon-based support nanomaterials (Yang et al., 2021).
Carbon nanotubes (CNTs) have great potential among nanomaterials used to increase the heat transfer of PCMs due to their excellent thermal and chemical stability, high thermal conductivity, and low density (Kuziel et al., 2021). The researchers achieved a latent heat of melting of 172.14 J/g with the composite with 88% paraffin content by weight, without any leakage. In the composite prepared by reducing the paraffin ratio to 75%, the latent melting temperature was determined as 143.81 J/g. Qu et al. (2019) prepared a paraffin-HDPE-based composite by melt blending method by adding carbon nanotube additives (CNT), and according to the results compared with pure paraffin, the addition of CNT additives has a slight effect on the phase change temperature, while the shape stabilization and it was found to support thermal stability. Kuziel et al. (2021) analyzed the thermophysical properties of nanocomposites prepared by mixing multi-wall carbon nanotubes (MWCNTs) and paraffin, which they prepared by catalytic chemical vapor deposition method, in a magnetic stirrer at 60 °C for 24 hours and then cooling them in silicon molds. The addition of MWCNT resulted in a 37% increase in thermal conductivity and 6.3% higher phase change enthalpy compared to base paraffin.
In this study, composite phase change material (CPCM) developed with carbon nanotubes was prepared for thermal energy storage and the chemical and thermal properties of these composite PCMs were determined. Wax produced from waste LDPE was used as PCM, waste LDPE was used as support matrix and CNTs produced from waste was used to improve thermal properties. Overall, this study highlights the benefits of forming composite PCM with CNTs to increase the potential and performance of using waste LDPE as a low-cost and environmentally friendly material for thermal energy storage.

2. MATERIAL AND METHODS

2.1. Materials

Waste LDPEs were obtained from a material recovery facility and reduced to 1 × 1 cm for the pyrolysis process. As a supporting carbon-based nanomaterial, it was used multi-walled carbon nanotubes produced in our laboratory (Yapıcı, 2022). These CNTs were produced with chemical vapor deposition method using gas product obtained from the pyrolysis of waste composite LDPE.

2.2. Methods

The pyrolysis process was carried out to produce wax from waste LDPE at a temperature of 450˚C and a heating rate of 10 ˚C/min. After the pyrolysis process, the liquid phase was collected in condensers placed in an ice bath maintained at about 0 °C and washed with dichloromethane (DCM) solvent. Afterwards, the solvent was removed in the rotary evaporator and the process was continued until the wax product remained. The resulting liquid product (PE-Wax) was used in the composite PCM.The PE-Wax obtained from pyrolysis of waste LDPE as PCM matrix and waste LDPE (reduced to 10x10mm) supporting polymer material were mixed with twin screw extrusion at 50/50 ratio. Composite PCMs were produced in a 16 mm diameter, 8-zone twin screw extruder with an initial temperature of 130 °C, the other 7 zones at 140 °C, screw speed of 35 rpm. To improve the thermal properties of composite PCM, 5% CNT was added during the extrusion.

2.3. Characterization of Products

Thermal Gravimetric Analysis (TGA) to measure the thermal stability of PCMs, Fourier Transform Infrared Spectrometer (FT-IR) analysis to determine their chemical structures, Differential Scanning Calorimetry (DSC) analyzes to determine their thermal properties and phase change behaviors were performed. The thermal decomposition temperatures of the samples were measured using the TGA Q500 - TA instrument. The purpose of TGA analysis is to examine the thermal stability, immiscibility, and homogeneity of PCMs over the operating temperature range. All samples (app. 10-15 mg) were heated from 30 °C to 800 °C in a nitrogen atmosphere under a heating rate of 10 °C/min. FT-IR analysis of functional groups constituting the resulting composites was performed using a Thermoscientific Nicolet IS10 FTIR equipped with an ATR sampling accessory. ATR-FTIR spectra were recorded for 64 scans at cm-1 resolution in the 650-4000 cm-1 spectral range. The chemical compatibility between composite PCMs developed with PE-Wax/Waste LDPE and 5 % CNT addition to them was determined in this way. Melting (Tm) temperatures and latent heats of melting (ΔHm), composite PCMs were measured using DSC device. All samples (5-7 mg) were cycled from 20 °C to 160 °C (heating/cooling) in nitrogen atmosphere with a heating/cooling rate of 10 °C/min.

3. RESULTS AND DISCUSSION

TGA graph showing the mass loss of composite PCM produced against heating temperature are given in Fig. 1. The decomposition temperature of the prepared mixture is in the range of 300-500 C. Two-phase degradation is seen in the mixture, representing PE-wax and waste LDPE. The results show that the PCM is thermally stable.

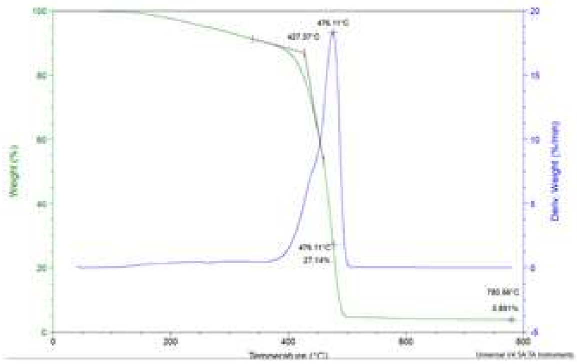
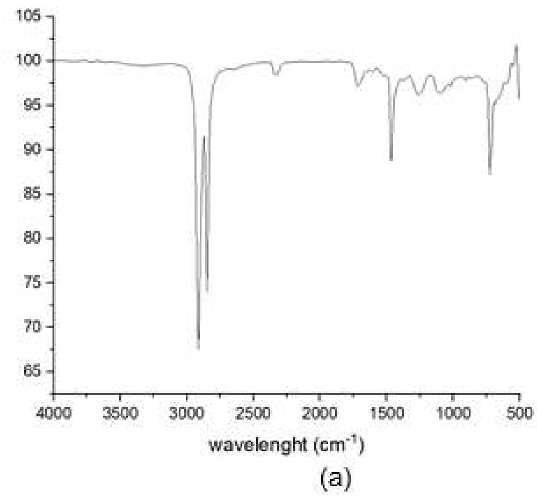


Fig. 1. TG curve of PE-wax/waste LDPE CPCM

FTIR spectrums of composites prepared with PE-wax/waste LDPE and PE-wax/waste LDPE/CNT are given in Fig. 2(a-b).



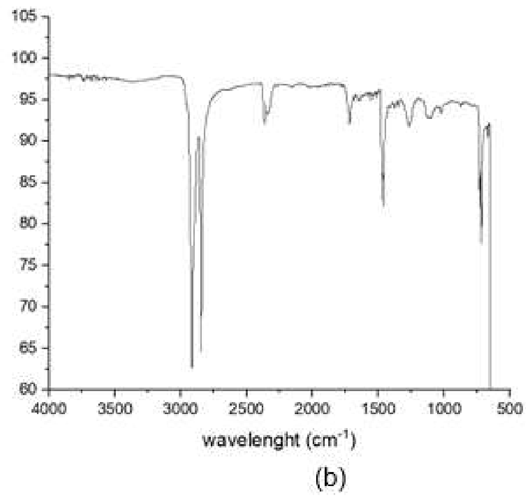


Fig. 2. FT-IR Spectra a)PE-wax/waste LDPE b)PE-wax/waste LDPE/CNT composite

When the spectra are examined, there are 4 basic peaks showing the presence of wax. The peak seen at 2800 cm-1 defines the C-H stretching vibration of CH3/CH2 groups. The peak around 1500 cm-1 is assigned to the bending vibration of C-H. The 717 cm-1 absorption band is due to the in-plane deformation swinging vibration of the wax molecule. The peak seen at 3000 cm-1 corresponds to CNT and this is due to stretching of the C=C bonds. The bonds resulting from C-C stretching of the CNT structure are seen at 1000 cm-1 (Almousa et al., 2021). No new bond was formed with the addition of CNT to the PE-wax/waste LDPE mixture, which clarified that there was no interaction between them other than physical interaction while forming the composite.

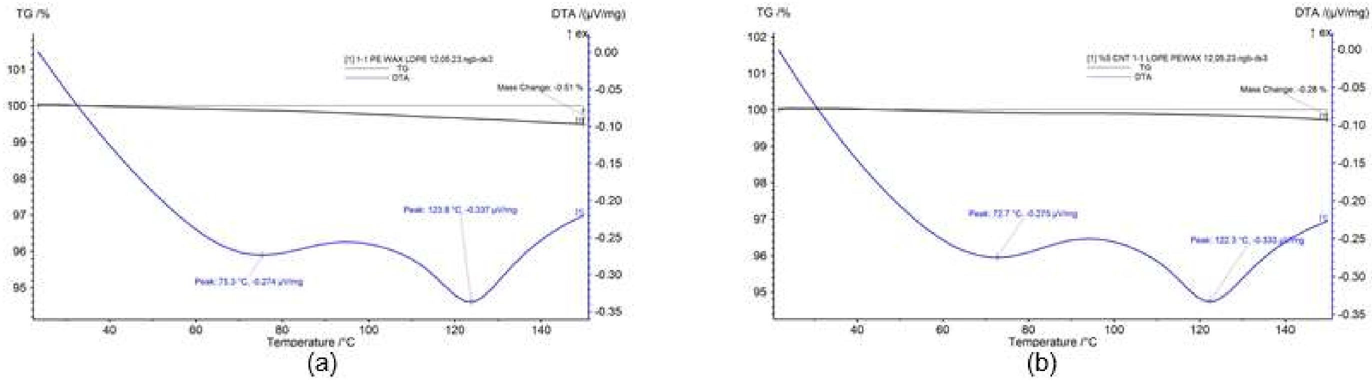


Fig. 3. DSC curves of composites a)PE-wax/waste LDPE b) PE-wax/waste LDPE CNT

DSC thermograms of PE-wax/waste LDPE are shown in Fig. 3a. The graph shows two peaks at 75.3°C and 123.8°C, corresponding to the melting point of PE-wax and waste LDPE, respectively. In addition, according to the DSC of the obtained composite (Fig. 3(b)), adding CNT to the mixture shifted the melting peaks by about 3°C. This shift can be thought to be due to super-cooling (Jeong et al., 2013).

4. CONCLUSIONS

In this study, PE-wax/waste LDPE/CNT composite material was prepared successfully. TGA results showed that the prepared composite was thermally stable. The fact that no new bonds were formed with the addition of CNT in the FT-IR spectra clarified that there was no interaction other than physical interaction between them while the composite was being formed. According to the DSC thermograms of the resulting composite, the addition of CNT shifted the melting peaks by about 3°C. The use of wax obtained from waste LDPE as PCM has demonstrated the reusability of waste materials for sustainable solutions. Overall, this work demonstrates the potential to use a combination of waste materials and advanced materials to create innovative solutions that are both environmentally friendly and high-performance.

Acknowledgement

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GRAPHENE NANOSHEET SYNTHESIS FROM WASTE PLASTICS VIA PYROLYSIS

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ABSTRACT
Plastics are widely used in modern society for their durability and versatility but unfortunately, their widespread use brings together significant environmental impacts. One way to address this issue is through upcycling. In this study, as an upcycling application, graphene nanosheet synthesis was carried out from waste low density polyethylene (LDPE) packaging by two-stage pyrolysis method. Waste LDPEs were mixed with bentonite nanoclay and subjected to two-stage pyrolysis at 450°C and 800°C under nitrogen atmosphere using 5 °C/min and 10°C/min heating rates, respectively. After purification of the obtained graphene nanosheets, XRD and Raman analyses were performed. A sharp 002 peak at 27° and a 101 peak at 44.1° were observed in the XRD as the output of graphene nanosheet samples. Raman analysis showed characteristic peaks of graphene nanosheets at ~1353 cm-1 and ~1591 cm-1 corresponding to D and G bands, respectively. Additionally, a broad 2D peak was observed at ~2765 cm−1 corresponding to the presence of few-layer graphene nanosheets.

Keywords: GRAPHENE NANOSHEET, LOW DENSITY POLYETYLENE, PYROLYSIS, UPCYCLING

1. INTRODUCTION
Plastic products have become a permanent feature of human life. This is primarily because of their high thermal stability, low cost, ease of fabrication, lightness, flexibility, chemical inertness, and durability. Due to these superior properties, plastics can be used for many applications such as packaging, storage and electrical insulation (Thompson et al. 2009). The demand for plastic has been increasing, in 2021, 390.7 million tonnes of plastic were produced (Statisca, 2023). As a result of this demand, plastic production is expected to quadruple by 2050 (International Energy Agency, 2020). However, plastics also have a number of drawbacks, including low biodegradability, toxicity, environmental pollution and adverse health impacts. Between 2000 and 2019, global plastic waste generation reached 353 million tonnes. Almost two thirds of plastic waste come from plastics with a lifetime of less than five years, with 40% coming from packaging, 12% from consumer goods and 11% from clothing and textiles (OECD, 2022).

Municipal solid waste contains about 10-13% of plastics consisting of high-density polyethylene (HDPE), LDPE, polyvinyl chloride (PVC), polyethylene terephthalate (PET), polystyrene (PS) and polypropylene (PP). Among the different types of plastics, polyethylene (HDPE and LDPE) and PP are the most widely used polymers in a variety of applications. Polyethylene (PE), which is used in plastic bags, storage boxes, plastic bottles, pipes and cable insulation, accounts for about 70% of the total plastic waste (Jahirul et al., 2022).

Recycling and upcycling are the ways in which the plastic waste problem can be addressed. This is done to make new products and reduce the amount of waste sent to landfill or incineration. However, plastic recycling/upcycling faces several challenges, including contamination, low collection rates and the difficulty of recycling certain types of plastic. Only 9% of the 8.3 billion tonnes of plastic produced between 1950 and 2015 was recycled (Geyer et al., 2017; Wyss et al., 2023). Pyrolysis is one of the methods employed to recycle/upcycle plastic waste. Pyrolysis is an emerging technological solution for large volumes of plastics that cannot be economically recovered by conventional mechanical recycling. It is the process of converting high molecular weight organic polymers into oil, char and gas at high temperatures by thermal or catalytic decomposition of the polymer waste without combustion. The ability to convert both thermoplastic and thermoset plastic waste into high quality oils and chemicals is the main advantage of pyrolysis technology. It can also be used for the treatment of mixed, unwashed and unsorted waste without the release of toxic substances into the atmosphere. On average, depending on the pyrolysis technology, 45-50% oil, 35-40% gas and 10-20% char is recovered from different types of plastic waste (Gebre et al., 2021).

In recent years, as a sustainable and cost-effective approach, researchers have explored the synthesis of carbon nanomaterials from plastic waste (Tatrari et al., 2021; Karakoti et al., 2022). Therefore, the synthesis of graphene from waste plastics provides an alternative way of recovering waste materials with added value, as well as eliminating the environmental problems caused by these waste materials (Pandey et al., 2019). Graphene is a flat monolayer of densely packed carbon atoms in a two-dimensional (2D) hexagonal lattice structure.

The crystal structure of graphene can be seen as the building block of carbon materials such as graphite, carbon nanotubes and fullerenes. Graphene crystals were first discovered by two scientists, Andre Geim and Konstantin Novoselov, in 2004 using the simple and effective 'scotch tape' method (Geim and Novoselov, 2007). Graphene is electrically more conductive than other known materials with a charge transport mobility of 250,000 cm2/V.s at room temperature, and its mechanical strength (~1 TPa) is 200 times greater than that of steel, which is one-sixth of its weight. It has a large theoretical specific surface area (2630 m2/g) and optical transmittance (97.7%). Its thermal conductivity (500 W/mK) is higher than diamond (Xu, 2018). As a result, thanks to these properties, graphene is being investigated for use in many advanced technological applications such as aerogels, batteries, energy storage, thermal management, water treatment, wearable electronics, etc. (Yanik et al., 2017; Wu et al, 2018; Abou Chacra et al, 2018; Xu et al., 2018).

In the present work, it was aimed to synthesize graphene nanosheets by two-stage pyrolysis of waste LDPE in nitrogen atmosphere using bentonite nanoclay catalyst.

2. MATERIAL AND METHODS

For graphene nanosheet synthesis, waste LDPE packaging materials were selected as a precursor, and a two-stage pyrolysis method was used. Waste LDPE obtained from a local waste collection facility was washed to remove contamination and was cut into small pieces after drying in the oven. Before the pyrolysis, 25 grams waste LDPE samples were mixed with bentonite nanoclay (Sigma-Aldrich, Nanoclay, hydrophilic bentonite) which acts as a degradation catalyst, with a ratio of 100:3. After these steps, two-stage pyrolysis was applied in a nitrogen gas atmosphere. The pyrolysis process was carried out in a fixed bed Heinze type pyrolysis reactor with a volume of 240 cm3 made of 380 S stainless steel. The first stage was carried out at a heating rate of 5 °C/min up to 450 °C and the temperature was kept at 450 °C for 30 minutes. At the second stage, the heating process was continued up to 800 °C at a heating rate of 10 °C/min. As a result of this two-stage pyrolysis, graphene nanosheets (Figure 1) were obtained and subjected to purification using 5% HCl and distilled water.

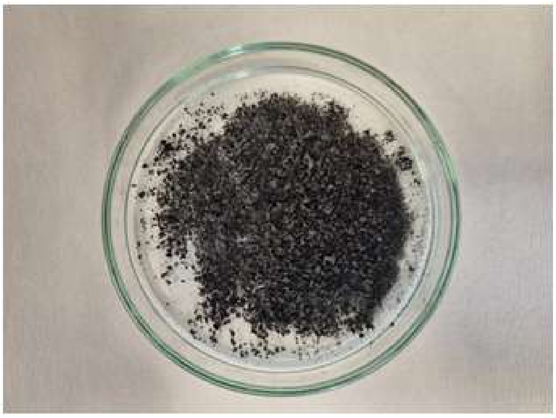

Figure 1. Obtained graphene nanosheets

For the identification and structural confirmation of the synthesized graphene nanosheets, X-ray diffraction (XRD) and Raman analyses were performed. XRD was performed using Rigaku Miniflex 600 in the diffraction 2θ range of 5°-80° for the primary characterization of graphene nanosheets properties like crystal structure, crystallite size, and strain. Raman spectroscopy (Renishaw inVia, excitation beam length 532 nm) was used to demonstrate the vibrational property of graphene nanosheets.

3. RESULTS AND DISCUSSION

XRD spectrum of the graphene nanosheets was given in Figure 2. As shown in Figure 2, a sharp 002 peak at ~27°, a 101 peak at 44.1° and a peak at 54° are observed. This sharp peaks corresponds to the characteristic peak and graphitic peak of graphene nanosheets (Akber et al., 2015; Wang and Zhang, 2019; Aziz et al., 2022).

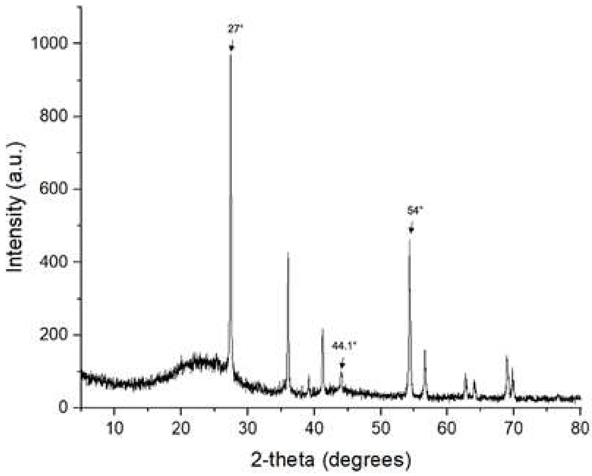

Figure 2. XRD spectrum of graphene nanosheets

Raman spectroscopy technique is used to analyze graphene materials and can provide insights into the quality and integrity of graphene nanosheets. The Raman patterns of the graphene nanosheets are shown in Figure 3. The spectrum obtained from Raman analysis shows characteristic peaks of graphene nanosheets at ~1353 cm-1 and ~1591 cm-1 corresponding to D and G bands, respectively. The D band represents the breathing mode of sp2 carbon atoms and is an indicator of defects or disorder in the graphene nanosheets and it rises due to the presence of structural defects, disorder, or sp3 carbon hybridization. The G band is the most prominent peak in Raman spectrum of graphene nanosheets. It corresponds to the in-plane stretching of carbon-carbon bonds and represents the E2g vibrational mode at the centre of the Brillouin zone. The intensity ratio of the D band to the G band (ID/IG) is commonly used to characterize the different types of disordered sp2 carbons, and an increasing ID/IG value is usually attributed to the presence of more structural defects. It was calculated that ID/IG ratio of the synthesized graphene nanosheets was 0.85. Additionally, A broad 2D peak was observed at ~2765 cm−1 corresponding to the presence of few-layer graphene nanosheets (Tatrari et al., 2021; Garg et al., 2022).

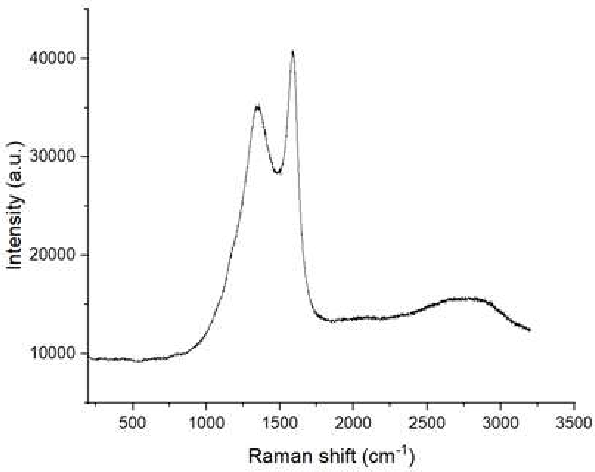

Figure 2. XRD spectrum of graphene nanosheets

4. CONCLUSIONS

The production of graphene can be a complex, expensive and challenging process. There are a number of different methods available for the synthesis of graphene, each of which has its own advantages, limitations and complexities. There are two prominent production methods. A common method of producing graphene is mechanical exfoliation, or the ‘Scotch tape’ method, which involves repeatedly peeling off layers of graphene from graphite using adhesive tape. This method is labour intensive and not suitable for large-scale production, although it can produce high quality graphene. Another widely used method for producing graphene is chemical vapor deposition (CVD). Under controlled conditions, a carbon-containing precursor gas is deposited on a substrate.

CVD has the potential for scalable production and can produce large area graphene films. It does, however, require specialized equipment and precise control of the growth parameters. On the other hand, LDPE which has carbon-rich structure is a type of plastic widely used in packaging, bags and various consumer products. While LDPE offers benefits such as flexibility, durability and resistance to moisture, it is not biodegradable and is most commonly used in single-use applications, contributing to a global waste problem. In this study, these two aspects are taken into consideration and graphene nanosheets were produced from waste LDPE packaging materials using a two-step pyrolysis process and bentonite nanoclay. XRD, and Raman spectroscopy were performed to confirm the synthesis of graphene nanosheets. Briefly, this work presents an efficient and simple technique for the synthesis of graphene nanosheets using cost-effective and alternative carbon-containing precursor materials.

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NET ZERO ENERGY BUILDING IN THE UNITED ARAB EMIRATES: LIFE CYCLE ASSESSMENT OF GLOBAL WARMING POTENTIAL

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ABSTRACT
Global warming is a major challenge for engineers, researchers, governments, and the entire world. Buildings have a huge contribution to global greenhouse gas emissions, especially from the continuous electricity production and consumption of fossil fuels. Net Zero Energy Buildings (nZEB) are emerging as a promising solution for an efficient and gradual transition toward clean energy utilization. Within UAE's vision toward Net Zero Energy in 2050, Department of Public Works in Sharjah built Sharjah Ports, Customs, and Free Zones Authority Building as an nZEB. This paper performs a life cycle assessment on the global warming and ozone layer depletion potentials for this building. The results show a major reduction in these potentials compared to a traditional building model.
Keywords: Global Warming, nZEB, Net Zero Energy, Life Cycle Analysis

1. INTRODUCTION
In recent years, there has been growing concern over the environmental impact of buildings and their contribution to greenhouse gas emissions. These emissions blanket the Earth and trap the sun's heat which leads to global warming and climate change. One of the main aspects of buildings that have a major contribution to these emissions is the use and generation of electricity from fossil fuels. According to the International Energy Agency, 19% of global energy-related and process-related CO2 emissions resulted from the generation of electricity and heat used in buildings [1].
Utilizing solar energy to reduce the dependency on fossil fuels is a promising solution to mitigate the environmental impacts associated with it (Kannan et al., 2016). However, total dependence on solar energy to provide our needs of electrical energy is impractical due to several reasons; The amount of sunlight that reaches the earth's surface varies based on the time of day, season, and weather conditions. Moreover, solar energy is only produced during the day while the energy demand continues for 24 hours. Also, large areas are required to produce usable amounts of energy which may not be feasible in some locations. Therefore, a gradual transition is required to adopt this type of energy and the hybrid energy models are very efficient to counter these challenges and maximize the benefits of clean energy.
Net zero energy buildings (NZEBs) have emerged as a promising solution to implement clean energy sources and reduce the generation of greenhouse gases, and potentially mitigate global warming. Gouveia et al. (2020) modeled an nZEB and found that it has much lower environmental impacts when compared to a complete electricity supply.
Tumminia et al. (2020) found that implementing an nZEB model can reduce the kg CO2 emissions by up to 50%. The study also emphasized that the use of storage batteries of kWh highly contributes to this reduction. Marzsal and Heislberg (2011) reported that in order to build an effective nZEB model, energy use must be reduced through other measurements. This could be achieved through interior smart design and thermal insulation techniques (Deshmukh et al. 2017). Although studies on nZEB models are plenty, most of these studies are based on theories and simulations (Zhou et al. 2016). There are a lot of challenges that can be faced in actual implementation.
As an initiative to reduce the impact of its projects on the environment. Department of Public Works in Sharjah built the Sharjah Ports, Customs, and Free Zones Authority Building as a nZEB. The building is located at Al Zahia in Sharjah at a total area of 336 m2. The building has an On-Grid System, which generates electricity from solar panels for building usage and stores excessive energy in lithium batteries. This smart system works interchangeably with the local grid where it can feed or take energy from it depending on the time of the day.

Fig. 1 shows the building exterior and solar panels.

Item	Model 1	Model 2
Photovoltaic Panel	-	56 Panel with a total Area of 90 m^2
Li-ion Battery	-	6 Batteries of 20 kWh
Inverter	-	2.5 kW
Grid Electricity	90 kWh per day	90 kWh per day

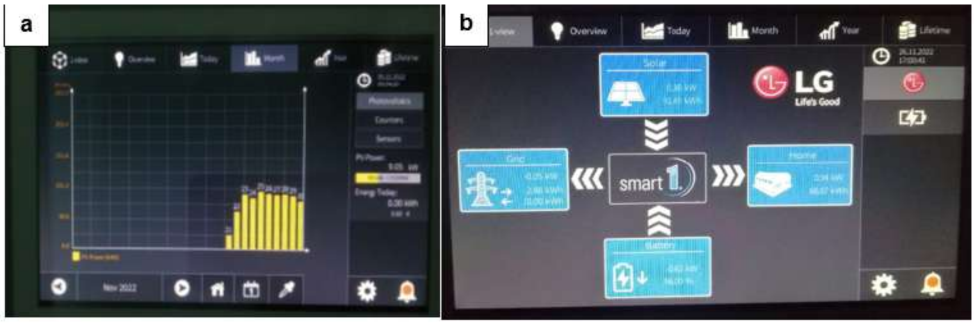

Fig. 2 Control unit readings, a) Daily electricity consumption where the average was 90 kWh b) Distribution of electricity gain and consumption for one day.

3. RESULTS AND DISCUSSION

In this section, the life cycle analysis results will be represented and discussed. It will compare the impact of Global warming and Ozone layer depletion for both building models.

Global Warming Potential – In Fig. 1, the contribution of kg CO2 equivalent emissions to the global warming potential is demonstrated. The emissions per kg of CO2 eq are almost tripled when implementing model 1.

Ozone Layer Depletion – In Fig. 2, the contribution of kg CFC-11 equivalent emissions to the Ozone layer depletion is demonstrated. It is shown that Model 2 has 70% less impact on the Ozone Layer Depletion.

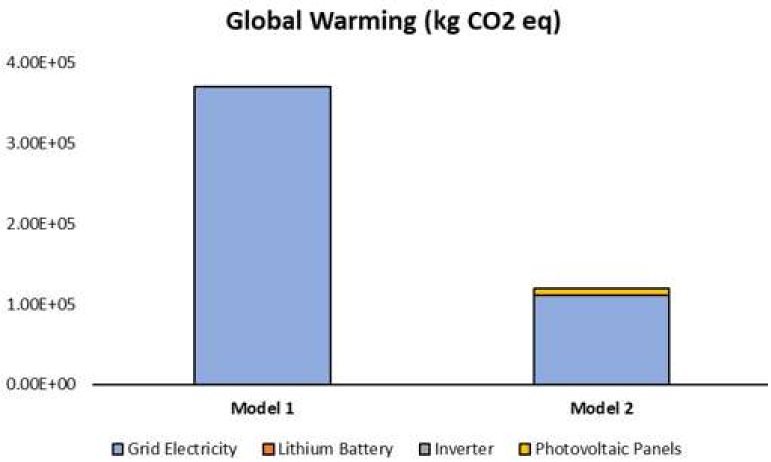

Fig. 3 Global Warming Potential for both models

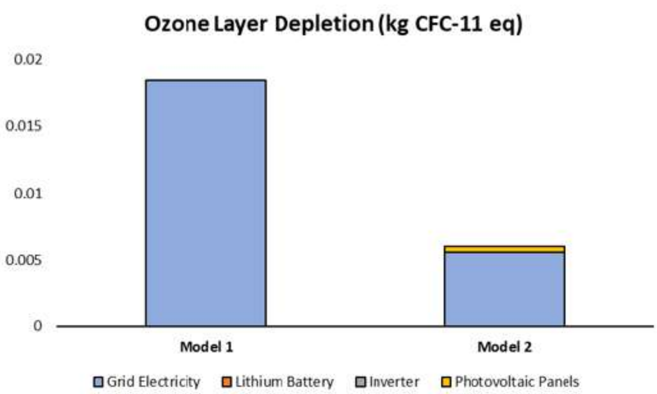

Fig. 4 Ozone Layer Depletion potential for both models

CONCLUSION

This study showcases the building of Sharjah Ports, Customs, and Free Zones Authority as an nZEB. It was built by the Department of Public Works in Sharjah as an initiative toward a more sustainable and environmental future in UAE.
A comparative life cycle assessment of two models. A traditional building model where it depends totally on the electricity grid and the actual On-Grid System model where uses both 70% Solar energy and 30% Electricity Grid. In 25 years, the nZEB building have 70% less impact on the Global Warming Potential and Ozone layer depletion.
The work herein shows an actual nZEB case and can encourage governments and professionals to adopt similar initiatives to contribute to mitigating the global challenge of Global Warming and Climate Change.

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ENVIRONMENTAL COMPARISON OF DIFFERENT COAL-FIRED TECHNOLOGIES USED BY THERMAL POWER PLANTS VIA LIFE CYCLE ASSESSMENT

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ABSTRACT

In this study, the environmental impacts of four different coal combustion technologies used by thermal power plants were determined and compared via the life cycle assessment method. These technologies are pulverized subcritical, pulverized supercritical, pulverized ultra-supercritical and fluidized bed. The functional unit of the study was 1 kWh electricity production. The system boundaries were applied as cradle-to-gate including coal mining and electricity production. Data for the coal combustion technologies were gathered from power plants websites, Environmental Impact Assessment reports and literature. ReCiPe 2016 Midpoint (H) method was used for the characterization. Results show that the environmental impact of fluidized bed technology is higher than pulverized systems in terms of all impact categories except fossil resource scarcity potential. Among the pulverized systems, subcritical technology has the higher impact values, this technology was followed by pulverized supercritical technology and the ultra-supercritical technology has the least environmental impact. The lower GWP, particulate matter formation, ozone formation and acidification potential values of pulverized supercritical and ultra-supercritical technologies are due to their lower amount of coal consumption and more effective SO2 and NOx removal systems.

Keywords: COAL COMBUSTION TECHNOLOGIES, ENERGY, LIFE CYCLE ASSESSMENT, THERMAL POWER PLANT.

1. INTRODUCTION

The global demand of electricity is increasing steadily with increasing development and technological advancements (Rasheed et al., 2021). The current global electricity use is around 27,000 TWh while it is expected to reach 35,400 TWh by 2035 (Andrae, 2020). Coal is projected to account for around 23% of the world energy mix by 2035 (Restrepo et al., 2015). In 2022, 34.6% of electricity production in Turkey will come from coal (https://enerji.gov.tr/bilgi-merkezi-enerji-elektrik). Coal-fired power generation leads to serious environmental pollution, such as air pollution, water pollution, and noise pollution (Wang et al., 2018). Two combustion technologies, pulverized coal combustion technologies and fluidized bed combustion technology, are at the forefront in coal-based thermal power plants. Pulverized coal combustion technologies consist of pulverized subcritical, pulverized supercritical and pulverized ultra-supercritical. The vast majority of thermal power plants in Turkey have pulverized subcritical technology. The distribution of coal combustion technologies in Turkey is 53% pulverized subcritical, 30% fluidized bed, 13% pulverized super critical and 4% pulverized ultra-supercritical (Çiftçi, 2023).

The differences on the combustion technologies effect the environmental performance of the power plant for electricity production. To determine the environmental effects of different coal combustion technologies Life Cycle Assessment (LCA) is a helpful methodology. LCA is a holistic approach which determined the environmental effect from cradle-to-grave go products and processes. In this study, the environmental impacts of coal-fired thermal power plants were determined and compared with the life cycle assessment method.

The determination of environmental impacts of coal-fired power plants by LCA has been applied many researchers in the literature. Jung et al. (2022) established an analysis model utilizing LCA data at the secondary data level, based on the actual data of the Taean coal power plant in the Republic of Korea. Rasheed et al. (2021) aimed to analyze the life cycle impacts of process stages (material and coal transportation, and plant operations) of a coal-fired power plant. Dunmade et al. (2019), performed a streamlined LCA of a coal-fired plant in South Africa. Another LCA study was adopted to analyze the environmental impact of coal-fired power generation in China by Wang et al. (2018). Günkaya et al. (2016), performed an LCA study to determined environmental impacts of electricity production in Turkey. On the other hand, LCA studies based on coal-firing technologies is limited. Petrescu et al. (2017) evaluated the environmental aspects of four supercritical pulverized coal process with post combustion carbon storage. Liang et al. (2013) realized an LCA study for four types of coal power generation technologies including integrated gasification combined cycle, sub-critical coal power generation, super-critical coal power generation and ultra super-critical coal power generation. Cui et al. (2012) performed an LCA to compare three coal firing technologies of subcritical, supercritical and ultra-supercritical. With this motivation, this study aims to determine and compare the environmental impacts of four coal-firing technologies of pulverized subcritical, pulverized supercritical, pulverized ultra-supercritical and fluidized bed technologies. The power plants that have these technologies exists in Turkey were considered.

2. LIFE CYCLE ASSESSMENT METHODOLOGY

LCA methodology will be performed in this study is based on the ISO 14040 framework and ISO 14044 guidelines and requirements including of four steps: goal and scope definition, life cycle inventory (LCI), life cycle impact assessment (LCIA) and interpretation.

2.1. Goal and Scope Definition

The goal of this study is to determine the environmental impacts of different coal combustion technologies used for energy production in power plants. These technologies are pulverized sub-critical (existing system), pulverized super-critical, pulverized ultra-super critical and fluidized bed technologies. The functional unit of the study is 1 kWh electricity production. System boundaries was applied as cradle to gate including coal mining and electricity production at the power plant.

2.2. Life Cycle Inventory Assessment

Data for the coal combustion technologies were gathered from power plants websites, Environmental Impact Assessment reports and literature. These raw data is available on Çiftçi (2023). The raw data was processed and given on functional unit basis in Table 1.

Table 1. Life cycle inventory data for the coal combustion technologies (f.u. 1kWh)

Inputs	**Amount**			
	Pulverized Subcritical	**Pulverized Supercritical**	**Pulverized Ultra Supercritical**	**Fluidized bed**
Coal consumption (kg) (lignite)	1.07	0.38	0.29	1.05
Cooling water consumption (m^3)	0.00082	0.00166	0.235	0.0020
Process water consumption (liter)	1.4	1.66	6.2	0.65
Outputs	**Amount**			
Wastewater generation (liter)	0.64	0.12	0.0257	0.46
Wastewater emissions (mg)				
Chemical oxygen demand (COD)	19.32	3.87	0.771	13.83
Suspended solids (SS)	64.40	12.9	2.57	46.10
Oil and grease	6.44	1.29	0.257	4.6
Total cyanide	0.32	0.064	0.01285	0.23
Atmospheric emissions				
SO_2 (g)	3.61	0.44	0.5	5.1
NO_x (g)	3.3	0.56	1.8	3.9
PM10 (g)	0.33	0.18	0.0531	0.59
CO (g)	0.095	0.053	0.53	1.6
CO_2 (kg)	1.05	0.70	0.61	1.25
HCl (mg)	7.1	0.56	7.68	470
HF (mg)	3.07	0.21	2.9	70
Fly ash (kg)	0.28	0.07	0.040	0.28
Slag(kg)	0.061	0.00001	0.0089	0.45

2.3. Life Cycle Impact Assessment

Life Cycle Impact Assessment was carried out by using ReCiPe 2016 Midpoint (H) method embodied in SimaPro 9.1 LCA software. The ReCiPe methodology are considered with selected nine impact (midpoint) categories: global warming potential (GWP), fine particulate matter formation potential (FPMFP), ozone formation terrestrial ecosystems potential (OFTEP), terrestrial acidification potential (TAP), freshwater eutrophication potential (FEFP), freshwater ecotoxicity potential (FETP), human carcinogenic toxicity potential (HCTP), human non-carcinogenic toxicity potential (HNCTP) and fossil resource scarcity potential (FRSP).

3. RESULTS AND DISCUSSION

The characterization results for coal combustion technologies are given in Table 2 and percentile distribution of impact categories into the combustion technologies in Fig.1. Table 2 and Fig.1. shows that the fluidized bed has the higher environmental impact values for all impact values except FRSP among the technologies. FRSP values of pulverized subcritical and fluidized bed technologies are similar to each other. The results were investigated on the pollutant basis.

The main technologies that have higher GWP values are fluidized bed and pulverized subcritical. CO2 is the dominant pollutant with the highest share of the GWP value (99%) for all technologies. The lower GWP values of pulverized supercritical and ultra-supercritical technologies are due to their lower amount of coal consumption to produce an equal amount of energy (1kWh). Additionally, amount of coal consumption shows its impact as FPMFP, ozone formation OFTEP and acidification potential TAP. FPMFP resulted from mainly SO2 (app. 65% - 77%) and NOx emissions (25% - 34%). OFTEP is mainly resulted from NOx emissions (app. 99%) whereas the percentage of SO2 emissions are higher than 68%. The lower values of pulverized supercritical and ultra-supercritical systems are due to more effective SO2 and NOx removal system beside the lower amount of coal consumption. The FEFP is resulted from coal mining and ash disposal. The phosphate content of the disposed spoils of coal mining is the main pollutant for that impact. The FETP is resulted from ash disposal and spoils from coal mining. The heavy metal content of ash causes to this impact. The main elements in the ash are arsenic (34-45%), chromium VI (27 - 35%), zinc (6- 20%) and nickel (<5%). Similarly, ash disposal and spoils from coal mining cause to human toxicity potential (carcinogenic and non-carcinogenic) due to chromium VI, arsenic, SO2, NOx, CO and particulate matter. Direct fossil fuel consumption was presented as FRSP. The values of pulverized subcritical and fluidized bed values for this impact category are so close to each other while those pulverized supercritical and ultra-supercritical are lower.

Table 2. The characterization results for coal combustion technologies

Impact Categories	Unit	Pulverized Subcritical	Pulverized Supercritical	Pulverized Ultra Supercritical	Fluidized bed
GWP	kg CO_2 eq.	1.07	0.71	0.61	1.27
FPMFP	kg PM 2.5 eq.	1.43E-03	1.96E-04	3.48E-04	1.93E-03
OFTEP	kg NO_x eq.	3.34E-03	5.73E-04	1.81E-03	3.94E-03
TAP	kg SO_2 eq.	4.84E-03	6.59E-04	1.16E-03	6.55E-03
FEFP	kg P eq.	2.59E-04	9.21E-05	7.03E-05	2.55E-04
FETP	kg 1,4-DCB eq.	3.22E-04	1.27E-04	9.11E-05	1.06E-03
HCTP	kg 1,4-DCB eq.	8.41E-03	3.45E-03	2.42E-03	3.59E-02
HNCTP	kg 1,4-DCB eq.	0.2306	0.0946	0.0663	0.9878
FRSP	kg oil eq.	0.2387	0.0848	0.06472	0.2343

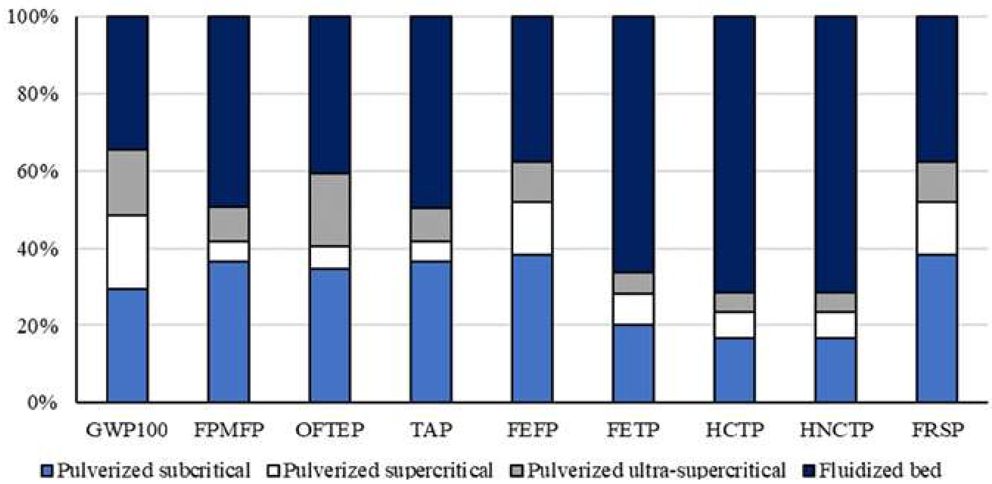

Fig. 1. The distribution of the impact categories for coal combustion technologies

4. CONCLUSIONS

The aim of this LCA study is to compare the environmental effects of pulverized subcritical, pulverized supercritical, pulverized ultra-supercritical and fluidized bed technologies used in coal-fired thermal power plants. According to the results, among the technologies pulverized ultra-supercritical technology show the least environmental impact. This technology was followed by pulverized supercritical technology. It is thought that this study will help determine energy policies in determining the environmental impacts of thermal power plants to be built for energy sustainability in the future. Studies on the determination of environmental impacts by the life cycle assessment method of energy production in our country are limited in number and can be used as a guiding resource for future studies.

In this study, only the environmental effects arising from thermal power plants were examined. In the selection of technologies to be applied in thermal power plant projects, a holistic approach can be achieved by using multi-criteria decision support methods that include technical and economic criteria along with environmental assessment.

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A STUDY OF HYDROGEN PRODUCTION POTENTIAL VIA IRON-CHLORINE (Fe-Cl) AND MAGNESIUM CHLORIDE (Mg-Cl) OF THE A FUSION REACTOR

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ABSTRACT
The aim of this study is to investigate the amount of hydrogen production by the thermochemical cycle of modified Fe-Cl and Mg-Cl in the PACER fusion reactor. Ten different coolant zone thicknesses were determined at 25% molten salt (LiF + UF4) and 75% void operating conditions. Determination of hydrogen production amount by Fe-Cl and Mg-Cl methods depends on the energy multiplication factor. In the hydrogen production performance, both the total power (Phpf) required by the facility and the amount of hydrogen mass flow produced were calculated. As a result, it was seen that the hydrogen mass flow amount was better than Fe-Cl with the Mg-Cl thermochemical method.
Keywords: Nuclear hydrogen, PACER fusion reactor, Iron-chlorine cycle, Magnesium-chlorine cycle

I. INTRODUCTION
Increasing environmental pollution in parallel with the increasing energy need has led people to seek clean energy sources. Hydrogen, which can be stored, has a high energy density and is a clean fuel, draws attention as a promising material. It can also be produced anywhere in the world. Hydrogen will reduce foreign dependency for our country, which produces energy from fossil fuels, and will ensure that our country is less affected by possible resource crises in the world. When we compare hydrogen with fossil fuels, it is a great advantage that fossil fuels will be depleted in the near future as a result of calculations and that hydrogen is a renewable resource (Cumpston et. al.2020; Mazloomi and Gomes 2012; Şirin and Erdoğan 2013). There are many different hydrogen production methods in the literature. In this study, hydrogen mass flow rates of iron-chloride (Fe-Cl) and magnesium-chloride (Mg-Cl) thermochemical cycles were investigated.

II. PROBLEM DESCRIPTION
The fusion reaction part is located in the rock zone, Pacer fusion reactor has steel structure, void and coolant zone (Acır, 2004). In this study, PACER fusion reactor modified by Asal et. al (2023) was used. In this study, the amount of fuel to be used in the coolant region was determined as 25% molten salt (LiF + UF4) + 75% void. Then, calculations were made for 10 different coolant zone thicknesses. These proportions are 50cm, 100cm, 150cm, 200cm, 250cm, 300cm, 350cm, 400cm, 450cm 500cm and 550cm.

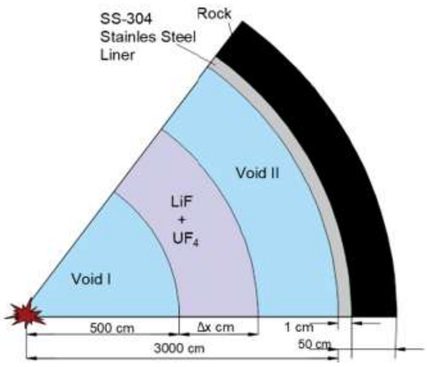

Fig. 1: Modified PACER fusion reactor geometry (Acır 2004)

In this study, the hydrogen production potential of the modified Pacer fusion reactor was calculated with the iron-chlorine (Fe-Cl) cycle and magnesium-chlorine, which is the hydrogen production method.

III. Hydrogen Production Analysis

The fact that nuclear power plants have the electricity and heat energy required for hydrogen production is a great advantage compared to many of the other energy sources. Only heat energy is needed for hydrogen production by the iron-chlorine (Fe-Cl) thermochemical cycle. But the magnesium chloride (Mg-Cl) thermochemical cycle needs both electrical and heat energy. The energies required for both cycles were obtained from the PACER fusion reactor.The required thermal power value required by the hydrogen generation unit was calculated by eq. (1) (Asal et. al., 2023).

$$P_{hpf} = (1-\psi) * \eta_{ihx} * \frac{P_f}{Q} * [Q * (x_a + x_n * M) + 1] \quad (1)$$

Where, (1-ψ) represents the thermal power ratio. It is the ratio of the total thermal energy produced by the system to the thermal energy required by the hydrogen production facility and is calculated by eq. (2) The energy multiplication factor M is defined as the energy production of the reactor and is calculated by eq. (3) (Asal et. al. 2023).

$$(1-\psi) = 1 - \frac{1}{\eta_{IHX} * \eta_{ds} * [Q * (X_a + X_n * M) + 1]\eta_{gt}} + \frac{X_{aux} + X_{isp}}{\eta_{IHX} * \eta_{gt}} \quad (2)$$

$$\mathrm{M} = \frac{200\ \mathrm{MeV} * \langle \Phi * \Sigma_f \rangle + 4{,}7484\ \mathrm{MeV} * T_6 - 2{,}467\ \mathrm{MeV} * T_7}{14{,}1\ \mathrm{MeV}} + 1 \quad (3)$$

In order to calculate the amount of hydrogen production, the qtot value must be calculated. This parameter can be calculated with the general energy balance and the shomate equation (Çengel ve Boles 2013).

$$\dot{E}_{in} = \dot{E}_{out} \quad (4)$$

$$\dot{Q}_{in} + \dot{W}_{in} + \sum n_{in} H_{in} = \dot{Q}_{out} + \dot{W}_{out} + \sum n_{out} H_{out} \quad (5)$$

$$Q = \sum n_{out} (\bar{h}_f^o + \bar{h} - \bar{h}_0)_{out} - \sum n_{in} (\bar{h}_f^o + \bar{h} - \bar{h}_0)_{in} \quad (6)$$

$$\bar{h}(T) - \bar{h}_0 = AT + B\frac{T^2}{2} + C\frac{T^3}{3} + D\frac{T^4}{4} - \frac{E}{T} + F - H \quad (7)$$

Where $\bar{h}_f^o$ is the enthalpy of formation. T is 1/1000 of the temperature specified as K. The A, B, C, D, E, F and H values given in Table 1 and table 2 are constant.

Tab. 1: Enthalpies of formation of compounds and Fe-Cl cycle constants required for Shomete calculation (NIST Chemistry WebBook)

Bileşikler	Sıcaklık (K)	(kJ/mol)	A	B	C	D	E	F	H
MgO(s)	723-673	-601.2408	47.25995	5.681621	-0.872665	0.1043	-1.053955	-619.1316	-601.240
HCl (g)	723-343	-92.31	32.12392	-13.45805	19.86852	-6.853936	-0.049672	-101.6206	-92.3120
$MgCl_2$ (s)	723-673	-641.612	78.307	2.435888	6.858873	-1.728967	-0.729911	-667.582	-641.616
H_2O (v)	723	-241.826	30.09200	6.83251	6.79344	-2.534480	0.082139	-250.8810	-241.826
Cl_2 (g)	673-343	0	33.0506	12.2294	-12.0651	4.38533	-0.159494	-10.8348	0
O_2 (g)	673	0	30.03235	8.772972	-3.988133	0.788313	-0.741599	-11.32468	0
H_2(g)	343	0	33.066178	-11.363417	11.43282	-2.772874	-0.158558	-9.980797	0

* $\Delta H_{H_2O(g)\,(398K)}$ = -238,59592 kJ (Çengel ve Boles 2013).

**$\Delta H_{FeCl_3\,(g)(698K)}$= -217,5502 kJ (SGTE 2000).

Tab. 2: Enthalpies of formation of compounds and Mg-Cl cycle constants required for Shomete calculation(NIST Chemistry WebBook)

Tab. 2: Enthalpies of formation of compounds and Mg-Cl cycle constants required for Shomete calculation (NIST Chemistry WebBook)

Compound	Temperature (K)	$\bar{h}_f^o$ (kJ/mol)	A	B	C	D	E	F	H
$FeCl_2$ (l)	1198	-311,34	102,173	-1,07882E-08	8,4244E-09	-2,0967E-09	-1,8464E-10	-341,799	-311,337
$FeCl_2$(s)	398 - 698	-341,83	73,6685	22,5409	-10,12172	1,4662	-0,252648	-365,564	-341,833
H_2O (g)	1198	-241,83	30,092	6,832514	6,793435	-2,53448	0,082139	-250,881	-241,826
Fe_3O_4 (s)	1198	-1120,89	200,83	1,58644E-07	-6,662E-08	9,45245E-09	3,18602E-08	-1174,14	-1120,89
Fe_3O_4 (s)	398	-1120,89	104,209	178,5108	10,6151	1,132534	-0,994202	-1163,34	-1120,89
HCl (g)	398 - 1198	-92,31	32,1239	-13,45805	19,86852	-6,853936	-0,049672	-101,6206	-92,3120
H_2(g)	1198	0	18,56308	12,257357	-2,859786	0,268238	1,97788	-1,147438	0
$FeCl_3$ (s)	398	-399,41	979,110	-4704,36	9295,174	-6246,963	-12,49577	-593,977	-399,406
Cl_2 (g)	698	0	33,0506	12,229	-12,0651	4,38533	-0,159494	-10,8348	0
Cl_2 (g)	1198	0	42,6773	-5,00957	1,904621	-0,165641	-2,09848	-17,2898	0
O_2 (g)	1198	0	30,03235	8,772972	-3,988133	0,788313	-0,741599	-11,3247	0
$FeCl_2$ (l)	1198	-311,34	102,1733	-1,07882E-08	8,4244E-09	-2,0967E-09	-1,8464E-10	-341,799	-311,337

Where, $\mathcal{U}$ is the molar mass of the compound, $\dot{m}$ is the mass flow rate and η is the efficiency of the reaction.

III. I. Hydrogen production by thermochemical method with iron-chlorine (Fe-Cl) cycle and Mg-Cl cycle

Thermochemical cycle with Iron - Chlorine (Fe-Cl) cycle consists of 4 different chemical reactions Hydrogen production takes place in the first step, this step, which is an endothermic reaction, is called hydrolysis. (Canavesio et. al. 2015; Adewale, Berrouk and Dara 2015; Safari and Dinçer 2020). Fig. 2 shows the schematic view of the iron-chloride thermochemical cycle.

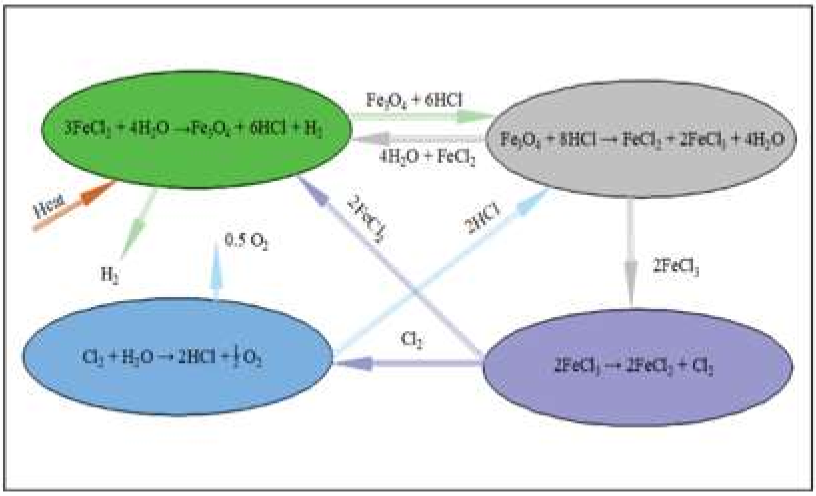

Fig. 2: Schematic representation of the iron-chlorine

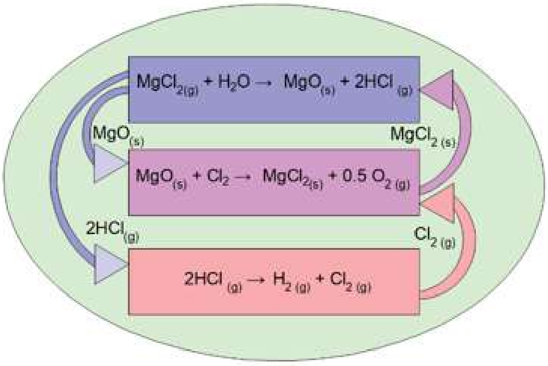

Fig. 3: Schematic representation of the magnesium (Fe-Cl) thermochemical cycle

Fig. 3 shows the schematic view of the three-stage magnesium chloride (Mg-Cl) thermochemical cycle. The hybrid Mg-Cl thermochemical cycle requires a maximum of 550 °C heat and electrical input as energy (Balta et. al., 2014).

IV. Results and discussions

With the thermal energy obtained from the Pacer nuclear power plant, the energy need of the hydrogen production facility, where the Fe-Cl thermochemical cycle and Mg-Cl thermochemical cycle are located, are met. As the energy multiplication factor (M) value increases, the energy production of the Pacer fusion reactor continues. The effects of these ratios on M values are given in Fig.4.

As shown in Fig. 5 and Fig. 6, the M value was used to calculate both the thermal energy (Phpf) needed by the hydrogen production plant and the amount of hydrogen production ($\dot{m}$). Increasing the thickness of the coolant zone increased the energy multiplication factor (M). Increase in M value increased the amount of thermal energy (Phpf). The amount of thermal energy increased with increasing the thickness of the coolant zone and the highest Phpf value was 1790.52 MW.

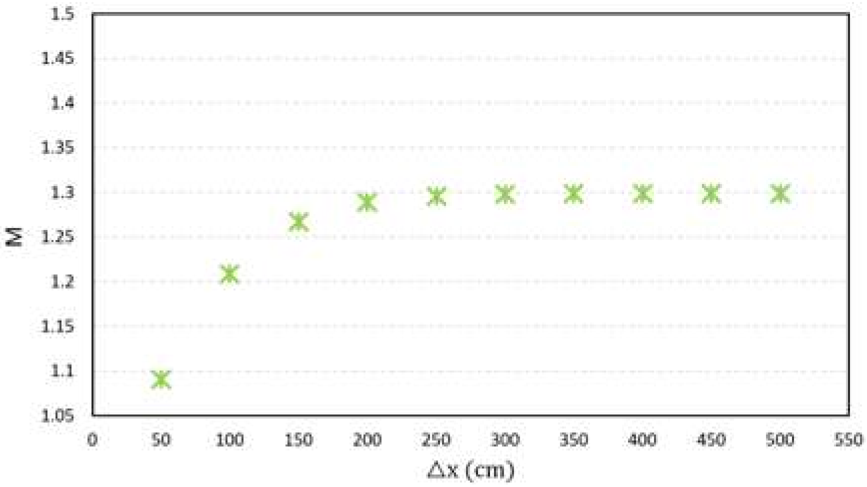

Fig. 4: Variation of Energy Multiplication Factor (M) Dependent on Coolant Zone Thickness

As a result, UF4 nuclear fuel mixed with molten salt increased the ratio of M and Phpf values. This increase increased the amount of hydrogen production. Thus, the value with the highest production amount of hydrogen, which is a clean energy source, is the value with the highest the thickness of the coolant zone. In other words, The highest hydrogen mass flow rate is 13.25 kg/s in Mg-Cl and 7.55 kg/s in Fe-Cl.

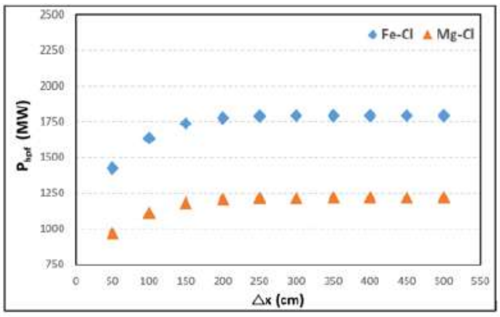

Fig. 5: Phpf (MW) Total Power Change Required for Hydrogen Production due to Coolant Zone Thickness

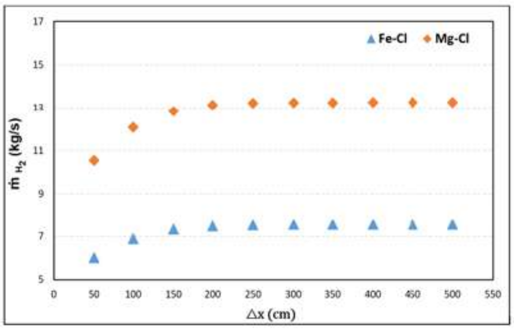

Fig. 6: Hydrogen production amount by Fe-Cl and Mg-Cl methods depending on Coolant Zone Thickness

V. Conclusions

According to the hydrogen production analysis for the modified Fe-Cl thermochemical cycle and Mg-Cl thermochemical cycle for the PACER nuclear power plant, the results obtained are given below:

◇Depending on the increase in the thickness of the coolant zone, the amount of hydrogen produced has also increased.

◇When Magnesium-chloride and iron-chloride thermochemical cycles are compared according to hydrogen mass flow rates; Mg-cl>Fe-Cl.

◇The maximum amount of the hydrogen production has been computed as 13.25 kg/s of coolant zone thickness 550 cm. (Mg-Cl)

◇The Pacer fusion reactor can be used as an energy source for hydrogen production by the Fe-Cl and Mg-Cl thermochemical cycle.

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TECHNO-ECONOMIC AND ENVIRONMENTAL ANALYSIS OF THE INTEGRATION OF SOLAR TRACKED OR FIXED-TILT PHOTOVOLTAIC POWER PLANTS TO OPEN COAL FIELDS OF THERMAL POWER PLANTS IN TURKEY

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ABSTRACT
In this study, it has been analyzed how feasible the transition to photovoltaic power plants as an alternative to fossil fuels is by fictionalizing that solar power plants are integrated into the open coal fields of fossil fuel-based thermal power plants, which cause serious greenhouse gas emissions, to the extent that the unshaded area and radiation data of the fields are suitable.

Keywords: Thermal power plants, solar power, solar tracked photovoltaic power plant, fixed-tilt photovoltaic power plant, greenhouse gas emissions.

1. INTRODUCTION
Reducing the increase in greenhouse gas emissions on a global scale is a necessity and even an inevitable goal for a sustainable environment in terms of preventing climate change. In this direction, the electricity generation sector; where fossil fuels are used most intensively and causes the highest increase in greenhouse gas emissions; should consider the transition of from the use of fossil fuels to renewable sources for to prevent the increase in greenhouse gas emissions. By ratifying the Paris Climate Agreement on April 22, 2016, Turkey joined the countries that made a commitment to work to keep the global temperature rise at 1.5 degrees. In the same period by ratifying the agreement, Turkey also announced its net zero emission target by 2053.

With this study, the integration of solar-tracked or fixed-tilt photovoltaic solar power plants in the open coal field of three selected coal-based thermal power plant from Turkey has been analyzed in the light of various parameters. Technical, economic, and environmental analyzes of this integration has been made in terms of thermal power plants and an Excel-based simulation has been created based on the objective function for the payback period calculation, which also includes the carbon trading mechanism parameter.

2. MATERIAL AND METHODS
In this study, coal-based thermal power plants producing electricity in three regions in Turkey have been selected and then the annual electricity production capacities of these power plants, the calorific values of the coal they use, the area sizes of open coal fields and the size of the unshaded area where photovoltaic solar panels can be installed, the interior energy consumption of thermal power plants, current investment and operating costs, carbon emissions and carbon footprint values have been investigated by literature research. In addition, cell types, efficiencies, costs, the interior energy consumptions of solar tracked photovoltaic systems and carbon footprint values of tracked and fixed-tilt photovoltaic systems have been determined by literature research.

The land conditions of the regions where these power plants have open coal fields have been examined, the total and direct solar radiation data of the regions obtained from the General Directorate of Meteorology. If the PV project needs to be designed with limited area, solar trackers could increase the efficiency without requiring extensive alterations, by this direction PVSYST Simulation Software has been used for analyzing if the solar-tracked or the fixed-tilt photovoltaic systems would be more efficient in energy production in this open coal fields.

After that, An Excel-based simulation has been created by making a decision-making algorithm that includes thermo-economic and environmental analyzes such as reduced carbon emissions by using the data obtained from literature research. By using this simulation, analyzes have been made for three different thermal power plants from Turkey and the results have been discussed.

3. RESULTS AND DISCUSSION

The most important added value of this study is creating a simulation including the parameters about the techno-economic and environmental feasibility analysis of the transition of coal-based thermal power plants to solar power plants in Turkey. Life-cycle assesment (LCA) of photovoltaic(PV) systems and thermal power plants have been searched. In this study numerical analyzes have been revealed in terms of fossil fuel-based electricity sector relating to European Union Emissions Trading System. In addition, applicability of the commitments made by Turkey under the Paris Climate Agreement and the obligations to be fulfill by energy sector in Turkey under the European Carbon Border Adjustment Mechanism; as part of the European Green Deal; has been examined.
Life-cycle assesment can help to determine environmental burdens from "cradle to grave" and facilitate comparisons of energy technologies. Comparing life cycle stages and proportions of greenhouse gas (GHG) emissions from each stage for PV and coal shows that, for coal-fired power plants, fuel combustion during operation emits the vast majority of GHGs. for PV power plants, the majority of GHG emissions are upstream of operation in materials and module manufacturing. Total life cycle GHG emissions from solar PV systems are similar to other renewables and nuclear energy, and much lower than coal.[1]

As can be seen from Figure.1, the CO2 emissions of the Solar-PV power plants is only a few grams of CO2 equivalent per kWh when compared to coal-based thermal power plants according to the life-cycle results. The United Nations (UN) Intergovernmental Panel on Climate Change (IPCC) has provided a median value among peer-reviewed studies of 48g CO2 equivalent per kWh for Solar-PV Utilities.

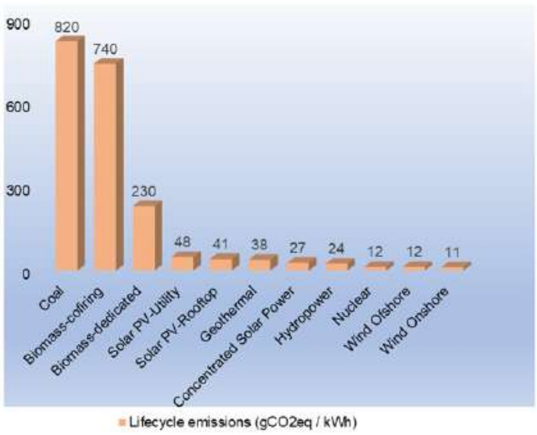

Figure.1 Emissions of selected electricity supply technologies (gCO2eq / kWh), [2]

Open coal fields's solar power potential of thermal power plants in Turkey has been examined by a report. 22 thermal power plants have been included in this report which have totally 10,495 MW current installed power. It has been calculated in framework of suitable areas in this open coal fields transformed to solar power plants; with a total of 13,189 MW installed capacity that solar power plant can be installed. 19,079 GWh/year electricity can be produced from this solar power plants that annual electricity needs of 6.9 million households can be met and 12.4 million tons of CO2 emissions per year that comes from these 22 coal-based thermal power plants can be avoided.[3]

Table 1. The Data of Transition of 22 Thermal Power Plants to Solar Power Plants

Solar Power Potential of Open Coal Fields of TPP İn Turkey	Amount	Unit
Number of TPP Included in the Calculation	22,00	Piece
Total Installed Capacity of Coal-Based TPP	10.495,00	MW
Total Installed Capacity in Transition to SPP	13.189,00	MWp
Total Electricity Production Capacity in Transition to SPP	19.079,00	GWh/year
Carbon Emission To Be Avoided	12,40	MT CO_2/year

4. CONCLUSIONS

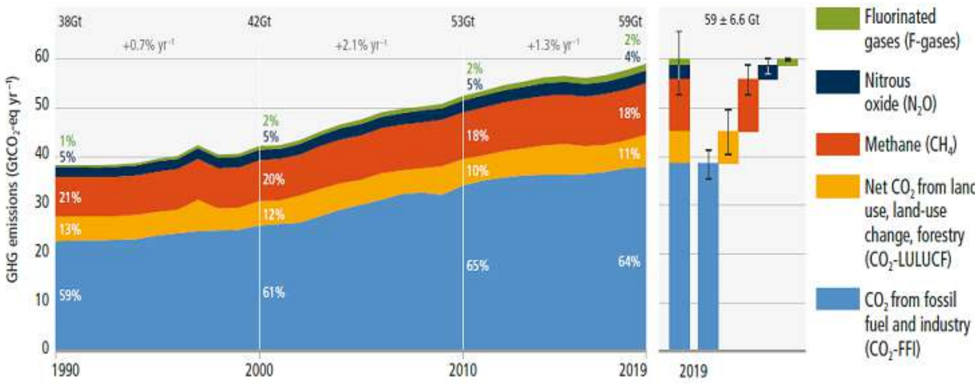

Figure.2 Global net anthropogenic GHG emissions 1990–2019 [4]

As can be seen from figure 2, in 2019; 59 Gt green house gas emission have been emitted. Global net anthropogenic GHG emissions include CO2 from fossil fuel combustion and industrial processes. According to IPCC Report 6th, in 2019, CO2 emissions correspond to 64 percent of these 59 GT emissions. With an annual increase of 1.3 percent of GHG emissions, the GHG emissions in 2022 has been calculated as in table 2.

Table.2 Annual GHG Emissions with an annual increase of 1.3 percent.

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
GHG Emissions (Gt/year)	53,69	54,39	55,09	55,81	56,54	57,27	58,02	58,77	59,53	60,31	61,09	61,89

With a 64.3 percent of CO2 increase of GHG emissions, approximately CO2 Emissions in 2022 has been calculted as;

61,89 Gt*0.643 = 39,79 Gt CO2.

By the report; If 22 TPP will turn to SPP in Turkey; annual 3,11 percent of global CO2 emissions will be avoided.

Table.3 Approximate avoided percentage of CO2 emissions in global.

Process	CO2
By 22 TPP's transition to SPP, annual avoided CO_2 Emissions in Turkey	12.400.000,00 (ton)
Global CO2 emission in 2022	39.792.404.883,48 (ton)
How much percent of total global $C0_2$ is coming from Turkey?	0,031161726 (%)

Today the apparent climate effect of CO2 has become a widespread concern and has a major influence on decisions about how the electricity should be generated. According to the results of this study, it is inevitable for the electricity sector to leave the coal source and turn to renewable sources such as solar power in order to fulfill the net zero emission commitments under the Paris Climate Agreement.

NOMENCLATURE

gCO2eq /kWh: gram carbon dioxide per kilo watt hour

GHG Emissions: Greenhouse gas emissions.

Gt/year: Gigaton per year.

IPCC: Intergovernmental Panel on Climate Change

LULUCF: Greenhouse gas emissions by land use, land-use change, and forestry

LCE: Life-cycle assessment

MT CO2/year: Megaton(1 million ton) carbon dioxide per year

PV System : Photovoltaic System

PVSYST: Photovoltaic System Software

SPP: Solar Power Plants

TPP: Thermal Power Plants

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THE USE OF ENHANCED CARBON NANOTUBES (CNT AND CNT/PVA) OBTAINED FROM COMPOSITE PACKAGING WASTES AS CARBON DIOXIDE ADSORBENT

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ABSTRACT
It is essential to find solutions to reduce carbon dioxide (CO2) emissions released into the atmosphere due to global targets. Today, different materials are used for CO2 adsorption. Among them carbon nanotubes (CNT) are attractive due to their high filtering properties, and their robustness. This study aims to determine the potential of CNT produced from waste composite low density polyethylene (C/LDPE) as a CO2 adsorber. To increase the adsorption efficiency, CNTs was enhanced with polyvinyl alcohol (PVA) to produce CNT/PVA. Adsorption studies were carried out with the native CNT and CNT/PVA, and the results were compared. The results show that PVA enhancement improved the CO2 adsorption capacity of CNT approximately 130%.
Keywords: ADSORPTION, CARBON DIOXIDE, CARBON NANOTUBE, COMPOSITE

1. INTRODUCTION
The concentration of carbon dioxide in the atmosphere has been increasing rapidly, primarily due to human activities such as the burning of fossil fuels, deforestation, and land-use changes. These activities have led to a significant increase in greenhouse gas emissions, which trap heat in the atmosphere and cause global warming. To mitigate the impact of greenhouse gas emissions, it is important to implement strategies to reduce emissions and capture and store CO2 from various sources. Carbon capture and storage (CCS) technologies are one such strategy that involves capturing CO2 from industrial processes, such as fossil fuel power plants, and storing it underground or utilizing it for other purposes. The development and deployment of CCS technologies have the potential to significantly reduce greenhouse gas emissions and mitigate climate change. However, there are still technical, economic, and regulatory challenges that need to be addressed to make CCS a viable option on a large scale (Açıkgöz et al., 2012).
According to Turkey's greenhouse gas emission statistics for 2021, the total amount of greenhouse gas emissions continued to increase in 2021 and reached 564.4 million tons, and the amount of greenhouse gas emissions per capita was 6.7 tons of CO2eq was recorded as. In 2021, approximately 71.3% of cumulative CO2 emissions were from energy, 13.3% from industrial processes and product use, 12.8% from agricultural activities, and 2.6% from waste. In the primary and secondary sub-sector breakdown of CO2 emissions, the weight of fuels combustion, cycle and energy sub-sector, mineral products, and metal production sub-sectors is higher than the others (http-1, 2023). Carbon nanotubes (CNTs) have a high surface area and high adsorption capacity, which makes them a promising material for capturing CO2 from industrial emissions and other sources.
CNTs are preferred materials in many fields due to their unique chemical, electrical and mechanical properties. In applications such as biosensors, gas sensors, temperature sensors, since they are sensitive to this change when environmental conditions change; as a capacitor and gas storer in nano-assemblies because of their small size; as a filter and adsorbent due to its high filtering properties; it is used in many areas such as composite material production due to its high strength. It has also been proven that CNTs have good adsorption capacity for removal of organic and inorganic pollutants due to their hollow and layered structure with a large surface area (Shawky et al., 2011). Not only the CO2 sequestration feature of CO2 adsorption materials is important. There is also a need for materials that must be highly flexible and mechanically strong enough. In this context, composite materials consisting of various carbon-doped polymers can be developed for CO2 capture (Zainab et al., 2017). The addition of surfactant to chemically activate CNTs can increase their CO2 adsorption potential. The grafting of a surfactant onto a CNT surface increases the adsorption capacity of the CNT. Lee et al. (2015) showed that the CO2 adsorption capacity increased by 200% by impregnating polyethyleneamine on multi-walled carbon nanotubes (MWCNTs). Lu et al., (2008) modified CNTs, granular activated carbon (GAC) and zeolites with 3 aminopropylthylethoxysilane (APTS) in their study and examined the obtained modified adsorbents as CO2 adsorber. Under the same conditions, modified CNTs exhibited the highest CO2 adsorption performance. In a similar study, Osler et al., in their study in 2017, determined that impregnation of a surfactant on a CNT surface increases the adsorption capacity of CNT.
In this study, it was aimed to determine the potential of carbon nanotubes produced from composite packaging waste as carbon dioxide adsorber and differently from the literature, composite material was produced by using CNT and polyvinyl alcohol (PVA) to increase the adsorption efficiency. It has been observed that PVA is used especially for adsorption in aqueous solutions, but has not been tested for gas adsorption, and in this study, the gas adsorption potential of the composite material produced with PVA was investigated.

2. MATERIAL AND METHODS

In the study, the potential using of CNT and CNT/PVA as CO2 adsorbent was determined. So, the study was realized three stages: CNT production, obtaining of composite material and adsorption studies.

2.1. Materials

CNT produced from waste C/LDPE were used as the basic adsorbent material in the study. CNT was obtained by chemical vapor deposition method (with nickel catalyst) of the gas product obtained from pyrolysis of waste composite low density polyethylene (C/LDPE) (Yapıcı, 2023). PVA with purity of 92-94% was purchased from Acros.

2.2 Methods

The CNT for purification were kept in 5M nitric acid solution for 24 hours, filtered through a 0.2μm pore PC membrane with vacuum filter method, washed with distilled water until neutral and dried at 110°C and used as adsorbent.
To prepare the PVA solution, 3 g of PVA was added to 100 mL of distilled water and stirred at 90°C for 6 hours. After 6 hours, 0.15 grams of CNT was added to the prepared PVA solution. The resulting solution was stirred at room temperature for 24 hours. Then, sonication (Sonics Vibra-Cell VCX-500 Ultrasonic Processor) was applied to the mixed solution for 1 hour. In order for PVA to gain swelling property, 0.133 ml glutaraldehyde (5% by weight based on PVA) and 10 ml H2SO4 were added for crosslinking (Abdeen, 2011). This mixture was stirred at a stirring speed of 80 rpm at room temperature for 24 hours. The resulting mixture was poured into a petri dish and left to dry at room temperature (Fig. 1).

Fig.1. Produced CNT/PVA composite material.

An adsorption column with a total length of 20 cm and an inner diameter of 1.5 cm was separately filled with CNT and CNT/PVA (Fig. 2). Then, mixing of CO2/N2 was fed for 5 minutes at a flow rate of 0.1 L/min. Tedlar Bag was connected to the output line of the column and the bags were changed every 30 seconds. The collected off-gases were analyzed with a Shimadzu GC-TCD 2014 brand Gas Chromatography (GC) device. In the device, helium was used as the carrier gas at a flow rate of 30 mL/min. The initial oven temperature was 43°C and kept at this temperature for 2 minutes. Then, with a temperature increase of 10°C per minute, 200°C was reached and kept at this temperature for 20 minutes. The obtained peaks were evaluated together with the previously created calibration charts and the volume composition (%) was determined.

By using Eq. 1, adsorption amounts per unit adsorbent were calculated. In the equation, m; adsorbent amount (g), t; time (min), Q; flow rate (L/min), C0; initial concentration (mg/L), Ct; is the concentration at time t (mg/L).

$$q = \frac{1}{m}\int_0^t Q \times (C_0 - C_t)dt \qquad (1)$$

Pseudo first, pseudo second and diffusion models were used to evaluate the adsorption kinetics according to Eq. 2, 3 and 4, respectively.

$$\log(q_e - q_t) = \log q_e - \frac{k_1 t}{2.303} \qquad (2)$$

The pseudo-second order model is expressed in Eq. 3.

$$q_t = \frac{1}{k_2 q^2} + \frac{1}{q_e} t \qquad (3)$$

The diffusion model is expressed in equation 4.

$$q_t = k_d t^{1/2} + C \quad (4)$$

qe: Amount of adsorbent adsorbed at equilibrium (mg/g), qt: Amount of adsorbent adsorbed at time t (mg/g), k1: Rate constant (min-1), k2: Rate constant (g/mg.min), kd: Diffusion rate constant (mg/g-1min-1/2), C: boundary layer thickness in the above equations.

Fig. 2. Adsorption setup

3. RESULTS AND DISCUSSION

According to the GC-TCD analysis results, the breakthrough curves of C/C0 versus time for CNT and CNT/PVA are given in Fig. 3 (a-b), respectively. According to the curves, the breaking point was reached rapidly with CNT (3.5 – 5 min.) while it took longer time to reach equilibrium with CNT/PVA. However, when the adsorption efficiency is considered, it is seen that PVA is effective. The adsorption amounts per unit adsorbent (q) were calculated as 134 mg/g and 483 mg/g for CNT and CNT/PVA, respectively.

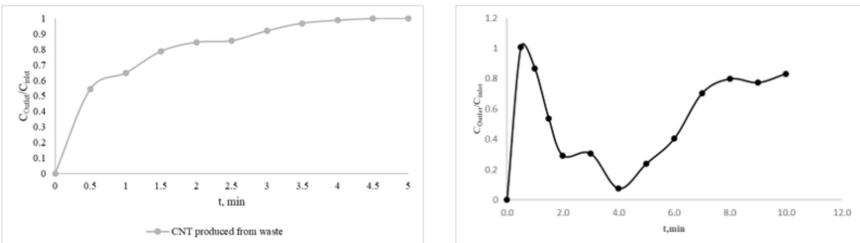

Fig. 3. Breakthrough curve for a) CNT b) CNT/PVA

Kinetic model coefficients and regression coefficients are given in Table 1. When the kinetic model results were examined, it was seen that the diffusion model was most suitable for the CNT (R2: 0.946), while the pseudo-second order models gave the highest R2 values for the CNT/PVA.

Table 1. Results of kinetic models

Model	Adsorbent	Constants	R^2
Pseudo-first order model	CNT	k_1: 0.7402 q_e: 1.5787	0.6902
	CNT/PVA	k_1: -0.3054 q_e: 9.3347	0.2607
Pseudo-second order model	CNT	k_2: 0.5782 q_{e2}: 1.2957	0.5507
	CNT/PVA	k_2:0.1056 q_{e2}: 4.9237	0.7617
Diffusion model	CNT	k_d: -26.894 C: 56.15	0.9461
	CNT/PVA	k_d: -15.05 C: 56.15	0.3984

4. CONCLUSIONS

The rapid increase in the atmosphere of CO2, known as the primary anthropogenic greenhouse gas, that causes global warming, raises great concern. Therefore, it should be aimed to develop and implement new technologies to limit greenhouse gas emissions. For this reason, the adsorption of CO2 with CNTs was targeted after combustion in this study. In the adsorption studies carried out for CO2, the adsorption capacity of CNT produced from waste was found to be 134 mg/kg. In order to improve the adsorption capacity, composite materials were produced with PVA, and significant yield increases were obtained with PVA. By modifying the CNT with PVA, the CO2 adsorption capacity was approximately 130%.

Acknowledgement

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A LESSON PROPOSAL FOR USING THE CIRCULAR ECONOMY IN DESIGN EDUCATION

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ABSTRACT

Along with the problems experienced in the ecological system of the world, approaches towards ecology and the environment have begun to come to the fore. For the solution of the system, a structure that prioritizes the natural environment and resources has been designed. In this structure, which is an environmentalist approach of the circular economy, the importance of reuse and recycling is emphasized. Design processes are also kept within the concept of circular economy to use reuse and recycling. Instead of the traditional Take-make-use-dispose production and consumption model, a sustainable and environmentally friendly model should be established. The aim of the study; By integrating the concepts of reuse and recycling into the design steps, to enable the undergraduate students of Architecture and Industrial design to participate in the course setup with these concepts. For this purpose, students are asked to make inquiries using the concepts specified in the first-year undergraduate courses and to enable them to solve the problems in line with these concepts.

Keywords: Circular economy, Design for Circular Economy, Design Education.

1. INTRODUCTION

Since the middle of the 20th century, problems with ecological and environmental factors have increased. The circular economy model has emerged to prevent these problems. The circular economy offers a structure that uses environmental factors and is compatible with nature. Recycling and redesigning wastes for the protection of natural resources is evaluated within the concept of circular economy. The concept of circular economy has been discussed on many different platforms and has been handled within the framework of sustainability.

In the capitalist production and consumption system, it created the perception that nature is unlimited, easily accessible, and cheap. For this reason, the circular economy system is more sustainable instead of the linear economy model that foresees the unlimited consumption model. Thanks to the circular economy model, which recommends the use of renewable energy, respects environmental factors, and causes less harm, the reusability of industry-oriented designs is also evaluated (Negiz & Yalçın, 2023).

Circular economy according to the definition of Organization for Economic Co-operation and Development (OECD); "The circular economy, as a concept, involves using resources more efficiently across their life cycle by closing, extending and narrowing material loops that could result in decoupling of primary raw material consumption from economic growth. The transition to a circular economy entails approaches that may lead to lower rates of extraction and use of natural resources. This in turn leads to improved resource efficiency and the promotion of sustainable materials management." (OECD, 2018). circular economy consists of concepts such as ecology, ecosystem, clean production, biomimicry, product service systems, renewable energy, recycling and reuse (Korhonen, Nuur, Feldmann & Birkie, 2018). In the 21st century, environmental-oriented problems such as global warming and climate change are experienced due to the uncontrolled consumption and use of natural resources. To take care of environmental factors and solve problems, design approaches also need to change. The idea of a single user affecting the whole is an important step for design. With this approach, a design idea that affects the whole ecosystem emerges from individuality.

The concept of design in the circular economy; should offer sustainable, energy efficient and nature-protecting solutions. For this reason, reducing and reusing natural resources and minimizing the use of new resources provide the necessary conditions to maintain the cyclical system (Corona, Shen, Reike, & Rosale, 2019). The circular economy minimizes the use of new resources in the consumption, production and transportation processes of products and services, reuses, recycles and saves existing resources (Güngör, 2023). In summary, design for the circular economy is to construct the product, service and experience that meets these conditions.

The old approach in the field of production and consumption, which is the result of traditional and habitual use, where there is a loss of value and the use of products is one-time, has been supported more by the idea of circular economic approach. For this reason, the design process has reached an effective position with multi-use and interaction between users in the field of design.

It has been increasingly supported in recent years as a model to replace the linear economic approach, in which traditionally products are produced, used and then eliminated with a significant loss of value(Ghisellini, Cialani, & Ulgiati, 2016). It directly affects all production and consumption sectors, especially technology, transportation, packaging, plastics, petroleum, chemistry, textile, construction and buildings, food and beverage within the supported areas (Sapmaz Veral, 2021).

For the circular economy to be considered in the act of designing, it must be combined with the education program. For this reason, a sustainable approach lesson plan proposal has been made for the Department of Industrial Design and Architecture, which is the subject of the study, which provides design-oriented education.

2. MATERIAL AND METHODS

This study analysed the design-oriented approaches of the circular economy. Afterwards, the design-oriented course contents of Haliç University Faculty of Architecture Department of Architecture and Industrial Design students were examined. Teaching the design approach for the circular economy within the first-year undergraduate courses was considered more suitable for design education. The study has been built on this approach.

In the study, design for reuse, design for maintenance, design for recycling, design for product life extension, design for remanufacturing and design for disassembly approaches will be associated with design education for course content. These contents are considered under design for circular economy (Sevgül, Eren, & Yavuzcan, 2020).

The circular design approach of Sevgül, Eren & Yavuzcan (Sevgül, Eren, & Yavuzcan, 2020) quoted from Poppelaars (Poppelaars, 2013) is shown in Table 1.

Table 1. Design Approaches for the Circular Economy

	Design For Repair	**Design For Reuse**	**Design For Refurbishment**	**Design For Remanufacturing**	**Design For Recycle**
METHODS	Improving working conditions.	Providing 2nd, 3rd life to the product	Improving the quality level.	Repairing the Quality Level as new.	Reusing the material.
	Repairing damaged parts.	Reaching the product to other consumers.	Replacing worn or broken components to improve quality or performance.	To reproduce the entire product. Reusing sub-components of the product in the same product family, in the same industry, or in another industry.	Separating materials/components.

In line with the approaches in Table 1., it is suggested to reach the essence of the subject by asking various questions, consisting of three stages, according to the studies that the students will do in the design-oriented course. These questions are compiled from the content of "The Circular Design Guide" prepared by Ellen Macarthur and IDEO. (IDEO and Ellen Macarthur, 2017).

•What are the needs of the user?
•How is it used?
•What features do users value, and which are essential?

The first purpose and use of the product is determined by the questions given above. After evaluating these questions, students are asked to think about what they will do next for the return of the products they designed. Continuously, they are guided to ask the following questions about the products they design. (IDEO and Ellen Macarthur, 2017);

• Is the product recycled into the environment?
• Is the product re-usable by a new user? (Refunctioning is included in this question)
• Is the product being repaired or refurbished?
• Is the product complete and reproducible?
• Is the Product Recyclable for Use?

After these questions, the students are asked to return to the first step and questions in which they designed the products. Students who successfully complete both steps move on to the third stage and are inquired to ask the following questions (IDEO and Ellen Macarthur, 2017).

• Can your design be made more modular and useful?
• Can your design be designed by taking nature/Living systems as an example?
• How can your design be renewed over time?
• What conditions can your design go through over time and be renewed?

The products designed as a result of the three-stage approach have emerged as the products that are planned to cause the least harm to nature and the environment.

3. RESULTS AND DISCUSSION

In this study, the design-oriented principles of the circular economy have been evaluated and new approaches have been proposed for the content of the design course. In project-based studies, it is aimed for students to consider design thinking as a whole and to think in a large system. In the course content, it is aimed to enable students to experience the design thinking based on design principles for the circular economy. For this purpose, it has been tried to enable students to question and research.

A three-stage design approach was created for students to question. They were asked to design in line with these approaches. As a result, it has been determined that the challenge to be solved is not only design, but the future steps of a designed product are also the designer's problem.

The design process is a long-term process. For this reason, the three-stage questions given in this study are not effective in providing products that contribute to the completely circular economy. However, they are created for students to take the first steps to design for the concept of circular economy.

4. CONCLUSIONS

Students' design approaches for circular economy should be given in the first year of the undergraduate period and these approaches should be reinforced with various presentations before they are given. In line with these approaches, it has emerged that the course content on design for circular economy should be taught more in design-based faculties and case studies should be increased. It has been aimed to protect the nature and to ensure that the questioning individuals take protective steps instead of taking polluting steps. This situation is not only the responsibility of the designers, but also of all units in the relational network that takes care of environmental factors.

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EXPERIMENTAL INVESTIGATIONS TO REDUCE CO2 EMISSION IN A SINGLE CYLINDER CI ENGINE USING WASTE PLASTIC OIL BLEND COMBINED WITH LEMON PEEL OIL UNDER DUAL FUEL MODE OF OPERATION

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ABSTRACT
The present study investigates the usage of waste plastic oil (WPO) blend in replacement for conventional diesel combined with lemon peel oil injection in the intake manifold for reduction of CO2 emission in a single cylinder CI engine. At first WPO B80 (80% of WPO + 20% diesel on volume basis) blend was chosen to be used as an alternative for diesel since waste plastics were available in plenty. Combustion of WPO B80 emits more CO2 due to longer carbon chain. The reduction in CO2 emission was done by injecting a plant based oil namely Lemon peel oil (LPO). Since the properties of LPO are very much suited for combustion, it has been made to induct at 10% 20% and 30% on volume basis in the intake manifold. The results indicated 15.05% reduction in CO2 emission for WPO B80 + 20% LPO compared to WPO B80 However, considering CO2 emission, WPO B80 + 20% LPO is optimum for reduction of CO2 and offers a better alternative for conventional diesel fuel.
Keywords: Global warming; CO2 emission reduction, Waste Plastic Oil, Lemon Peel Oil, Diesel Engine

1. INTRODUCTION
Global warming poses a major threat to the environment impacting people, wildlife and ecosystems. Intergovernmental Panel of Climate Control (IPCC) has predicted an increase of 1 – 2°C in the earth's surface temperature by 2020 and 2 – 5°C by 2070. The IPCC also anticipates that Asia will experience changing climate conditions – a rise in temperature, longer summer heat spell, increase in rainfall and a rise in sea levels in coastal areas around Indian ocean, northern and southern Pacific ocean (Christensen et al., 2007). The gases causing global warming are CO2, CH4 and water vapour. CO2 is one of the major constituents for global warming. The climatic change threatens basic elements of life for people around world – access to water, food, health and use of land as well as the environment. Increase in temperature, sea level and storm surges will have a substantial impact on transport infrastructure (Stern et al., 2007). India is a fast growing country and as one of the largest energy consumers was responsible for about 5% of global CO2 emission in 2010 (IEA, 2012a). As a part of Copenhagen accord, the Indian Government stated that total GHG emission will be reduced to about 25% by the year 2020 (IEA, 2012b). Diesel fuelled vehicles are more popular in India due to higher thermal efficiency, reliability and subsidised price offered by the government. Diesel fuelled vehicles emits about 2.7 kg of CO2 per litre of diesel. Use of biofuels in CI engine is a prominent method to reduce CO2 emission due to the advantage of eco recycling (Sureshkumar et al., 2008).

2. EXPERIMENTAL SETUP AND TEST PROCEDURE
A single cylinder four stroke water cooled naturally aspirated direct injection compression ignition engine with developing capacity of 5.7 kW power at 1,500 rpm was used for the experimentation. The engine was loaded with the help of a water-cooled eddy current dynamometer. The fuel flow rate was measured using a burette and a stop watch. The CO, HC, NO and CO2 emissions were measured using AVL five gas analyser. While the smoke opacity was measured using an AVL smoke meter. The engine was loaded from no load to full load in steps of 25%. The data was taken when the engine reached stable conditions. Initially, the engine was tested with neat diesel. In the second phase, WPO B80 blend was used and engine was made to run at 1,500 rpm, at various load conditions and the readings were noted down. In the third phase, for further reduction of CO2 emission, LPO was inducted into the intake manifold at 10%, 20% and 30% on volume basis by calculating the total fuel consumption of the engine.

3. RESULTS AND DISCUSSION

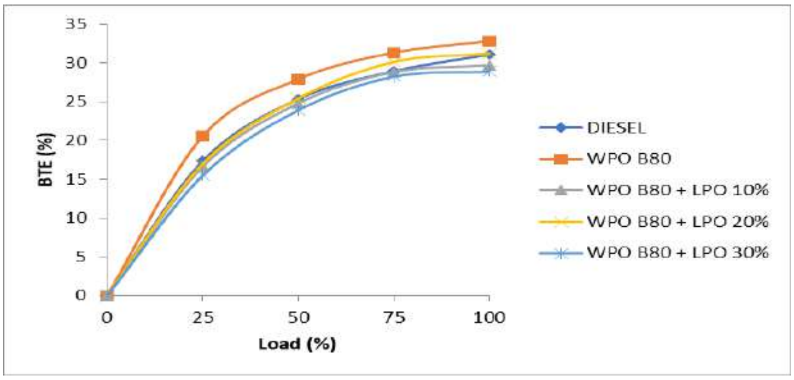

Fig. 1 Brake thermal efficiency versus load

Fig 1 shows the brake thermal efficiency versus load at different load conditions. It is seen that the efficiency increases with increase in load for all the test fuels as more fuel is injected with increase in load thereby releasing more heat energy. At full load, the engine efficiency is highest with waste plastic oil B80 having 32.81% efficiency when compared to diesel which is 31.09%. On adding LPO, the brake thermal efficiency slightly gets reduced for 10% and 20% percentages with 29.7% and 28.92% respectively for WPOB80 + LPO 10% and WPOB80 + LPO 30%. Whereas for WPOB80 + LPO 20% it gets slightly increased to 31.17% due to its low density and high CV of the blend and LPO.

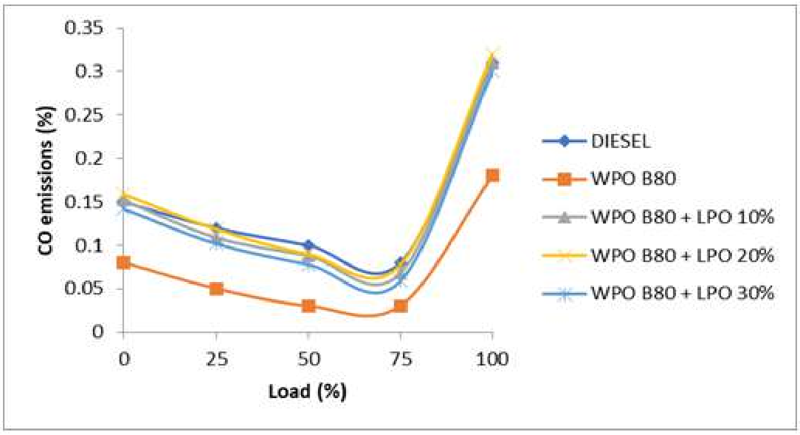

Fig. 2 Carbon Monoxide emission versus load

Fig 2 indicates the variation of Carbon Monoxide emission versus load for various test fuels. CO emission at maximum load for Diesel, WPO B80, WPO B80 + LPO 10%, WPOB80 + LPO 20% and WPOB80 + LPO 30% are 0.31%, 0.18%, 0.31%, 0.32% and 0.3% respectively. Increase in CO emission is the result of rich A/F mixture available for completion of combustion. Also, the high CO emission is an evidence of excess fuel being delivered to the engine for the available air at the engine intake causing partial burning. Decrease in CO for WPO B80 may be due to to more O2 molecules and lower carbon content in blends in comparison with diesel fuel which leads to improved combustion.

Fig 3 depicts the variation of CO2 emissions versus load for different test fuels. At 100% load conditions, CO2 values for Diesel, WPO B80, WPO B80 + LPO 10%, WPOB80 + LPO 20% and WPOB80 + LPO 30% are 10.9%, 11.5%, 10.3%, 9.89% and 10.2% respectively. The reduction in CO2 emissions is observed when LPO is added in various proportions, which may be due to complete combustion of fuel. Increase in CO2 emissions were observed for WPO B80 blend when compared to diesel is due to incomplete combustion or partial combustion.

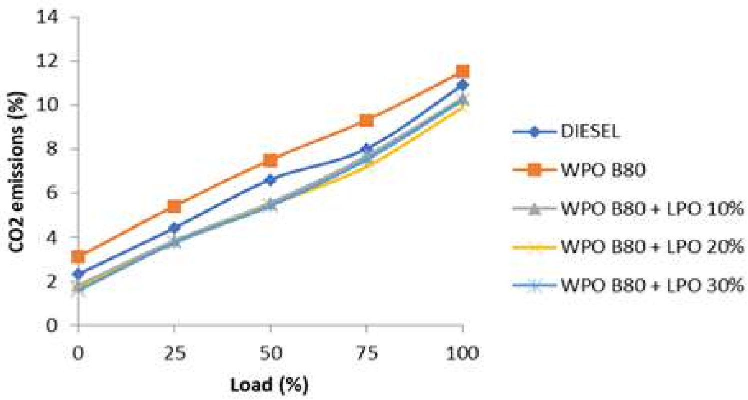

Fig. 3 Carbon Dioxide emission versus load

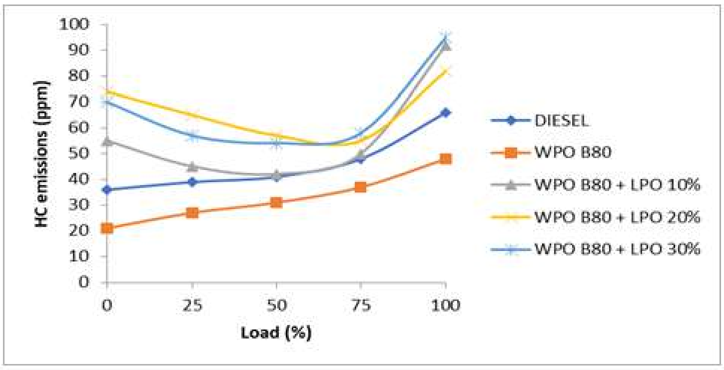

Fig. 4 Unburned hydro carbon emission versus load

Fig 4 depicts the variation of Hydrocarbon emission with that of load. At maximum load condition, Hydrocarbon values for Diesel, WPO B80, WPO B80 + LPO 10%, WPOB80 + LPO 20% and WPOB80 + LPO 30% are 66 ppm, 48 ppm, 92 ppm, 82 ppm and 95 ppm respectively. Once LPO is added, the HC emissions starts to increase. This is because of lower cetane index and more oxygen content in the test fuels. It is clear that the higher viscosity, density and poor volatility are also important factors for higher HC emissions.

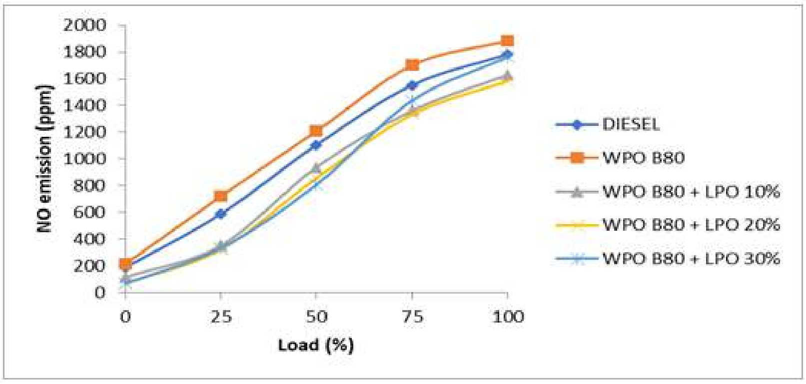

Fig. 5 Oxides of nitrogen emission versus load

Fig 5 indicates the NO emission versus load for various test fuels. At 100%load condition, NO emission for Diesel, WPO B80, WPO B80 + LPO 10%, WPOB80 + LPO 20% and WPOB80 + LPO 30% are 1783 ppm, 1885 ppm, 1629 ppm, 1584 ppm, 1766 ppm respectively. Longer ignition delay, higher combustion temperature, availability of oxygen and resident time are major causes of NO emission for all test fuels except for WPOB80 + LPO 10%, WPOB80 + LPO 20% and WPOB80 + LPO 30%. Increase in NO emissions is due to the improved combustion due to less density and better volatility of the blend resulting in higher in-cylinder temperature compared to diesel fuel.

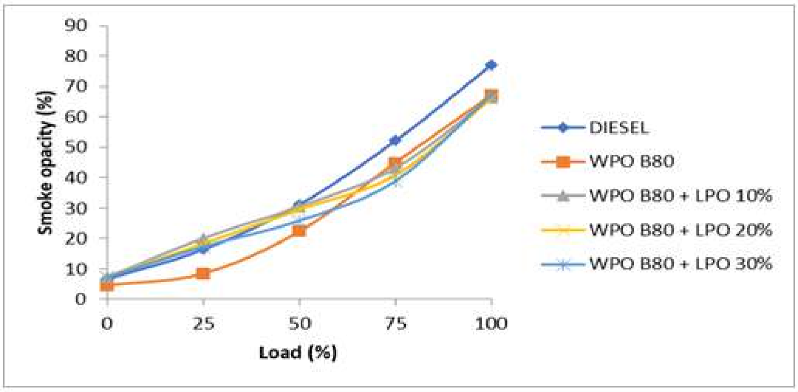

Fig. 6 Smoke emission versus load

Fig 6 displays the variation of smoke emission with load for different test fuels. At full load condition, the smoke emission for Diesel, WPO B80, WPO B80 + LPO 10%, WPOB80 + LPO 20% and WPOB80 + LPO 30% are 77.2%, 67.2%, 66.3%, 65.9% and 67.1% respectively. After adding LPO, the reduction in smoke emission is due to the presence of oxygen in LPO. The increased smoke emissions for diesel and WPO B80 blend at full loads are due to the fact that too much rich mixture leads to incomplete combustion thus leading to formation of smoke.

4. CONCLUSIONS

The following conclusions were drawn based on the experiments.

1.The brake thermal efficiency gets slightly lowered for all test fuels after adding LPO due to its lower calorific value and higher viscosity.
2.WPO B80 blend emits more CO2 compared to diesel because of higher number of carbon atoms. When LPO is added, the WPO B80 + LPO 20% offers better reduction of 15.05% of CO2 emissions when compared to other test fuels which may be due to complete combustion of the fuel.
3.CO emissions increases for all test fuels after adding LPO to the WPO B80 blend which may be due to rich A/F mixture supplied to the engine.
4.After adding LPO, the reduction in smoke emission is due to the presence of oxygen content in Lemon peel oil.
5.Increase in NO emissions is due to the improved combustion due to less density and better volatility of the blend resulting in higher in-cylinder temperature compared to diesel fuel.

Based on the experimental results, it is concluded that considering CO2 emission, WPO B80 + 20% LPO is optimum for reduction of CO2 and offers a better alternative for conventional diesel fuel without affecting its performance.

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GREEN FUTURE TRANSPORT

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ABSTRACT
This paper sets out a range of requirements for future transport systems and analyzes how these requirements are met by the solutions that are already used in the transport industry or will be employed in the foreseeable future.
Keywords: TRANSPORT, ENVIRONMENT, ECOLOGY, FUTURE TRANSPORT, STRING TECHNOLOGY

INTRODUCTION
The impact that the fast-growing transportation industry is having on the environment and society is hard to overestimate. The rapid development of the transport industry is driven by a growing global population, progressing urbanization and the processes associated with it, as well as the increasing globalization of industrial links between countries and continents. It may turn out that errors in assessing the prospects of transport development may also be one of the main reasons for its demise, in particular through the de-industrialization of the world economy, including in the transport and infrastructure industry.
We should keep the analysis within the next 25-30 years. It is during this period of time that drastic measures must be taken to improve the mobility of populations on all continents of the planet while ensuring the sustainability of civilizational development of mankind.

1.MODELING AND ANALYSIS
The emergence of transport, i.e. the ability of people and goods to move by means of technical solutions, has been the historical foundation of the birth and development of our industrial civilization. However, the increasing number of transportation means, their intensification and the expansion of infrastructure facilities in the future will cause a catastrophic impact on all biosphere resources of the planet (air, soil and water), as well as on economic development, living standards and social aspects of life of all mankind.
First and foremost, carbon dioxide emissions into the planet's atmosphere cause justifiable concern, which has already, in some estimates, led to climate change and, accordingly, to a negative impact on the flora and fauna of practically the entire Earth.
The second factor, which practically kills the environment and affects possible climate change, is the need to build new roads and road structures. As a result, billions of new square meters of soil are massively excluded from natural circulation and "rolled up" under asphalt, concrete, sleepers and rails. At the same time conventional construction of roads in the earth embankment creates artificial barriers and dividing lines for animal migration and destroys natural watercourses (surface and ground). This often causes swamping of large territories on one side and desertification on the other side of the road embankment. In the transport corridors, trees are cut down, fertile soils are destroyed, and natural ecosystems of small animal, insect, and microorganism communities that have developed over thousands of years are ruined.
The growth of the world's population, the number of vehicles and the scale of transport and logistics challenges undoubtedly lead to an increase in the number and size of the transport infrastructure elements. It is impossible to change the vector of development of our "transport and infrastructure civilization", which began with the construction of pyramids, aqueducts, Roman roads and ancient cities. But we need to dramatically reduce the material intensity of transport and infrastructure structures as well as their impact on the landscape and soil, vegetation and wildlife.

The new green transport must address not only environmental and climate change problems, but, more importantly, the socio-economic problems associated with the need to ensure the mobility of people and goods of our fast-growing civilization. The new "clean" transport must reduce the number of accidents that kill millions of people and billions of animals every year. This requires, in the first place, excluding the human factor from safety systems – the control systems of transport complexes must be fully automated, and all vehicles must become unmanned. In the second place, it is necessary to take the trajectories of the rolling stock beyond the Earth's surface, where practically all life and industrial activity actually exists. It is necessary to exclude other vehicles, people or natural and technogenic obstacles on its route. In the third place, the very possibility of collisions and derailment of a rolling stock from a traveling structure must be eliminated by equipping all vehicles with 100% reliable antiderailment system. Thus, the need to relocate the traffic to a space above or below the ground is apparent.

The well-known systems of above-ground and underground transport are very expensive, and only a few countries can afford the large-scale construction of above-ground road or railway overpasses. The developing countries of Asia, Africa, and America, which, by the way, are home to the majority of our planet's population, simply do not have the means to fundamentally address transportation challenges and create "clean", sustainable and "smart" passenger as well as cargo transport and infrastructure complexes.
Therefore, when deciding on the transport and infrastructure technologies of the future, one must consider their affordability, the extent of their development and, most importantly, the availability on the market.
Based on all of the above, such a logistics complex must differ from existing systems in terms of high energy efficiency and productivity, low material intensity, and the possibility to be operated safely under unmanned control. It must also be located on the "second level" – above the ground. At the same time, the capital expenditures for construction and operating costs must be low.
Today, transport complexes that fully meet the above-mentioned requirements for "clean" transport already exist and operate successfully. For example, there are 7 pilot passenger, freight and cargo-passenger complexes of Unitsky String Transport (uST), which are operated in the Innovation Technology Center in Sharjah (United Arab Emirates) and in EcoTechnoPark in Maryina Gorka (Belarus). In addition, the first commercial uST project, a tourist trail in Belarus, is scheduled to begin operation this June.
Unitsky String Transport is based on the use of a "second-level" string rail overpass and can be used for passenger and cargo transportation. The speed of vehicles can reach 150 kilometers per hour in the city and 500 km/h in the intercity traffic. The string rail track structure is based on the use of pre-stressed steel cords and does not require the construction of a massive reinforced concrete overpass. Besides, it is durable, reliable, equipped with an antiderailment system. It has no parasitic screen effect and is several times cheaper than any other transport solution due to its low material capacity and minimum land allotment. At the same time, the urban string transport complex can carry up to 50 thousand passengers per hour.

Currently, intensive pilot operation of several lines of string transport in the UAE and Belarus is underway. Although there is no experience in full commercial operation of this technology yet, in 2021 the uST complexes, including uPods (unmanned rail electric cars on steel wheels), a string rail overpass and "second-level" infrastructure, were certified in the United Arab Emirates in compliance with international regulations.

Fig. 1 illustrates a typical uST transport system [1]

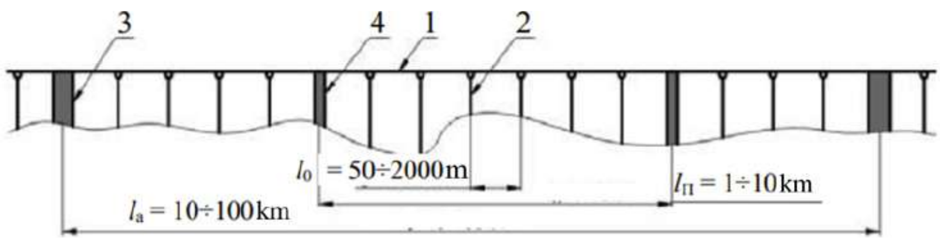

Fig.1. Structural diagram of a typical UST transport system

l0, lП, la correspond to the span size between the supporting towers, driveway anchoring and end anchoring structures, respectively.

This system is a structure containing a pre-stressed string rail track structure 1 placed on supports divided into three distinctive types: supporting tower 2, end anchoring structure 3 and passing anchoring structure 4. The latter differs from the end anchoring structure 3 as it is in a balanced state when the overpass is put into operation. However, during construction and tensioning of string elements, it is the outermost and terminates the forces from pre-stressed elements in the already assembled sections. The distance between supports depends on construction technology, terrain relief, materials used for load-bearing structural components, operating conditions, weight and design speed of vehicles, tensioning forces and other factors.

The economic efficiency of uST Transport & Infrastructure Complexes can be assessed by analyzing the design specifications and estimates of the complexes, which can be operated both in dense urban development and in the suburban area. Typical solutions in these projects are single-track circular and diametral routes. The main design characteristics on the example of a real developed facility for the Eastern region are given in Table 1. This project assumed the possibility of using a circular or pendulum route with a semi-rigid or flexible track structure.

Table 1. The main feasibility characteristics of string transport complexes on the example of a real developed object for the Eastern region [1].

Parameter	Route type			
	circular		pendulum	
Type of track structure	semi-rigid	flexible	semi-rigid	flexible
Route length, m	5 268		2187	
Number of passenger stations, pcs.	10		4	
Number of supporting towers, pcs.	10		4	
Time to run one cycle, s	836		712	
Maximum speed, km/h	85		85	
Standard embarkation/disembarkation time, s	25		25	
Capacity of uCar	16 passengers (6 seats)			
Interval with a max. number of uCars, s	42		712	
Interval with a min. number of uCars, s	167		712	
Passenger flow at a max. number of uCars (20 % turnover – 3.2 passengers on average), ppl/h	2 280		2 092	
Passenger flow at a min. number of uCars (20 % turnover – 3.2 passengers on average), ppl/h	585		674	
Passenger flow at a max. number of uCars (50 % turnover – 8 passengers on average), ppl/h	6 080		3 072	
Passenger flow at a min. number of uCars (50 % turnover – 8 passengers on average), ppl/h	1 560		1 024	
Route extension option	yes	yes	yes	yes
Integration into neighborhood buildings	yes	yes	yes	yes
Requirement to relocate utilities	no	no	no	no

2. CONCLUSIONS

The only technology that best meets all the requirements for the future transport is string transport technology, which could form the basis for a new transport and infrastructure industry capable of solving the mobility problems on the "second level", the logistical problems of the rapidly growing world economy and, at the same time, address most of the environmental, climatic and socio-economic challenges.

Creation of the "second-level" transport system integrated into human life, in particular, into the urban environment, seems to be a practical task using modern achievements in the fields of calculation models, materials science, safety methods and tools, and information technology. This concept has been implemented in uST String Transport Complexes, which are being tested in EcoTechnoPark of Unitsky String Technologies Inc. (Maryina Gorka, Belarus) and in uSky Test & Certification Centre in the Emirate of Sharjah (Sharjah, UAE)[1].

The introduction of new innovative technologies, and not only in transportation, is a challenge. It is a challenge that people, countries, and all of humankind must take on, because not only specific issues related to climate change, but also the survival of all humankind and the preservation of our civilization, our common home – the biosphere of planet Earth – depend on the courage and speed of our decisions.

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EFFECTS OF GREEN FINANCE ON RENEWABLE ENERGY GENERATION IN TURKEY

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ABSTRACT
The concept of green finance, which is one of the most important issues of recent times, gains a lot of importance in our country as well as all over the world, and both the public and private sectors continue to work in this field. Increasing carbon emissions have been the main cause of problems such as global warming and climate changes, which are the result of increasing human population in the world and constantly increasing consumption trends.
The concept of green finance, which emerged due to these factors, aims to encourage investment in clean and renewable energy resources. As in the rest of the world, the concept of green finance has become a top priority both in government policies and in the private sector in our country.
Keywords: Green finance, renewable energy, climate change

1. INTRODUCTION
There is a dire energy demand in the world due to development and growth, increasing population, and developing technology. This rising demand brings the problem of energy supply to the agenda. Especially countries dependent on foreign energy such as Turkey feel this problem much more. Establishing more production facilities, increasing the continuous production capacity, and organizing financial support in this field are among the main action plans of the public and private sectors to ensure energy supply security.
To meet the energy demand, it has always been the first target to increase the production capacity until the year 2000. But today, this problem has brought with it new problems. Until recently, energy production facilities were mostly built-in facilities that use fossil fuels, nuclear power plants, and thermal power plants, which are non-recyclable and waste. As a result of this, the damage to the environment and the atmosphere, increased carbon emissions, and the fact that these facilities make countries more dependent on foreign countries have started to direct countries to new investments and projects. The concept of green finance has entered the energy sector at this point. The concept of renewable, sustainable, and clean energy has gained more priority among the action plans of each country.
In the ranking of renewable energy and capacity total power capacities, the first five countries with the highest share in the world are given. Project, China is the country with the highest power in consuming energy, bioenergy, hydroelectric energy, solar energy, and wind energy. The country with the highest share in the list of energy capacity per capita (excluding hydraulics) is Iceland. The USA is in the first place with its geothermal energy feature and Spain with its concentrated thermal solar energy power feature. Turkey ranks fourth in geothermal energy capacity (Güler, 2021).
Energy production in Turkey has turned from fuels with limited capacity to renewable energy sources with unlimited capacity. In the last 20 years, serious investments and serious incentives have been provided by many countries for energy production from hydraulic, wind, solar, geothermal, biomass, wave, current and tidal resources, which are used as renewable energy sources. These incentives started with the YEKDEM (Renewable Energy Resources Support Mechanism) mechanism with the RES Law No. 5346 enacted in 2005 in our country.
At a time of 35% in 2010, the energy resource capacity reached around 50% of the atmosphere in 2020. One of the biggest reasons for this increase was YEKDEM. In this way, besides reducing our energy consumption, serious reductions in carbon emission rates are reduced.
Developing technology and opportunities have led every country to benefit more from its natural resources. Investments and R&D in clean and reliable energy alternatives are constantly increasing to reduce the pollution of the ecological environment we live in. Turkey should not stay away from this situation and should constantly renew and develop itself in this area.

2. ADVANTAGES AND DIS ADVANTAGES OF RENEWABLE ENERGY

Renewable natural energy source means low or zero carbon and greenhouse emissions. While fossil fuels cause global warming, they emit large amounts of greenhouse gases and carbon dioxide, which are largely responsible for climate change and deteriorating air quality.

Renewable energy sources are inexhaustible and endless. Since energy alternatives such as fossil fuels (oil, gas, and coal) are not unlimited, the danger of extinction is high in the future. Renewable energy can significantly reduce many countries' dependence on fossil fuels. winds, groundwater heat, solar energy, and rivers and flowing waters can provide a country with a large and stable energy supply over long periods of time.

Renewable energy investments make a very serious economic contribution to the place where it is located because it is a lesser alternative to traditional energy sources. According to my orientation towards renewable energy sources, so far, new and achieved jobs are reserved for most world economies.

Turning to renewable energy sources means the stability of energy prices around the world. This is because the cost of renewable energy depends on the initial cost of installing renewable energy technologies versus fossil fuels, which increases and decreases due to current inflation and resource availability. Renewable power plants do not need financial resources other than the initial installation cost.

After the infrastructure is prepared for the commissioning of the renewable resource, less than zero maintenance should be done. This means that power plant owners can make big profits while providing cheap electricity to the public, as the facilities do not have high maintenance costs. An advantageous situation is provided for both the producer and the consumer.

If governments leap to build more renewable energy plants, they will be making a beneficial investment in the health of societies, directly and indirectly. Because renewable energy means cleaner air and less carbon emissions. Investments made in this area mean better quality of life for people, especially since it indirectly affects health problems very seriously.

Renewable energy technologies are still insufficient to generate electricity compared to traditional energy production methods such as fossil fuels. To solve this problem, it is necessary to increase renewable energy capacities and encourage more investors in this regard.

Renewable energy technologies depend entirely on the weather (e.g., solar and wind) to take advantage of any source. Where atmospheric conditions are not good enough, renewable energy technologies lack the ability to generate energy. This could trigger campaigns by authorities to reduce energy use to serve the population for a longer period. There may not be continuity, so it is more reasonable to use it to support the existing system.

Renewable energy technologies are new to the energy markets, meaning they still lack the efficiency we so much need. This low yield also presents problems and investors are hesitant to invest money because they are not getting the returns very quickly.

Establishing a renewable energy production facility requires a large amount of money. Wind turbines, solar panels, and hydroelectric power plants are much more expensive to install. These facilities require investments that require installation costs, high maintenance costs, and careful planning and implementation. Also, the electricity produced must be delivered to towns and cities, which means additional spending on installing power lines.

3. WHAT IS THE YEKDEM?

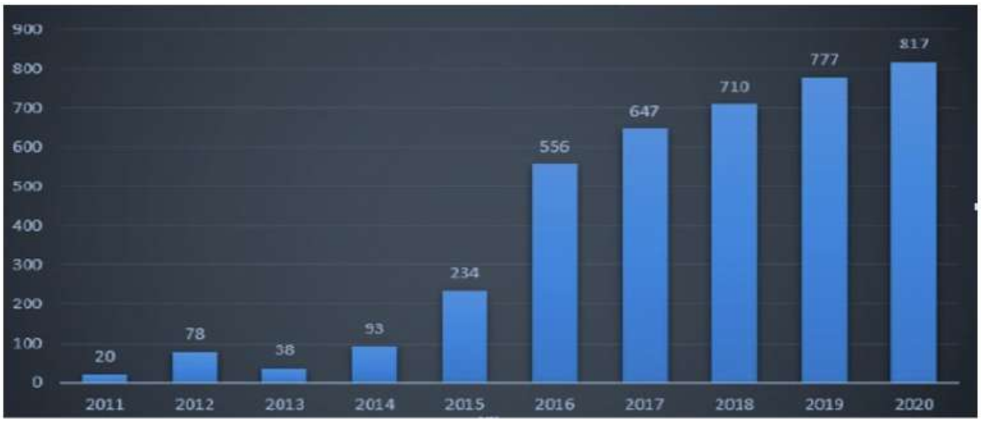
YEKDEM is a support mechanism applied to wind, solar, geothermal, biomass, biomass gas (including landfill gas), wave current energy, tidal energy, canal, river, and hydroelectric generation facilities with a reservoir area of less than fifteen square kilometers.

The aim of YEKDEM is to increase the number of production facilities based on renewable energy sources in our country, reduce the need for fossil-fueled generation facilities harmful to the environment, and reduce foreign dependency on energy.

The electricity produced by the relevant generation facilities within the scope of YEKDEM is guaranteed to be purchased at a fixed price for a maximum of 10 years. These prices to be applied to the facilities are determined by the RES Law.

YEKDEM is an annual mechanism. Production facilities that want to be included in this system make the necessary applications to EPDK every year. EPDK evaluates the applications and announces the facilities that will receive support for the next calendar year. The dates of these application and evaluation processes within a calendar year are fixed and do not change unless otherwise stated.
In addition to these incentives, the acquisition by YEKDEM ensures that a certain level of equipment in the facilities is provided in addition to the production facilities based on energy resources, which use domestically, with the regulation of "Supporting Domestic Parts Used in Facilities Producing Electricity from Renewable Energy Sources". With this practice, the facilities are encouraged to use highly domestically produced parts and components. Incentive amounts will go to the source type and exhausts of the facilities according to the local components.
Within the scope of the RES law published in 2005, many domestic and foreign investors have started to turn to renewable energy. This situation has led to a transformation into cleaner and more sustainable energy, as well as reducing foreign dependency in our country. It is known that this transformation requires long-term and serious financial resources in the beginning. The number of YEKDEM participants has increased significantly in recent years, together with public support and the transfer of financial resources to this field, as well as banking activities.

Tablo 1: Number of YEKDEM Participants



Since 2011, the number of participants in the increase in renewable energy production has shown a very serious increase, as can be seen from the graphic above. In 2023, the RES pre-registration list announced by EPDK is 891 companies.
In recent years, there has been a very serious series for energy resources working with the support of YEKDEM and producing in this context. The development and spread of green finance have only been with the support of the state. The support and work of banking and finance investments in these areas also make a significant contribution to using this area.

Sources: ((https://www.elektrikport.com/teknik-kutuphane/yekdem-nedir/22440#ad-image-0, 2019) date of access 2023)

4. GREEN FINANCE PROGRAMS IN TURKEY

4.1. Kosgeb

KOSGEB renewable energy and energy efficiency supports. Organizations that can help: Limited, joint stock or sole proprietorships that will invest in solar energy, renewable energy and energy efficiency development in the trade, service, and manufacturing sectors. Support Amount: Non-refundable support upper limit: 30.000 TL. Pre-study studies 1500 TL for 200-500 TOE, 2000 TL for 501 and above. 200-500 TOE 15.000 TL for detailed studies, 20.000 TL for 501 and above. 200-500 TOE 3000 TL for productivity-increasing projects, 5000 TL over 501. 200 TEP and above 3000 TL for energy manager training.

4.2. Turkey Technology Development Foundation

Renewable energy support program. Organizations that can help: Renewable Energy Support, Energy Efficiency Support and Environmental Technology Support. Support Amount: The lower limit of the Turkey Technology Development Foundation renewable energy support amount is 100,000 and the upper limit is 1,000,000 USD. Renewable energy is at most 50% of the project budget.

4.3. Turkey Sustainable Energy Financing Program

Organizations that can help: All projects using renewable resources to generate energy are supported by the program, if they meet the minimum conditions that vary within the scope of the project. Support Amount: For producers, financing can be provided, with a total of up to 5 million € per investment, not exceeding 1 million € per investment. Eligible beneficiaries other than producers may receive financing up to a maximum of €15 million in total, provided that each tranche does not exceed €5 million.

4.4. Solar Energy Support

Solar energy system grant support differs based on program and project. For example, 50-90% support is given within the scope of KOSGEB. There is a total of 50,000 TL grants and 100,000 TL loan support.
In the KKYDP grant, there is an upper limit of 3,000,000 TL for new investments and 50% of the investment is given within the scope of the grant. The investment cost is calculated excluding VAT. The investor must obtain the Value Added Tax (VAT) entirely from its own resources.
Solar energy loans are loans given by banks to users and SMEs for solar energy conversion. Many public and private banks support investors in this field.
According to the last regulation published in 2022, with the roof SPP, energy producers can now produce unlicensed electricity only to meet their consumption. It has been informed that VAT and customs taxes are not collected from expenses such as equipment and parts included in the investment to be made for this electricity generation (https://www.piagrid.com/enerji-tesvik-ve-destekleri date of access 2023).

5. CONCLUSIONS

The energy crisis that has been experienced for a long time in the world has led every country to invest more in this field and to increase their production capacity to meet the demand. There were two major problems posed by this situation. The first is energy supply security, that is, the increasing foreign dependence of countries on energy. The second is that the life of the world we live in is decreasing day by day with the wastes generated by energy production facilities and increasing carbon emissions. Many factors such as global warming, climate change, and deterioration of natural balance have increased the tendency towards cleaner and renewable resources in energy policies. Especially when the last 20 years are examined, the tendency to these resources is increasing all over the world. Due to the disadvantages of renewable energy sources, this increase needs to be supported. Because the demand is too high, and it does not seem possible to meet it with renewable energy sources alone for now. Technological opportunities developing with more investments and incentives will enable us to get more efficiency from these resources. The increase in the number of facilities connected to renewable energy sources will lead to a decrease in the costs in this area, and investors to show more interest in this area.
In our country, especially after 2005, with the YEK legislation and YEKDEM, investors started to show more interest in this field. The support provided by the public and foundations, the financial resources, and loans provided by the banks in this regard enabled Turkey to go a long way in terms of renewable energy resources. Of course, these supports are not enough. It is necessary to attract more investors to this field and to support it technologically. Directing universities and scientific committees to work more in this area and developing technology to reduce the installation costs of renewable energy plants should become a top priority in our energy policies.

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CALCULATION OF THE FOOTPRINT OF A LOCAL GOVERNMENT IN TURKEY: THE CASE OF SEYDIKEMER DISTRICT

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ABSTRACT
According to the Paris Agreement, the responsibility of tackling global warming should start with local governments. With time running out, carrying out carbon footprint (CF) analysis on a local scale has become urgent. This study carries out the CF calculation of Seydikemer District for the year 2017, which is located in the central north of Turkey, according to the Global Protocol for Community-scale Greenhouse Gas Emission Inventories (GPC). Seydikemer, with its airport, ever-growing organized industrial site housing several industries leading in foreign exports in the sectors they are active, high-yielding agricultural land, and a population of over 74,000, has one of the oldest municipalities. As a result, Agricultural, Forestry, and livestock sector lead the stationary greenhouse gas emissions with 45.8%, due mainly to presence of greenhouses. Within the stationary energy sector which comes second with 36.88%, agricultural, forestry and fishing activities has the highest share with 15.7%, residential buildings are a close second with 13.7% and Commercial and Institutional Buildings and Facilities, including NGOs are a distant third with a share of 6.3%.
Keywords: Urban carbon footprint, GHG emissions, GPC

1. INTRODUCTION
The use of Carbon Footprint (CF) calculations has become crucial in determining carbon emissions and identifying the contributions of countries, cities, and individuals. Urban areas, with their high population density and human activities, are significant sources of greenhouse gas emissions. However, calculating the Urban Carbon Footprint (UCF) of a specific city is challenging due to the unique nature of each city. Some publications highlight valuable fieldwork experiences that have contributed to the development of a global methodology, shedding light on the strenuous effort required to calculate the CF of a city (Netchanakan Sununta et al., 2018) (Lombardi et al., 2018).
The Global Protocol for Community Scale Greenhouse Gas Emission Inventories (GPC), developed by the World Resources Institute (WRI), the C40 Cities Initiative, and the International Council for Local Environmental Initiatives (ICLEI), is a technique used in this study. It comprises three parts: Part I sets inventory limits and reporting requirements, Part II provides industry-specific accounting capabilities and guidance, and Part III helps set targets for reducing emissions and tracking progress. Before conducting an inventory study, it is important to determine the inventory boundary and the main sources of emissions for the area of interest, which can be limited to a district, municipality, province, or region. The five main sectors that produce greenhouse gas emissions are stationary energy, transportation, wastes, industrial processes and product use, and agriculture, forestry, and other land use. GHG emission calculations are divided into three categories or scopes. Scope 1 covers direct emissions that originate within the city boundary. Scope 2 covers indirect emissions that result from the use of purchased electricity, heat, steam, and/or cooling within the city boundary. Scope 3 includes other indirect emissions that come from activities within the city limit but emerge beyond the city boundary.

There are several studies of carbon footprint calculation of urban areas which varies not only in terms of methodology, data collection and emission inventories, but also size and contents of towns (Lu & Li, 2019) (Lin et al., 2013) (Hillman & Ramaswami, 2010) (Ramachandra et al., 2015) (Lombardi et al., 2018) (Kongboon et al., 2022) (Sununta et al., 2019) (Li et al., 2017). In numerous researches claimed that urban CF calculations lack certain attributes, such as inconsistencies in methodology, not defining assumptions clearly, insufficiency and uncertainty in data sets, incompleteness of sectors or sub-sectors and absence of follow up complementary studies (de Souza Leão et al., 2022) (Yurtsever, 2022) (Baltar de Souza Leão et al., 2020). A properly structured and arranged GHG emission inventory can be advantageous for a number of reasons. With this knowledge, mayors can establish a risk management plan on the basis of the inventory. Additionally, GHG mitigation measures can be identified properly. Moreover, emphasizing regulations and implementation eco-friendly innovation measures could be imposed.

Lastly, by engaging the private sector and driving green investments, a city's competitiveness on the global stage will increase (Lombardi et al., 2018). Various new studies propose systematic approaches that matches GHG emissions mitigation options with available recommended implementation policies (Karimipour et al., 2021) (Chang et al., 2019) (Ottelin et al., 2018) (Sununta et al., 2019) (Michaelowa, 1996). Mitigating climate change can improve people's quality of life while also reducing GHG emissions (Chomaitong & Perera, 2014).

The purpose of this study is to create and report a comprehensive, comparative, and transparent GHG inventory for mid-sized district. In order to overcome the abovementioned gaps, the data quality is evaluated as well as emission factors specific to Turkey are developed. In addition, emission inventory is evaluated on the basis of five main sectors mentioned in the GPC standard. Furthermore, mitigation strategies are proposed for GHG emission reduction.

2. METHODOLOGY

GHG calculations in this study are mainly based on GPC guidelines and the IPCC inventory method. Initially, inventory boundaries are defined. Secondly, the baseline year is chosen for the data collection according to prior emission studies. Then, GHG emission factors for Turkey are calculated in detail, considering national-scale electricity production, including transmission and distribution losses. All GPC calculation factors are either recalculated or sourced from reliable domestic sources. If no reliable emission factors are available for a specific greenhouse gas calculation in Turkey, then EU emission factors are used. If those are unavailable, DEFRA, United Kingdom, or USA factors are employed in that order. Data was gathered for the baseline year in the selected district to calculate GHG emissions, which were then categorized into six main sectors: stationary energy, transportation, waste, industrial processes and product use (IPPU), agriculture, forestry, and other land use (AFOLU), and any other emissions outside the geographic boundary. The methodology steps are shown in Figure 1.

Figure 1. Methodology Steps

2.1. Defining the Inventory Boundary and the Baseline Year

Urban entities need to establish an inventory boundary following the GPC guidelines by identifying the geographic area, time span, gases, and emission sources. The inventory can cover a wide variety of geographic boundaries, depending on the inventory's purpose, such as a local government, district, or metropolitan area. The GPC requires emissions to be reported for a full year (Fong et al., 2015). In this study, Seydikemer district with 65 neighborhoods/villages is chosen as the greenhouse gas emissions inventory boundary. Solid wastes are deposited outside the boundary, and wastewater treatment is partially performed within the borders. The baseline year is 2017 because no prior emission data are available.

2.2 Calculating GHG Emission Factors

In order to calculate the carbon emissions for 2017, which was chosen as the baseline year, it is necessary to determine the main energy and the biogenic emission coefficients. Turkey-specific GHG emission factors for stationary energy were calculated, while other emission factors were incorporated from the IPCC Guidelines for National Greenhouse Gas Inventories. If, for whatever reason, a valid coefficient cannot be found for Turkey or a specific emission cannot be calculated due to the absence of emission factor/data, IPCC, EU values are used; otherwise, DEFRA, UK values are applied. Table 1 gives the source of emission factors.

Table 1. Source of Emissions Factors

	Turkey	IPCC	EU	DEFRA	Calculated by the Authors
Stationary Energy - Fuels	x		x		
Electricity					x
Transportation			x	x	
Waste		x			
Industrial Processes and Product Use		x			

The emission coefficients released in the electricity generation and consumption for Turkey are calculated by and can be summarized in Table 2 In the equivalent carbon emission calculations, transmission and distribution losses that is %15 in Turkey, is also taken into consideration.

Table 2. Greenhouse Gas Emissions from Electricity Production and Consumption in Turkey - 2016

Greenhouse Gases (GHGs)	kg GHG/kWh
Total Direct CO_2 Emission (kg CO_2/kWh)	0.554
Total NO_x Emission (Kg NO_x/kWh)	0.00017
Equivalent CO_2 Emission (Kg NO_x/kWh x 265)	0.045
Total Equivalent Carbon Emission (kg CO_2 e/kWh)	**0.60**
Total SO_2 Emission (kg SO_2/kWh)	0.00391

2.3 Data Collection

For gathering the data in order to calculate GHG emissions, comprehensive surveys and face-to-face interviews were conducted in Seydikemer District in 2017 with the assistance of municipal staff. In addition, the authors collected data directly from officials and market operators (for electricity, wastewater, solid pollutants, and fuel stations), and in some instances they used national official references (for vehicle numbers).

In Seydikemer district, there are no fossil-fuel power facilities. On the other hand, renewable production such as hydroelectric and solar power facilities have been constructed and are still in progress, particularly between 2012 and 2017. Although precise figures are unavailable, it is estimated that these power plants produce roughly 10 percent of the district's total electricity. Aydem Energy, the regional electricity supplier, provides statistics and consumer information pertaining to electricity. On the premise of registered consumer distribution, number of registered consumers, and tariffs, Aydem provided information regarding the consumption of electricity. In addition, the authors conducted a comprehensive survey to ascertain the distribution of fuels used for heating purposes in the district. In addition to heating and cooling, LPG is an essential source of consumption. In 2017, there were 76 industrial enterprises operating in Seydikemer District. Aside from fuel, mining, quarrying, and marble production make up the largest group of 34 industrial establishments, consuming approximately 64 percent of the total electricity. Significant LPG consumption is associated with industrial activities.

The total number of vehicles for Seydikemer was estimated by using the population figures and number of registered vehicles in Muğla for 2017 from the TURKSTAT. In 2017, total vehicle number were 31,039 of which the majority is passenger cars with 42%, followed by motorcycles with 32%, pickup trucks with %15, tractors %7 and others. Greenhouse gas emissions in transportation were calculated using the Top-Down methodology of GPC. In this approach, the total fuel sales for a year within the boundaries of the district were taken as a basis, and emissions from transportation were calculated by multiplying the total fuel sold and the GHG emission factor of that fuel type. For this reason, fuel sales data are gathered from the majority of gas stations in the district. 18,135,233 liters of diesel (of which approximately 8,000,000 liters used in agricultural activities), 1,015,895 liters gasoline and 2,858,984 liters LPG is sold in Seydikemer in 2017. According to the information received from the municipality, there is no electric vehicle or electric vehicle charging station in Seydikemer District in 2017. Table 3 demonstrates the fossil fuel and electricity consumption in the sectors of stationary energy and transportation.

Table 3. Fossil Fuel and Electricity Consumption in Seydikemer, 2017

STATIONARY ENERGY					
Sector	Electricity (kWh)	Wood (ton)	Coal (ton)	LPG (ton)	Olive-pomace oil (ton)
Residential Buildings	35,703,291	13,437	2,520	1,384	-
Commercial Buildings, Public Buildings, including NGOs	43,260,606	2,206	664.6	342.2	200
Industry	9,808,382	159	150	65	-
Energy Industry	24,800	-	-	-	-
Agricultural, Forestry, and Fishing activities	10,592,157	500	22,200	4,6	
TOTAL STATIONARY ENERGY	99,389,236	16,302	25,535	1,791	200
TRANSPORTATION					
	Diesel (l)	Gasoline (l)		LPG (l)	
TRANSPORTATION	18,135,233	1,015,895		-	2,858,984

The disposal of solid waste in the Seydikemer district takes place outside the boundaries of the local government. There are no sanitary landfills or operated open landfills (garbage) within the boundaries of Seydikemer. In 2017, all solid and liquid waste was sent to the regular solid waste storage waste facility in Fethiye district. Totally, 12.500-ton solid waste is disposed in 2017 according to Seydikemer municipality reports. There is no comprehensive sewerage infrastructure in the Seydikemer district. The majority of the household sewage was disposed of in septic tanks. It is observed that there is no significant industrial wastewater. According to the municipality, in 2017, 41 km of roads were covered with asphalt in Seydikemer district, and approximately 600 tons of asphalt and 5,600 tons of crushed stone were used. Due to the lack of information, the consumption of industrial and automotive oils in Seydikemer for 2017 was calculated by using the statistics of Turkey. In Seydikemer district, the refrigerant consumption is mostly due to the use of refrigerators and air conditioners in residences and businesses. In addition, although limited, there are large-scale cooling in the industry and cold storage for fisheries and agricultural products. According to face-to-face interviews and surveys, it has been found that in 2017, there were 42,418 air conditioners, 39,448 household refrigerators and 106 industrial-sized refrigerators in Seydikemer. As of 2017, there are 76 industrial establishments in Seydikemer district. There are almost no processes with intense greenhouse gas emissions here. On the other hand, the use of industrial products is present at a significant level. The names of the industrial products used in Seydikemer in 2017 and causing greenhouse gas emissions are: industrial and automotive oils, kerosene, refrigerants and asphalt (bitumen). Soils in Seydikemer district seem very fertile in terms of quality. Since the pH values are suitable, there is no need for calcination. According to the information received from the experts of the Chamber of Agriculture in Seydikemer, the fertilizer and pesticides used in greenhouses and agricultural fields are 66,773 tons and 28,469 tons, respectively in 2017. According to Chamber of Agriculture in Seydikemer, there was 50,000 ha of regularly used agricultural land. In these areas, around 450 kg of harvest is taken per acre and this harvest leaves approximately 15% stubble, thus 60 kg of stubble is obtained in one acre. Considering that the level of uncontrolled stubble burning is 10% of the agricultural lands, the total amount of burned stubble is found as 600 tons. Information on cattle/sheep and poultry in Seydikemer district for 2017 is gathered from Seydikemer Agriculture District Directorate. There are 25,915 cattle, 161,054 goats and sheep, 1,637 horses and donkeys and 83,761 poultry animals.

2.4 Calculation and Verification of Urban Carbon Footprint

GPC Method includes more than one calculation methods for various sectors. Thus, depending on the available data appropriate calculation method must be chosen. GHG emissions for a district is evaluated on the basis of five main sectors: stationary energy, transportation, wastes, industrial processes and product use, and agriculture, forestry and other land use. GPC standards constitute the backbone of calculations. GHG calculations for each gas, emissions considered and converted into CO2 equivalent (CO2e) by using 100-year Global Warming Potential (GWP) coefficient. The total greenhouse gas emission (tCO2-e/year) of a district (GHGTotal) can be calculated by using Equation 1.

$$GHG_{Total} = GHG_s + GHG_t + GHG_w + GHG_{ind} + GHG_{afo} \quad (1)$$

Where:
GHGs: GHG emission from stationary energy consumption (tCO2-e/year)

GHGt: GHG emission from transportation (tCO2-e/year)

GHGw: GHG emission from wastes (tCO2-e/year)

GHGind: GHG emission from industrial processes and product use (tCO2-e/year)

GHGafo: GHG emission from agriculture, forestry and other land use (tCO2-e/year)

All individual GHG emissions mentioned in Equation 1, are calculated by multiplying relevant emission factors and relevant activity data. The most important step in the methodology is the verification of the results. Verification processes should be carried out by able personnel. The principles of the verification include completeness, consistency, accuracy and transparency.

3. RESULTS AND DISCUSSION

The distribution of the equivalent CO2 emissions by sources is given in Table 4. As can be seen from Table 4, the amount of CO2-equivalent released to the atmosphere originating from the Seydikemer district in 2017 has been calculated as approximately 530,900 tons. Looking at the details of 539,973 tons of emissions, it is seen that the highest emissions come from agriculture, forestry, and land use, with 240,429 tons. The second highest emissions are from the stationary sector, with 195,844 tons. The emissions from waste are in third place with 64,848 tons.

Table 4. Distribution of GHG Emissions in Seydikemer, 2017

Emission Source	Scope	CO_2-e (Kg)	Percentage Including Biogenic Emissions (%)	Percentage Excluding Biogenic Emissions (%)
STATIONARY ENERGY				
Residential Buildings	I, II	72,494,138	13.7%	19.9%
	III	428,172		
Commercial and Institutional Buildings and Facilities, including NGOs	I, II	32,725,124	6.3%	9.1%
	III	518,803		
Manufacturing Industries and Construction	I, II	6,249,353	1.2%	1.7%
	III	117,627		
Renewable Energy Industry	I, II	11,954	0.002%	0.003%
	III	268		
Agricultural, Forestry, and Fishing activities	I, II	83,171,064	15.7%	22.7%
	III	127,026		
TOTAL		*195,843,529*	*36.9%*	*53.4%*
TRANSPORTATION				
Transportation – On Road	I	14,824,983	2.8%	4.0%
TOTAL		*14,824,983*	2.8%	4.0%
WASTES				
Solid Waste Disposal	III	64,056,000	12.2%	17.7%
Wastewater Treatment and Discharge	I	593,600		
Wastewater Treatment and Discharge	III	198,240		
TOTAL		*64,847,840*	12.2%	17.7%
INDUSTRIAL PROCESSES and INDUSTRIAL PRODUCT USE				
Industrial Product Use	I	15,027,632	2.8%	4.1%
TOTAL		*15,027,632*	2.8%	4.1%
AGRICULTURE, FORESTRY and LAND USE				
Agriculture, Forestry and Land Use - Emissions from other aggregate resources, and land use	I	75,977,455	14.3%	20.7%
Agriculture, Forestry and Land Use - Emissions from livestock	I	164,451,564	31.0%	-
TOTAL (Including Biogenic)		*240,429,019*	*45.3%*	-
TOTAL (Excluding Biogenic)		75,977,455	-	20.7%
GRAND TOTAL				
SCOPE I + II	I + II	465,526,867		
SCOPE III	III	65,446,136		
SCOPE I + II + III	I + II + III	530,973,003		

The population of Seydikemer is given as 61,000 for the year of 2017 by TURKSTAT. The total greenhouse gas emission per capita is calculated in two different ways and shown in Table 5

Calculation Method	Scope I+II (tons CO_2-e)	Scope III (tons CO_2-e)	Scope I+II Per Capita (tons CO_2-e/person)	Scope III Per Capita (tons CO_2-e/person)	Scope I+II+III SO_2 Emissions (tons SO_2)	Scope I+II+III Per Capita (ton SO_2/person)
Total Greenhouse gas Emissions including Biogenic Emissions	465,527	65,446	7.63	1.07	416.5	0.0068
Total Greenhouse gas Emissions excluding Biogenic Emissions	301,075	65,446	4.94	1.07	416.5	0.0068

Considering the total CO2-e emission value of 465,526,867 kg, the per capita greenhouse gas emission (carbon footprint) will be 7.63 tons/person for Scope I and II and 8.70 tons/person for Scope I, II and III total. These figures are 16% and 36.7% higher, respectively, than the 6.3 tons/person figure given by TURKSTAT for Turkey in 2016. However, it should be emphasized here that agriculture, forestry, fisheries and land use values are not included in the TURKSTAT figures.

4. CONCLUSIONS

Agricultural, Forestry, and livestock sector lead the stationary greenhouse gas emissions with 45.8%, due mainly to presence of greenhouses. Within the stationary energy sector which comes second with 36.88%, agricultural, forestry and fishing activities has the highest share with 15.7%, residential buildings are a close second with 13.7% and Commercial and Institutional Buildings and Facilities, including NGOs are a distant third with a share of 6.3%.
As it can be seen from Table 4, the main conclusion of this study is that the total emissions for Seydikemer District is 530.970 tons of CO2-e including biogenic emissions. This means per capita emissions 8.70 tons of emissions per person which is %36.7 higher than the national average given for the same time for Turkey. It should also be noted that agriculture, forestry, fisheries and land use values are not included in the TURKSTAT figures. It should also be emphasized that there is also 416 tons of SO2 was also emitted in 2017. The most important step is the verification of the results. If possible ISO14064 British Standard's steps must be followed.

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ESTIMATION OF THE COST OF CONVERTING ALL ROAD TRANSPORTATION VEHICLES IN TURKEY TO NET ZERO EMITTING ELECTRICAL VEHICLES BY 2035

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ABSTRACT
The European Union (EU) is actively promoting the transition to electric vehicles (EVs) and has set ambitious targets for increasing the number of zero-emission vehicles on the road. This study estimates the cost of transitioning all road transportation vehicles in Turkey to net-zero emitting EVs by 2035. The aim is to quantify the financial implications of this large-scale transition and provide insights into the economic feasibility and potential challenges. The research considers factors such as the cost of EV adoption and required charging infrastructure investments. The findings reveal that the total cost of converting to all electric vehicles in Turkey would be approximately 2.96 trillion US dollars, with an average allocation of 23,101 US dollars per capita. While the upfront investment is significant, the long-term benefits of electrifying the transportation sector, including reduced carbon emissions and improved air quality, make it a crucial step toward a more sustainable and resilient future.
Keywords: Electrical vehicles, Urban carbon footprint, GHG emissions

1. INTRODUCTION
The rapid growth of global road transportation has contributed significantly to environmental degradation, air pollution, and climate change. To address these challenges, there is a growing interest in transitioning from conventional internal combustion engine (ICE) vehicles to electric vehicles (EVs) that offer lower emissions and reduced dependence on fossil fuels. Converting all road transportation vehicles to electric vehicles has emerged as a potential solution to mitigate the environmental impact and promote sustainable mobility. The current global transport model significantly and adversely affects human health and the environment. For example, 38% of US CO2 emissions and about 25% of GHG emissions are from the transport sector which results in air pollution, noise pollution and destruction of nature. Unfortunately, the transportation is the major sector globally which has continually increased over the years, with the exception of the height of the COVID-19 pandemic era. Emission and their distribution presented in Table 1 (IEA, 2021).

Table 1. Global Transport Sector Emission and their Distribution among the Sub-sectors

	2000	2010	2020	2030 APS	Percentage (%)	2030 NZE	Percentage (%)
Aviation	675	751	640	1147	14.30	783	13.93
Shipping	625	796	825	902	11.26	699	12.44
Heavy Truck	1119	1484	1776	2040	25.44	1614	28.72
Rail	85	86	94	81	01.01	60	1.07
Bus and Minibus	336	415	414	509	06.35	390	6.94
Light Duty Vehicles	2675	3127	3292	3160	39.40	1930	34.34
2 and 3 wheelers	115	192	178	180	02.24	144	2.56
TOTAL	5630	6851	7219	8019	100.00	5620	100.00

APS = Announced Pledges Scenario. NZE = Net zero emissions by 2050 scenario. Trucks include road freight vehicles with a gross vehicle weight of more than 3.5 tonnes.

The EU's commitment to decarbonization and sustainable mobility is evident in initiatives such as the European Green Deal and the European Commission's strategy for sustainable and smart mobility. These initiatives aim to support the deployment of low-emission vehicles, including electric cars, and encourage the expansion of charging infrastructure across member states. Europe aims to become climate-neutral by 2050 and Turkey by 2053. However, these pledges cannot be fulfilled unless transportation sector becomes more sustainable with at least the following:

•All transportation modes, namely aviation, shipping, road transportation of all types and rail transportation shall be more sustainable backed up with green alternatives.

•Cleaner and preferably electrical cars based on renewable energy systems,

•Reducing the need for transportation if possible and promoting bicycles and walking among others,

•The longer the trip becomes cleaner transport modes should be preferred.

To follow up this net zero emissions scenarios EU has identified various milestones, which should also be followed by Turkey as well. Some of the important milestones are demonstrated below (European Commission, 2023) (Claire, 2023):

•By 2030, a minimum of 30 million zero-emission electrical cars will be on the road in Europe.

•By 2030, high speed rail traffic will double across Europe.

•By 2030 all in Europe journeys under 500 km should be carbon neutral.

•By 2050 in Europe and by 2053 in Turkey, almost all cars, light duty vehicles, vans, buses and heavy trucks will be zero emission. The rail traffic will double that 2030 goal for Europe and rail freight will be compatible to truck freight in terms of tonnage. Trans-European Transport Network (TEN-T) for sustainable and smart transport with high-speed connectivity and will extend to Turkey.

Globally zero-emission marine vessels will be market-ready by 2030 and zero-emission large aircraft will be market-ready by 2035. Being responsible for the 11% of the carbon dioxide emissions in the global transportation, the shipping industry is the primary mode of freight movement in the international supply chain may be with the exception of the USA and Canada. For example, 77% of European external trade has been via shipping. Although aviation has become one of the means of intercontinental travel with endless benefits, it has increased the negative effects of flying on climate change, air quality and noise pollution. Aviation has produced economic benefits, stimulated innovation, and improved connectivity globally. There was a brief pause in the aviation increase as was the case with the other modes of transport due to the COVID-19 pandemic, but air travel is growing again. It should be emphasized here that with the exception of intercontinental travel, a shift from air to rail travel can play a crucial role in helping the countries in reducing their greenhouse gas emissions from transport by 90% by 2050.

Finally, per capita transportation emissions in 2020 (Statista, 2023) demonstrate that, large countries with rather low populations per km, have high per capita CO2 emissions, whereas developing and smaller countries have low emissions. It is interesting to note that, as expected the USA, lead the world with transport related greenhouse gas emissions with 4,486 kg of CO2 per capita. EU-28 has 1,712 and Turkey with 947 kg of CO2.

The transition to electric vehicles presents a range of environmental and economic advantages. EVs produce zero tailpipe emissions, reducing local air pollution and improving urban air quality (Environmental Protection Agency [EPA], 2021). Moreover, electric vehicles have the potential to contribute to greenhouse gas emissions reductions when powered by low-carbon electricity sources, such as renewable energy (Creutzig et al., 2020). In addition to environmental benefits, the electrification of road transportation can enhance energy security and reduce reliance on imported fossil fuels, particularly in developing countries (International Energy Agency [IEA], 2020).

While the benefits of electric vehicles are clear, the transition to an all-electric road transportation system is not without challenges. One of the primary obstacles is the development of a robust charging infrastructure that supports the charging needs of a vast number of EVs (Gallagher et al., 2018). The availability of public and private charging stations, along with fast-charging technologies, will be crucial to address range anxiety and enable long-distance travel for EV owners. Furthermore, the affordability and accessibility of EVs remain key considerations for widespread adoption, as the upfront cost of electric vehicles and the availability of incentives can impact consumer demand (Bachmann et al., 2020).

The aim of this paper is to estimate the cost associated with converting all road transportation vehicles in Turkey to net-zero emitting electric vehicles (EVs) by the year 2035. As the transportation sector is a significant contributor to greenhouse gas emissions in Turkey, transitioning to electric vehicles presents a viable solution to reduce carbon emissions and mitigate the impacts of climate change. By conducting a comprehensive analysis, this study seeks to quantify the financial implications of such a large-scale transition and provide insights into the economic feasibility and potential challenges associated with achieving a net-zero emission road transportation system in Turkey. The research will consider factors such as the cost of EV adoption and required charging infrastructure investments. The findings of this study aim to inform policymakers, industry stakeholders, and researchers about the financial aspects and considerations involved in transitioning Turkey's road transportation sector to electric vehicles, facilitating informed decision-making and sustainable planning for a cleaner and greener future.

2. CALCULATION OF THE COST OF INTRODUCING ZERO EMISSION VEHICLES INTO THE TURKISH MARKETS

Although Turkey is not a member of the European Union, the ultimate goal of the majority of the Public is to join the European Union and become an integral part of Europe. In addition, Turkey is an active UN member and has signed and ratified all climate change related protocols such as Paris Agreement, is an avid follower of UN sustainable Growth 2030 Program, and many other related international agreements. According to Fig. 3, Turkey emitted 947 kg of CO2 per person in 2020. This corresponds to 15% of the total greenhouse gas emissions for Turkey for 2020 given by TURKSTAT as 6.7 tons/per person. We know that this figure is not quite reliable, because it omits important emissions such as agricultural, forestry, and land use emissions, together with military based emissions, which is not included in the total value. Also, emissions given for the waste is also questionable.

The primary concern of this work is to calculate the cost of electrification of all the two and three wheelers, cars, light duty vehicles, caravans, buses and minibuses and most of the heavy trucks by 2035. The major principles employed in this study follows the basic criteria in line with EU criteria:

•All transportation modes, namely aviation, shipping, road transportation of all types and rail transportation shall be more sustainable backed up with green alternatives.

•By 2035, all the vehicles on the road in Turkey will be net zero emission vehicles with the exception of military vehicles, very heavy-duty trucks, but includes all the tractors and agricultural equipment.

•By 2035, electrical trains will double, and the rail traffic will follow in Turkey.

•By 2035 all city traffic and journeys under 500 km should be carbon neutral within Turkey

•By 2050 in Europe and by 2053 in Turkey, almost all cars, light duty vehicles, vans, buses and heavy trucks will be zero emission types. The rail traffic will be double of 2035 goals for Europe and Turkey and rail freight will be compatible to truck freight in terms of tonnage.

•When Trans-European Transport Network (TEN-T) for sustainable and smart transport with high-speed connectivity reaches Turkish border, it will be extended to major Turkish road transportation network within the country.

The following assumptions are made for the calculations:

•Because no detailed and reliable CO2 emissions data by sectors is available for Turkey, which should be provided by TURKSTAT, it is assumed that 25% of the total emissions in the country is due to transportation sector.

•The customs duties, value added taxes and other relevant taxes will remain at the same levels.

•The population will increase at about the current rate of 3% until 2035. Similarly, the number of vehicles will also increase by the same annul amount until 2035.

•The electrification of the rail system will result in an additional increase of the renewable energy investments by 25%.
•No aviation or shipping conversion costs are included.

•Military vehicles of all types are excluded.

•The number of electric charging stations will be a minimum of three times of the number of current gas stations at the time of calculations.

Based on the principles and assumptions above, the following tables are prepared. Table 2 represents the population and number vehicles projections from 2021 to 2035. Accordingly, it is expected that by 2035 the population will be 128 million with the number of vehicles reaching 37 million. With the assumptions given above, assuming an average US dollars value for a new zero emission vehicle be around 75,000 US dollars, the total cost of converting to all electrical vehicles will be around 2,775,000,000,000 US dollars. Unfortunately, the majority of the present fossil fuel vehicles will not be resold after 2030. Thus, there will only be salvage value approximately 5,000 per vehicle totaling 185,000,000,000 US dollars. Thus, the total cost of converting to all electrical vehicles will be 2,590,000,000,000 US dollars for 2035.

Table 2. Population and The Number Vehicles Projections from 2021 to 2035 of Turkey Projection

Year	Population	Vehicle Number
2021	84,680,273	24,500,000
2025	95,308,393	27,574,966
2030	110,488,549	31,966,943
2035	128,086,511	37,058,448

Based on Table 2, for the number of population and number of vehicles, the figures for 2021 need to be multiplied by 1.51 for 2035. The study assumes that all the electricity that will be produced in Turkey will be based on renewable energy investment. However, hydraulic energy is not used for this purpose simply because it is expected that Turkish hydraulic potential will drop over %30 by 2035 and water will potentially be used for agriculture and provision of the drinking purpose. Renewable energy investment mainly covers two topics. The first one is the conversation of all the fossil fuel power plants to renewable energy power plants for electricity production, and the second one is the conversion of the fuels used in road transportation to electricity from renewable sources. While doing these conversions present renewable sources utilization factors were assumed to stay constant. Table 3 demonstrate the electricity production for 2021 in Turkey in terms of energy sources. Accordingly, %18 percent of the total production was by renewable energy sources excluding hydraulic energy. The distribution of this 18% is given in Table 5.

Table 3. Energy Sources for Electricity production in Turkey for 2021

Source	Electric Production (MWH)	Percentage
Hydraulic	55,549,254	16.79%
Wind, Solar, Geothermal and Biomass	61,260,248	18.52%
Fossil Fuels and others	213,996,351	64.69%
TOTAL	330,805,853	100.00%

Table 4 gives the investment cost per MW of the renewable energies. Solar seems to be least expensive investment. It should also be noted that the investment costs are coming down over the years.

Table 4. Investment Costs of Renewable Energy for Power Production

Type	US Dollar/MW
Wind	1,300,000
Solar Photovoltaics	1,000,000
Geothermal	4,000,000
Biomass	5,000,000

Table 5 demonstrates the cost of converting fossil fuel electricity production with renewables excluding hydraulic. As it can be seen in 2021, more than half of the renewable electric production was achieved by wind energy in Turkey. Solar was second, followed by geothermal in third. Thus, 87,428,545,344 US dollars is needed to convert fossil fuel electricity production with renewables excluding hydraulic in 2021, and by multiplying this figure by 1.51 as mentioned above, 2035 figure is calculated to be 132,243,519,346 US dollars.

Table 5. The Cost of Converting Fossil Fuel Electricity Production with Renewables

Type	Distribution of Electricity Production from Renewables	MWh of Fossil Fuel Based Electricity Production to be Replaced	Capacity to be Installed for Conversion (MW)	Cost (US Dollar)
Wind	50.83%	108,324,677	27,081	35,205,520,137
Solar Photovoltaics	21.16%	45,108,200	15,036	15,036,066,563
Geothermal	17.68%	37,684,506	4,711	18,842,253,242
Biomass	10.33%	22,013,646	3,669	18,344,705,402

Similarly, Table 6 gives the consumption of fossil fuels used in road transportation and conversion to MWh for 2021 in Turkey.

Table 6, Consumption of Fossil Fuels Used in Road Transportation in Turkey, 2021

	Consumption (ton)	Consumption (MWh)
Diesel	24,937,142	278,368,096.74
Gasoline	3,021,527	36,539,396.28
LPG	3,117,462	39,874,513.95
Fuel Oil	243,550	2,888,616.28
Total		**357,670,623.26**

By using the figures in Table 6, the cost of converting fossil fuel used in road transportation with renewables is calculated to be 146,720,176,332 US Dollars in total in 2021 and demonstrated in Table 7. By multiplying the total cost figure by 1.51 as mentioned above, 2035 figure is calculated to be 221,927,431,149 US dollars.

Table 7. The Cost of Converting Fossil Fuel used in Road Transportation with Renewables

Type	Capacity to be Installed for Conversion (MW)	Cost (US Dollar)
Wind	45,447	59,080,934,059.26
Solar Photovoltaics	25,233	25,233,112,696
Geothermal	7,905	31,620,550,329
Biomass	6,157	30,785,579,249

The total cost of converting all the road transportation vehicles to electric vehicles by 2035 is calculated and summarized in Table 8 for Turkey. The table 8 also include the estimation of the charging infrastructure cost. Based on the study of conducted in U.S. metropolitan areas the cost of charging infrastructure including home, work and public charge stations options investment is on the average 400$/electrical vehicle (Nicholas, 2019). Using this figure for Turkey, the infrastructure cost will be approximately 14,800,000,000 US dollars. Thus, the total cost of electric car conversion will be 2,958,970,950,495 US dollars.

Table 8. Total Cost of Electric Car Conversion by 2035 in Turkey

The total cost of production of electricity by renewable sources	132,243,519,346 $
The total cost of road transportation fuels conversion to electricity by renewable sources	221,927,431,149 $
The total cost of conversation of all the vehicles in to electrical	2,590,000,000,000 $
The total cost of charging infrastructure	14,800,000,000 $
Total	2,958,970,950,495 $

4. CONCLUSIONS

In conclusion, the total cost of transitioning all road transportation vehicles in Turkey to electric vehicles has been calculated to be 2,958,970,950,495 US dollars. This significant investment indicates that by 2035, an average of 23,101 US dollars per capita would need to be allocated for this purpose. Furthermore, conversion of rail transport will increase the total cost by approximately 25%. Transitioning to electric vehicles involves several expenses, including the acquisition of new electric cars, the installation of charging infrastructure, and the development of supporting technologies. The cost estimate takes into account these factors and provides an estimation of the financial resources required for a complete transition to electric vehicles in Turkey. It is important to note that while the upfront investment may seem substantial, the long-term benefits of electrifying the transportation sector can be significant. Electric vehicles offer advantages such as reduced dependence on fossil fuels, lower greenhouse gas emissions, and improved air quality. Additionally, electric vehicles have the potential to contribute to a more sustainable and resilient energy system.
The cost per capita figure serves as a guideline for understanding the scale of investment needed on an individual basis. However, it's worth considering that this amount can be influenced by various factors, including government policies, incentives, and the pace of technological advancements. Additionally, cost reductions and economies of scale in the electric vehicle market could potentially lower the per capita expenditure over time. Overall, transitioning to electric vehicles represents a substantial investment, but it also presents an opportunity for Turkey to embrace sustainable transportation and contribute to a greener future with a decrease of greenhouse gas emissions by at least 30%.

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ENERGY EFFICIENCY EVALUATION AND FORECASTING OF THE SUSSEX PORTS TO ADDRESS CLIMATE CHANGE CONCERNS: A DATA-DRIVEN DECISION MODEL

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ABSTRACT
The economic output and societal influence of ports are vital for the economy of the Sussex region in the United Kingdom. The Sussex ports facilitate not only the movement of freight but also fishing, passenger transport, leisure, and offshore supply operations. However, the port industry cluster in Sussex is facing a number of upcoming challenges as a result of climate change and the growing demand for sustainable port operations. In this study, a data-driven mathematical model combining a multi-criteria decision-making (MCDM) framework with machine learning techniques (MLT) is proposed to compare forecasts of short and medium-term sustainability performances of ports in the Sussex cluster. The methodology of the study particularly applies the Multi-Attribute Value Analysis (MAVA) model to evaluate the performance of the Sussex ports based on the main criteria and related sub-criteria. The Autoregressive Integrated Moving Average (ARIMA) model is also used to forecast changes in the data used for the criteria for the short term (by 2025) and medium term (by 2030). The data are obtained and elaborated from an AIS data platform and other available secondary sources. The energy efficiency performance of the ports in the Sussex cluster will be revealed in terms of port operations. The early findings of this study will suggest the port with the highest MAVA score in 2023, 2025, and 2030. This information can inform the decisions of policymakers in determining which ports are best equipped to handle increases in shipping traffic and demand in the most energy-efficient way.
Keywords: Energy Efficiency, Sussex Ports, Multicriteria Decision-Making, Machine Learning, Forecasting

1. INTRODUCTION
Ports are critical coastal structures delivering various socio-economic benefits to the urban areas and helping the cities and towns to conceive their distinctive cultural and commercial identities (Mega, 2016). The urban ports in the South of England have a crucial role in facilitating foreign trade, regional maritime transport, offshore supply, commercial fishing, and marine tourism. Consequently, they generate a profound influence on the economic landscape. These seaports not only serve as essential nodes for freight transportation but also act as vibrant centres of economic activity. They contribute to creating a significant number of jobs and supporting the revenue growth of local and regional businesses. However, it is necessary to acknowledge that these ports also have substantial environmental and social ramifications, encompassing concerns about pollution including air and water pollution, noise pollution, and congestion (Sharma and Das, 2020). Moreover, they have intense impacts on the health and well-being of residents in the vicinity. Therefore, there is a growing research need to address those issues and generate alternative solutions.

The geographical boundaries of the Sussex port cluster retain both Counties of East Sussex and West Sussex, located in the South of the United Kingdom. The region is surrounded by significant port/maritime clusters including the Solent maritime cluster in Hampshire. However, the port industry in the Sussex is yet in the development stage. Moreover, there is a growing industrial interest in further development of the Sussex Ports to streamline regional economic activities (Tyson, 2018). Main maritime activities are generally focused on not only cargo transportation but also offshore supply and fishing. The region includes three ports performing cargo operations, such as the Shoreham Port, the Port of Newhaven, and Littlehampton Ports (Brookfield, 1955). Additionally, the cluster hosts many essential marinas and anchorages due to the high tourism volume of the cities and towns in the region. The Sussex Port cluster has the potential to be a vital hub for many goods and service sector businesses located in the port hinterlands and depending on efficient and sustainable port operations.
Despite the economic advantages that Sussex ports provide, the industry is encountering powerful climate change challenges and the growing demand for sustainable operations. Climate change is triggering sea level rise and threatening daily port operations (Christodoulou et al., 2019). Additionally, extreme weather conditions can damage port infrastructure and provoke unanticipated disruptions in port operations (Yang & Ge, 2020). Moreover, the shipping industry accounts for a substantial share of the global greenhouse gas emissions. Consequently, ports are under pressure to enhance their environmental impact and establish a transition toward sustainability. To address these challenges, policymakers and industry stakeholders need access to reliable data and tools to evaluate and benchmark the sustainability performance of different ports (Bjerkan & Ryghaug, 2021). The proposed study aims to generate a reliable data-driven methodology to respond to industrial expectations.

The main objective of this study is to develop a data-driven mathematical model to compare the sustainability performance of ports in the Sussex counties. The model combines a multi-criteria decision-making (MCDM) framework with machine learning techniques (MLT) to forecast short and medium-term sustainability performances of ports in the Sussex cluster. This study concentrates on determining the energy efficiency performance of the three major ports in the Sussex cluster regarding port operation. Energy efficiency is a vital element of sustainable port operations, as it may help to reduce greenhouse gas emissions, lower operating costs, and enhance competitiveness. The research outputs suggest the port with the highest results in 2023, 2025, and 2030. This information can help policymakers and industry stakeholders for evaluating the capabilities of ports to handle boosts in shipping traffic and demand in the most energy-efficient way. The second section of this research summarizes the literature explorations and specifies the research gap. The third section of the study introduces the methodological steps developed to apply to the research problem. The fourth section clarifies the data collection stages and explains the numerical analysis performed in this study. The fifth section creates a conclusion and describes the potential future research direction.

2. LITERATURE REVIEW

The energy efficiency of ports has become a central focus for maritime transport research, especially in the context of environmental sustainability and climate change. Several important studies in the literature have explored the energy efficiency of ports, shedding light on key factors and strategies for improvement. Di Vaio et al (2018) determined the managerial key performance indicators (KPI) of the port authorities in environmental sustainability and energy efficiency investments by reviewing the literature. They underlined the role of port infrastructure investments in lowering the shipping emissions in port areas. Their research revealed the great potential of energy efficiency savings in ports by adapting technological innovations and operational solutions. Acciaro et al (2014) highlighted the responsibilities of port authorities in the energy efficiency of ports. Their study focused on two main areas including power generation and energy consumption. They emphasized the importance of renewable energy use in power generation and electrified equipment in energy consumption to achieve better energy efficiency performance. Iris and Lam (2019) reviewed the literature on energy efficiency strategies in ports. Their research not only investigated technological advancements and energy management systems but also operational strategies increasing energy efficiency in ports.

Alamoush et al. (2020) also examined the technical and operational measures to enhance port energy efficiency performance. They focused on both portside measures and ship-port interface measures including all subcriteria. Sifakis & Tsoutsas (2021) determined the main criteria of the zero-emission port concepts as; environmental management, renewable energy systems, and alternative/renewable fuels and waste management. They underlined the importance of vessel speed reduction and eliminating port congestion, as well as using renewable energy power generation and supplying alternative marine fuels to the ships. Sthyre et al. (2017) investigated GHG emissions of different ports around the world by focusing on ship speed reduction, reduced port turnaround time, onshore electric energy supply, and alternative marine fuel parameters.

In the last decade, many studies focused on the influence of the ships' time spent at the port on ship-port interface energy efficiency. In an essential study, Johnson and Sthyre (2015) investigated the correlation between energy efficiency and a ship's total time spent in a Port for Dry Bulk shipping. Their study showed that it would be possible to save up to 8% of energy by decreasing unproductive port times with just-in-time arrival. In another study, Besikci et al. (2016) mentioned that ships' time on anchorage would not be in favour of both ship or port operators and it could be possible to save energy by around 10% in a container ship by reducing the ship's speed and arriving to port just in time. Canbulat et al. (2018) and Canbulat et al. (2019) attempted to create a ship-port energy efficiency interface aiming to minimize carbon emissions and energy consumption via just-in-time arrival and collected historical data. Their studies showed the possibility of a significant amount of energy savings through the reduction of port congestion. In a more recent study, Hoang et al. (2022) also emphasized the significance of the port-to-ship pathway to mitigate carbon emissions and increase energy efficiency in the shipping industry.

Gibbs et al. (2014) examined the influence of port operations on total maritime transport chain emissions in UK ports. Their findings showed that only 32% of the UK ports were reporting their carbon emissions. Additionally, their results showed that emissions and energy consumption spent for ships' shifting activities between terminals or ports were much higher than port operations. Asgari et al. (2015) developed an Analytical Hierarchy Process (AHP) model to rank the sustainability performances of the five major UK ports. Their study highlighted the importance of energy efficiency and environmental policy implications in UK ports.

Overall, the literature indicates a growing research direction in ship-port interface research to increase total energy efficiency and lower GHG emissions. An existing well-established approach in the literature adapts the MCDM methods to the port energy efficiency performances. Most of those studies use qualitative literature searches or holistic assessments of port environmental sustainability. Additionally, there is an emerging area regarding the application of MLT in data-driven complex decision-making and forecasting models (Fan et al., 2020). However, there is not any former study integrating MLT with MCDM methods in the literature to employ in port and maritime research. Therefore, this study attempts to fill that research gap by developing an MCDM-MLT integrated data-driven model. The model is also functional to apply to a selected UK case study that was not examined before by researchers in terms of energy efficiency and port environmental sustainability.

3. METHODOLOGY

This study integrates Multi-Criteria Decision Making (MCDM) with Machine Learning Techniques (MLT) within a methodological framework to enhance forecasting capabilities. MLT plays a significant role in leveraging historical data patterns and correlations to generate projections for the future. Specifically, the Autoregressive Integrated Moving Averages (ARIMA) is a commonly used MLT for time series analysis. ARIMA involves decomposing the time series into autoregressive (AR) and moving average (MA) components and applying differencing until stationarity is achieved.

The methodology employed in this study incorporates the Multi-Attribute Value Analysis (MAVA) model to assess the performance of Sussex ports based on three primary criteria and their associated sub-criteria within a decision hierarchy. The MAVA model is a robust decision-making tool that simultaneously considers multiple criteria and assigns weights according to their relative importance. Additionally, the ARIMA model is utilized to forecast changes in the data inputs used for the criteria scores in the short-term (by 2025) and medium-term (by 2030). To gather the necessary data, the study relies on the Automatic Identification System (AIS) data platform and other relevant published secondary sources. The collected data is instrumental in informing the decision-making process and providing a comprehensive understanding of port energy efficiency evaluation.

In the initial stage of the methodology, the MAVA method is applied, which serves as a multicriteria decision-making framework for addressing complex decision problems. The MAVA method involves evaluating the ranking of alternatives within a decision tree structure that comprises multiple layers of criteria hierarchy. Normalized measures at the lowest level are aggregated using weighted objective functions to guide the decision-making process (Canbulat et al., 2015). Mathematically, the value function is the fundamental equation embedded within the MAVA modelling framework. The value function of the MAVA model can be expressed as follows (Belton and Stewart, 2002):

$$V(a) = \sum_{i=1}^{n} wi.\, vi\ (a) \quad (1)$$

Where;
$V(a)$ symbolizes the total value of the alternative a.
$vi\ (a)$ is the value score indicating the alternative a 's scoring on criterion i.
wi is the weight allocated to indicate prominence of the criterion i.

In the second stage of the methodology, the ARIMA model is applied. The ARIMA model contemplates a value y at time point t and adding/subtracting based on the y values at previous determined point of times (e.g.,t-1,t-2, etc.). It also includes adding/subtracting error terms from previous time points. The basic equation of the ARIMA model is explained as follows (Abugaber, 2023):

$$Y_t = c + \emptyset_t y_{dt-1} + \emptyset_p y_{dp-1} + \cdots + \theta_1 e_{t-1} + \theta_q e_{t-q} + e_t \quad (2)$$

Where;
$\emptyset$ is slope coefficient.
θ is moving average parameter.
e symbolizes an error term.
c is a constant.
p means the number of preceding y values in the model.
d represents the number of times that the data changes to produce a stationary signal.
q represents the number of preceding values for the error term that are added/subtracted to y.

4. DATA COLLECTION & EARLY FINDINGS

In this research, historical data on the key performance indicators (KPIs) of ports in the Sussex cluster are collected using ship AIS (Automatic Identification System) data. Ship arrival and port congestion data, along with other relevant factors such as ship speed reductions and auxiliary engine energy consumption at ports, are collected to assess port energy efficiency performance. These data are utilized in the evaluation of the three main ports in the Sussex port cluster. To determine criteria weights, secondary data are considered.

Early findings from the study, based on AIS data, suggest that ports with higher ship traffic and longer port turnaround times perform the worst in terms of energy efficiency, while ports with less traffic and shorter port turnaround times perform the best. However, when considering berth utilization rates, the performance of different ship types requiring longer port visits or waiting on the anchorage becomes more influential in terms of shipping emissions at the ship-port interface. The comprehensive results also indicate the influence of forecasting on the outcomes for 2025 and 2030, assuming no significant dynamic changes in port energy efficiency management. These findings highlight the importance of considering port operations, ship traffic patterns, and energy management strategies to enhance energy efficiency and mitigate environmental impacts in the Sussex port cluster.

5. CONCLUSIONS

Energy efficiency and decarbonization are the key directions of the shipping industry in contemporary times. Many factors should be considered to improve the energy efficiency performance of ports. Previous studies suggested that the main problem of carbon emission in the port area was rooted in the energy consumption of ships in the port and the port's energy usage. Renewable energy investments and electrified equipment use, and operational and technological innovation strategy adaptations were recommended by the previous research to enhance the energy efficiency performances of ports. Moreover, MCDM models were commonly applied on assessing the environmental sustainability of ports. Furthermore, the literature review indicated a research gap in the integration of a data-driven approach to MCDM modelling. To conclude, this study put forward the justification of the approach by developing clear aims and objectives with the motivation of filling the research gap in the literature.

In this study, the energy efficiency performances of the three main cargo ports in the Sussex port cluster are examined by the authors. The methodological framework of this research integrated MAVA and ARIMA models to determine the actual energy efficiency performances of the ports by utilizing AIS data. The results of this study suggest that it would be possible to enhance the port energy efficiency, particularly, focusing on the ship-port interface parameters including port turnaround time, ship arrival time, onshore electric supply, and alternative marine fuels. This study has also potential implications for future research. The methodology developed in this study should further be adapted to the entire logistics chain. Therefore, it will be possible to calculate the carbon footprint changes of the imported products by enhancing ship and port energy efficiency. Further studies should also focus on the adaptation of advanced technological innovations and operational solutions in the UK ports to meet the maritime decarbonization target of the International Maritime Organizations.

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ENERGY, EXERGY AND EMISSION PERFORMANCE PREDICTION OF THE HYDROGEN-FUELED SCIMITAR ENGINE WITH MACHINE LEARNING METHODS

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ABSTRACT
Machine learning methods become popular in recent years for the analysis and optimization of energy systems. In this paper, energy, exergy and emission performance of the hydrogen-fueled Scimitar engine is predicted machine learning approaches. Models are constructed with neural network, nearest neighbors, decision tree, gradient boosted trees, random forest, Gaussian process and linear regression approaches to predict the impacts of hydrogen mass flow rate, air mass flow rate, combustion chamber wall heat flux, cruise speed and cruise altitude on the overall efficiency, exergy efficiency and NOx emission index of the Scimitar engine. The results show that the Gaussian process approach has the best predictive capability for overall and exergy efficiencies while the linear regression provided the best results for the NOx emission index.
Keywords: Scimitar Engine, Energy, Exergy, Emission, Machine Learning.

1. INTRODUCTION
Scimitar engine is a hybrid system designed for hypersonic propulsion (Jivraj et al., 2007). The engine is derived from the synergistic air-breathing rocket engine and it is fueled by hydrogen. Therefore, in addition to shortening the flight time, it is also a promising candidate for green commercial aviation. Scimitar engine operates as a turbofan up to a cruise speed of Ma=2.5 at which it switches to ramjet-turborocket mode for Ma=2.5-5.0, and finally works as a turborocket when Ma=5.0. The engine employs a specially designed precooler to transfer heat from air to cryogenically stored hydrogen through a regenerator that utilizes helium as the working fluid.
Scimitar engine has been the topic of many studies. Villace and Paniagua (2013) carried out an analysis of the engine to determine its energy-based performance indicators of propulsive efficiency and thermal effectiveness. The energy and NOx emissions of the engine was studied by Tanbay et al. (2020) through a thermodynamic model, while an exergy-based ecological analysis of the system was performed by Tanbay and Durmayaz (2020). Multi-objective optimization of the Scimitar engine was presented and the impacts of core nozzle geometry and combustion chamber wall heat loss on the performance of the engine were investigated in Tanbay and Durmayaz (2022a) and Tanbay and Durmayaz (2022b), respectively. Thermodynamic analysis and optimization of precooled engines were also performed by Dong et al. (2018), Yu et al. (2020), Wei et al. (2022) and Wang et al. (2023).
Machine learning (ML) methods are being widely used in recent years for predicting the performance and optimizing energy systems. In this study, ML methods are used to predict the energy, exergy and emission performance of the Scimitar engine. Hydrogen mass flow rate, air mass flow rate, combustion chamber wall heat flux, cruise speed and cruise altitude are considered as the input variables and predictive models for overall efficiency, exergy efficiency and NOx emission index (gNOx/kgH2) of the engine are constructed by neural network, nearest neighbors, decision tree, gradient boosted trees, random forest, Gaussian process and linear regression approaches. The training data is obtained from an exact model of the engine and the predictive capability of the methods are examined with numerical experiments. The novelty of this study is that the ML methods are used for the performance prediction of a precooled hypersonic aeroengine for the first time.

2. PREDICTION OF SCIMITAR ENGINE PERFORMANCE WITH MACHINE LEARNING
2.1. Modelling of the Engine
Fig. 1 shows the schematic representation of the Scimitar engine for hypersonic cruise mode. Air enters the engine with a mass flow rate of at a cruise speed and altitude of and , respectively. Air is decelerated and its temperature significantly increases in the intake. The high-temperature air is cooled with the precooler (HX1+HX2) to core compressor (C) inlet conditions which is driven by a helium turbine (T1). Hydrogen fuel enters the engine with a mass flow rate of in liquid phase and it is heated to preburner (PB) and combustion chamber (CC) inlet conditions by the heat exchangers HX4L, HX4H and HX5. Part of the fuel is burned in the PB that aims to keep the inlet temperature of T1 at 1000 K at all flight modes.

Slightly burned air then enters the CC and reacts with hydrogen. Heat loss from the CC is characterized by the wall heat flux, q_{wall}. Combustion products leaving the CC are expelled from the converging-diverging core nozzle (CN) to produce the thrust of the Scimitar engine. Air and hydrogen are thermally coupled with a helium regenerator cycle consisting of seven heat exchangers, nine compressors and three turbines.

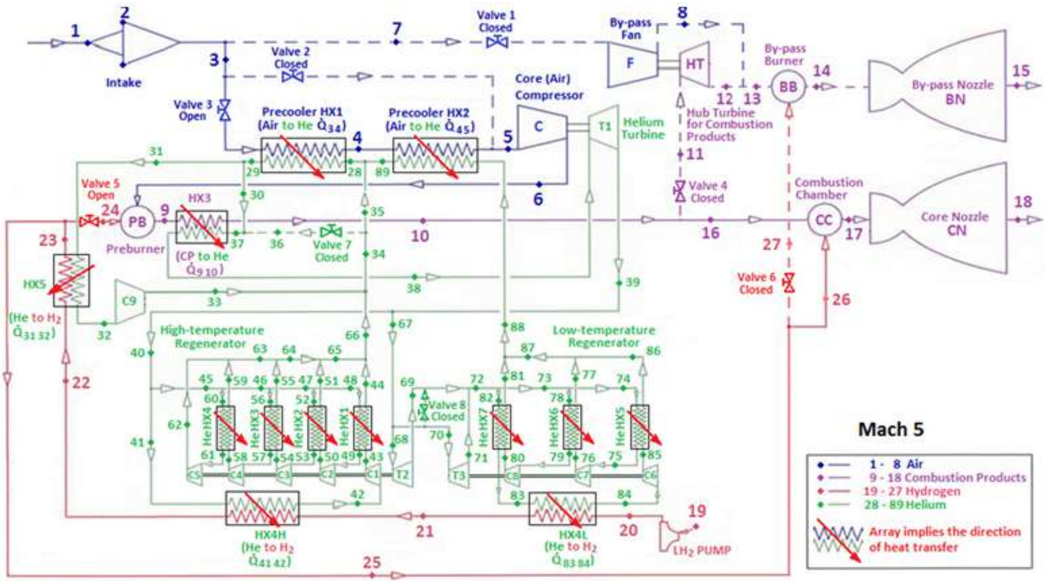


Fig.1. Schematic representation of the Scimitar engine at hypersonic cruise conditions.

2.2 Prediction of Engine Performance with Machine Learning

Application of mass and energy conservation, entropy balance equations on the components together with the use of combustion and dissociation-formation reactions for CC of the Scimitar engine represented in Fig.1 leads to a system of 81 nonlinear equations. The nonlinear system can be solved numerically to yield the thermodynamic conditions of all states and emission values of the engine. Hence the performance indicators, namely overall efficiency (η_o), exergy efficiency (η_{ex}) and NOx (EI_{NO_x}) emissions, of the engine can be calculated for different design and operating conditions. The ML-based predictive model of the Scimitar engine is constructed by using the results of performance indicators obtained with 108 different sets of $\dot{m}_{air,1}$, $\dot{m}_{H_2,20}$, $\dot{q}_{wall}$, v_1 and Alt. The model is trained with randomly chosen 88 of the data while the rest is used for testing. Neural network (NN), nearest neighbors (NeNe), decision tree (DT), gradient boosted trees (GBT), random forest (RF), Gaussian process (GP) and linear regression (LR) are employed as ML approaches and the prediction capability of these methods is compared by calculating the maximum and RMS errors defined by

$$\varepsilon_{\max} = \|f_{exact} - f_{ML}\|_{\infty} \quad (1)$$

$$\varepsilon_{RMS} = \|f_{exact} - f_{ML}\|_2 / \sqrt{N_{test}} \quad (2)$$

Where $f = \eta_o, \eta_{ex}, EI_{NO_x}$ and N_{test} is the number of test cases

3. RESULTS AND DISCUSSION

The ML models to predict the energy, exergy and emission performance of the Scimitar engine are constructed with the built-in functions of Mathematica 11. The ranges of the training data are given in Table 1. The maximum and RMS errors of the seven ML approaches in computing the overall efficiency, exergy efficiency and NOx emissions are presented in Table 2. Since training data is randomly chosen, simulations are carried out 10 times in order to eliminate the effect of training data selection on the comparative analysis of ML approaches, and the results shown in Table 2 are the average error values of these simulations. The results show that GP and LR methods yield the lowest maximum and RMS errors for the energy, exergy and emission performance indicators. GP approach has the best prediction capability for overall and exergy efficiencies, while LR algorithm gives the best result for the NOx emission index. On the other hand, the NN approach produced the least accurate results for all performance indicators.

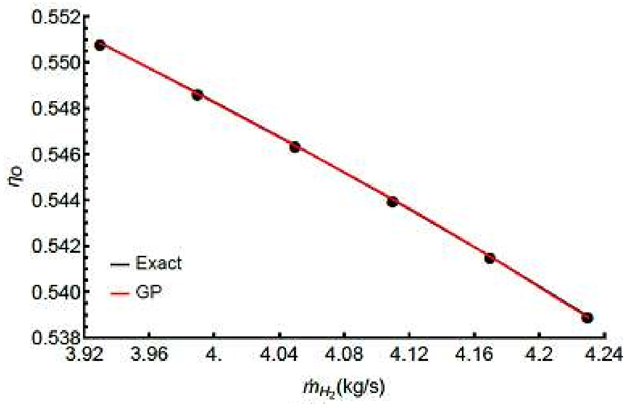
Table 1. Ranges of the training data for Scimitar engine ML predictive models.

Parameter	Range
Hydrogen mass flow rate (kg/s)	$3.93 \le \dot{m}_{H_2,20} \le 4.23$
Air mass flow rate (kg/s)	$166.6 \le \dot{m}_{air,1} \le 178.6$
CC wall heat flux (MW/m²)	$0 \le \dot{q}_{wall} \le 10$
Cruise speed	$4.8 \le Ma \le 5.2$
Cruise altitude (km)	$22 \le Alt \le 26$

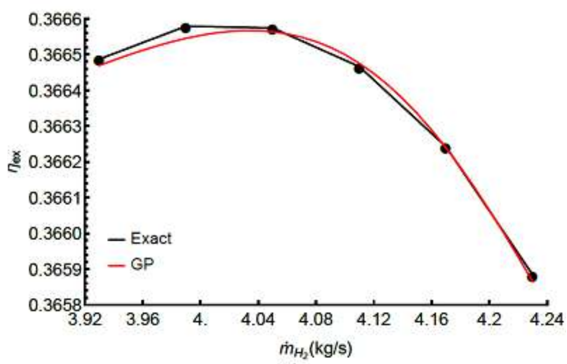
Table 2. Comparison of ML methods for predicting the performance of the Scimitar Engine.

	NN	NeNe	DT	GBT	RF	GP	LR
				Maximum error			
Overall efficiency	0.0182	0.00410	0.0104	0.00331	0.0122	0.00252	0.00239
Exergy efficiency	0.0105	0.00231	0.00401	0.00109	0.00393	0.000274	0.00155
NO_x emission index	165.261	20.085	100.059	26.312	82.162	8.081	5.66142
				RMS error			
Overall efficiency	0.00791	0.00178	0.00542	0.00130	0.00579	0.000846	0.000925
Exergy efficiency	0.00571	0.00100	0.00202	0.000368	0.00167	0.0000903	0.000620
NO_x emission index	81.164	8.719	47.525	11.051	41.521	3.064	2.1116

The prediction capability of the GP approach is illustrated further in Fig 2, where curves obtained with the exact results and GP predictive model for the variation of overall efficiency, exergy efficiency and NOx emission index with the fuel mass flow rate are given. These results are found with an air mass flow rate of 172.6 kg/s, a CC wall heat flux of 6 MW/m2 a cruise speed of Ma=5 and a cruise altitude of Alt=25 km. The GP method matches the exact solutions for overall efficiency and NOx emission index and it provides a good fit for the exergy efficiency which exhibits a maximum with respect to fuel mass flow rate. The results show that the GP method is an accurate technique for predicting the energy, exergy and emission performance of the Scimitar engine.



(a)



(b)

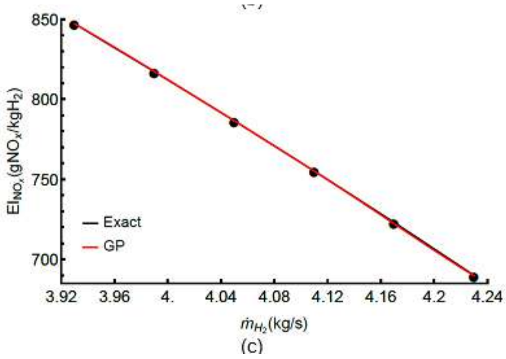


Fig. 2. Comparison of exact solution with GP predictive model for (a) overall efficiency, (b) exergy efficiency and (c) NOx emission index of the Scimitar engine.

4. CONCLUSIONS

This study presents the application of machine learning methods to the hydrogen-fueled Scimitar engine. Neural network, nearest neighbors, decision tree, gradient boosted trees, random forest, Gaussian process and linear regression are used as machine learning algorithms. Predictive models are constructed with these approaches to investigate the impact of hydrogen mass flow rate, air mass flow rate, combustion chamber wall heat flux, cruise speed and altitude on the energy, exergy and emission performance of the engine. Gaussian process provides the least RMS error and hence the best prediction capability for energy and exergy efficiencies while the linear regression method give the best performance for predicting engine emission.

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ECO FRIENDLY PRODUCTION OPTIONS IN SANITARY WARE INDUSTRY: CARBON FOOTPRINT AND SUSTAINABILITY APPROACH

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ABSTRACT
A leading ceramic sanitary ware and bathroom accessories company based in Istanbul, Turkey, is committed to sustainability and contributing to the UN's 2030 Agenda for Sustainable Development. They prioritize economic growth, social inclusion, and environmental protection, following the "planet, people, and profit" approach. The company aims to reduce its carbon footprint by implementing energy-efficient practices, investing in renewable energy sources, and optimizing resource and material consumption. They have set ambitious targets to reduce CO2 emissions, increase water-saving solutions, and become carbon neutral by 2050. By focusing on quality, long-lasting products and employing sustainable manufacturing processes, the company aims to be a leader in the sustainable sanitary industry while minimizing environmental impact and maximizing benefit. This study provides a comprehensive overview of sustainability performance, priorities, energy consumption, environmental considerations, and greenhouse gas emissions of the company. It serves to assess the company's progress, set targets, and guide future sustainability initiatives.
Keywords: Sustainability, Sanitary industry, GHG emissions

1. INTRODUCTION
A leading company of ceramic sanitary ware, bathroom and kitchen accessories based in Istanbul, Turkey has been producing, marketing, and selling ceramics sanitary ware, care and comfort products for the elderly and handicapped, armatures for the bathroom and the kitchen, bathroom furniture, bathtub and wash cabins, built-in reservoirs, bathroom accessories and kitchen sinks. Main sectors served are the domestic sector, construction materials markets, hotels, airports, hospitals, schools, office buildings and others. With the advanced technology, it possesses and unrelentingly investing with the primary objective of expanding its product range to new heights. With is capable workforce of approximately 600 employees, the company currently has a production capability of 1,000,000 units. With its qualified sales team located in Turkey, Europe, the USA, and several other countries and having secured a wide network of ceramic products users. In 2017, 2018, 2019, 2020, and 2021 has been in the top three in total exports to the world in Turkey.
2021 Sustainability Report, being the first, contains the company's sustainability performance from January 1 to December 31, 2021. The financial, personnel, energy, and environmental key figures are calculated. Sustainability and carbon footprint evaluations are performed and reported by ZETA Consulting Company Ltd, employing appropriate methods, calculations, and estimates universally acceptable by GRI and IPCC.
Significant short- and long-term investments in energy efficiency and production expansion have continued without a significant delay, and more white-collar education and training as well as blue collar training on health and safety has continued as planned. One investment that deserves more attention than the others is the work on digitalization, which is in progress. The company continues to invest to capture opportunities in key growth markets worldwide. Currently, it has approximately 80 suppliers and locations in 6 countries to support the delivery of products and services to the global customers.
The stakeholders listed under GRI 102-40 have been identified as critical for systematic stakeholder dialogue because they meet at least one of two criteria: either the stakeholder group has a significant impact on company's "profit, planet, or people" performance or the stakeholder group is significantly impacted by company's "profit, planet, or people" performance.

2. COMPANY'S PRIORITIES FOR UN SUSTAINABLE DEVELOPMENT GOALS AND SUSTAINABILITY IN GENERAL
The company is determined to contribute to the UN 2030 Agenda for Sustainable Development through its operations, considering 17 sustainable development goals of the United Nations to transform the World In addition, the company totally agrees with The Ten Principles of the UN Global Compact. The Group believes, for sustainable development to be achieved, it is crucial to harmonize three core elements: economic growth, social inclusion and environmental protection.
The company applies the 'planet, people, and profit' approach, which was coined by John Elkington in 1994 to describe the triple bottom line and the pursuit of sustainability (Elkington, 1997). This approach guides their appreciation for and referral to sustainable practices that consider environmental, social, and economic aspects.

Material factors are important to the company from both an internal and external standpoint and have major economic, environmental, or social consequences (Silvestri et al., 2020), (Gu et al,. 2019). There was no distinct assessment based on these varied dimensions. Instead, after consulting with stakeholders, experts, and management, it was established which themes were finally regarded as material. The company identified priorities as material in the economic, environmental, and social dimensions. The company priorities for the Coming Year include; employing more women to achieve gender equality, invest and employ renewable energies while emphasizing on the improved use of recovered waste heat, implement full and productive employment to equal pay for work of equal value. Another company target for sustainable production, Board of Directors aims to operate an extensive system for monitoring and controlling the risks (including environmental risks) linked to the business activities.

3. COMPANY'S ENERGY CONSUMPTION WITHIN THE ORGANIZATION IN 2021

The company typically purchases energy from outside sources. The combustibles natural gas, diesel for production, generators and forklifts are included in the direct energy carriers (Scope 1). Electricity is the indirect energy carrier (Scope 2). Natural gas consumption (primarily for ceramic production) still accounts for the greatest share of energy consumption at 86.9%, followed by electricity with 11.7% and diesel oil with 1.4%. Table 1 provides the fuel and electricity consumption for 2021 for the company.

Table 1. Fuel and Electricity Consumption for 2021 for the company

	Natural Gas Consumption (m^3)	Electricity Consumption (kWh)	Diesel Consumption (lt)
The company	6,019,896.20	7,792,678.04	78,728.00
TOTAL in joules			
TOTAL	207,794,777,031,600	28,053,640,944,000	3,359,859,110,400

The energy efficiency project that started in 2020 was completed in 2021. The consulting firm has prepared a detailed dossier for seeking tenders for the energy efficiency project, and tenders have been collected from the leading energy equipment manufacturers. It is planned that the whole project will be completed in 2023 and will lead the company to sustainable production. The dossier is founded on two pillars: energy conservation and enhanced energy efficiency. In addition, the company owns 23 vehicles in and outside Turkey. The details are given in Table 2.

Table 2. Fuel Consumption of Vehicles owned by the company 2021

Location	Type of Vehicle	Number	Fuel used (lt)	Fuel used (joules)
Turkey	Diesel	17	765,000	32,647,752,000,000
	Gasoline	3	12,000	410,400,000,000
Outside Turkey	Gasoline	2	8,500	290,700,000,000
	Electric	1	N/A	N/A

Energy consumption outside of the organization

The company focuses on distribution logistics and employees & business travel when it comes to energy consumption outside the firm. In 2021, The company produced and sold 16,400 tons of sanitary ware and accessories. External transportation service providers are used for logistics services. The transport service providers handled 69,235,837 ton-kilometers in 2021. This resulted in 133 TJ of energy use. Personnel services are provided for the employees from their homes to the plant primarily by leasing to a sub-contractor. A total of 17 diesel mini service buses used in 2021. In total, 1,524,000 km is covered by the mini service buses resulting in 202,692 liters of diesel usage. The employees that use their own cars used an average of 8,000 liters of diesel, 3,000 liters of gasoline and 2,000 liters of LPG in 2021. The flight distances are estimated based on the airports of departure and arrival. Due to the COVID-19 epidemic, corporate flight energy usage dropped. Energy consumption arising from business flights is calculated to be approximately 54.3 GJ in 2021.
In total, the energy consumption outside of the organization is summarized in Table 3.

Table 3. Energy Consumption Outside of the Organization in 2021

Type of Energy Consumption	Energy Consumption (GJ)
Logistics Services	133,000
Personnel Services	8.64
Employee Cars for Commuting to Work	150.56
Rental Cars	24,083
Business Flights	54.3
Other	8,000
TOTAL	**165,296**

The consumption of energy in the form of electricity, combustibles, and fuels is company 's highest environmental impact, accounting almost hundred percent of the company's eco-balance. Energy consumption, as well as greenhouse gas (GHG) emissions of the company, is closely monitored by the top management. Table 4 demonstrates the distribution of the total energy consumption for the company in 2021.

Table 4. Distribution of the Total Energy Consumption in 2021

Energy Consumption Distribution	Energy Consumption (GJ)	%
Within the organization	272,557	62.2%
Outside of the organization	165,296	37.8%
Total	437,853	100.0%

According to Table 4, for each ton of goods produced by the company, 26.7 GJ/ton of energy was consumed in total.

4. ENVIRONMENTAL CONSIDERATIONS

Starting from the foundation date, the company began collaborating on energy efficiency-related projects and ecologically friendly design (eco-design). Since 2020, environmental issues have begun to take a significant place in the decisions taken by the management group. Material consumption, as well as resource and energy consumption, are being constantly optimized in sanitary ware production.

A long-term CO2 target was defined in 2021 that is compatible with the target set in the Paris Agreement. The company plans to reduce its absolute CO2 emissions (Scopes 1 and 2) by 10% in 2023 and 18% in 2025 to under 30,000 tons. The environmental impact will be reduced by 4% annually in the following years. The impact per net sales will drop even further. This progress is founded mainly on continuous improvements in efficiency at the energy-intensive ceramics plant. It is fair to say that the company places its faith in energy saving and energy efficiency, process optimization and continuous digitalization and modernization of the infrastructure and the machine fleet, the optimization of the kilns used for ceramic production, the improved use of waste heat (heat recovery) as well as the careful use of compressed air. In addition, the company aims at a 50 % reduction in 2035 and will become carbon neutral in 2050.

The water footprint throughout the company value chain shows that nearly 100% of the water consumption, which amounts to more than 200 tons daily, is attributable to the production of the company's products. Water-saving solutions can therefore exert a significant impact. The company fully supports the economical use of water in the sanitary industry.

Most decision-making processes take environmental factors into account. The company possesses almost all the ISO standards needed to carry out sustainability and energy management applications. The company has been fully committed to reducing its environmental impact and contributing to achieving global climate goals. With the completion of the energy efficiency projects, a decision was made, which can also be called the new CO2 reduction strategy. All eight ceramic furnaces were to be furnished with recuperators and various heat exchangers. However, the reaching height of the COVID 19 pandemic and accompanying economic turmoil has delayed this investment drive, and it is expected that all the investments will be completed in 2023 and contribute significantly to Group's target of reduction by 50% in 2035. A net energy saving of double figures is expected to be achieved. The Group expects CO2 emissions to fall below the target value of 20,000 tons CO2-e by 2035. The company's products typically have a very long service life, most likely exceeding several decades. Because of such a long service life, spare parts are guaranteed to be available for at least 10 years and studies extending this guarantee period in the future. The materials used are determined by manufacturing processes in the company; including processes such as ceramic manufacture, molding, extrusion, metal and thermoforming, and assembly.

Plastic and metal raw materials, mineral raw materials, and other semi-finished and final goods are the most important elements for production. The material usage in direct production in 2021 for the company totals approximately 27,000 tons.

Greenhouse Gas Emissions

As part of the company's eco-balance, production emissions were recorded, computed, and analyzed for the first time in 2021. As demonstrated in Table 5, Scope 1 emissions make up 71.7 % of all CO2 emissions, and this is the reason why the main carbon emission mitigation lies in this scope. On the other hand, emissions due to electricity make up 11.9%, and emissions occurring outside of the company account for 16.4%.

Table 5. Major GHG Emissions of The company in 2021

	ton CO_2-e	kg SO_2
SCOPE 1	26,458	55.1
SCOPE 2	4,378	26,495.1
SCOPE 3	6,044	3,974.3
TOTAL	**36,879**	**30,524.5**

Raw materials, combustibles and fuels, product manufacturing at the company, logistics, use, and disposal are all covered for emission calculations. In 2021, emission intensity per product is calculated as 2.24 ton CO2-e/ton product (2.25 kg CO2-e/kg product). This figure is especially related to the production of ceramic sanitary ware.

5. Conclusions

The company aims to be the leader in the sustainable sanitary industry, both in Turkey and globally. The company is committed to leading the sustainable sanitary ware industry by developing and producing eco-friendly products that have a minimal impact on the environment. They are using solid carbon analysis and sustainability reports to guide their efforts to reach their goals. Although they plan to use the best raw materials available in Europe, they are also working on a plan to increase the regional percentage of the raw materials to the highest possible level in order to minimize the transportation related emissions. The ongoing energy efficiency investments are to improve their energy efficiency as well as their production quality efficiencies, thus reducing energy related emissions. With the increased life cycle of the products coupled with quality spare parts, The company can achieve the overall goals of increased added value to their products with the lowest possible consumption of resources.

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REDUCTION OF CO2 EMISSIONS AND COBUSTION STABILITY IN LEAN LIMITS BY OPTIMIZING THE ENGINE SPARK TIMING FOR HYDROGEN INDUCTION IN GASOLINE DIRECT INJECTION ENGINE

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ABSTRACT

The effect of hydrogen induction (0-8 liter per minute) into the intake manifold of the small-bore Gasoline Direct Injection (GDI) Engine is investigated experimentally. The intake manifold is slightly modified to accommodate the hydrogen induction system, where premixed mixture of hydrogen and air is formed in the intake manifold, attaining the excess air ratio of 1.0 to 1.08. With the increment of hydrogen fraction the fuel leaning (Gasoline) is attained and achieving economical fuel consumption rate. The decrement in torque characteristics is compensated with the increase of hydrogen fraction. For the lean limits it was found that the peak pressure of the lean air fuel ratio was reduced consistently. It was noted that optimization of spark timing with respect to the hydrogen flow rate is delivering improved combustion behaviour than the stock spark timing. The spark timing was optimized using the maximum brake torque attainment and CA 50 location. The hydrogen induction improves the combustion rate and mean effective pressure; shortens the flame propagation, maximize the heat release rate and peak pressure attainment. On the emission side consistent decrease in CO and HC emission; and increase of NOx emission since the mean gas temperature has increased. The cycle-to-cycle variation during the lean operating condition at 1.08 shows the combustion stability and effective flame propagation.

Keywords: Hydrogen Induction, Small Bore, Gasoline Direct Injection, Spark Timing

1. INTRODUCTION

The reputation of Internal Combustion Engine in recent days with fossil fuel as the working fuel has been has been in the downfall as the intense promotion of electric vehicle technology. The transportation sector contributes to 10% of the greenhouse gas (GHG) emission which makes it meager when compared to the energy sector [1]. The 100 years of scientific improvement in engine technology makes it more mature than other recent alternative technologies. It is clear those alternatives to compete with IC engine do not cover the vast range of application. A lot of times the blame of the IC engine is about the source of the working fuel and not on the IC engine technology. Compared with conventional fossil fuels hydrogen pose superior characteristic and more suitable for SI engine, where it offers wider flammability range with high diffusivity and low ignition energy. With the safety precaution and advancement towards the storage of hydrogen makes it viable option for alternate for fossil fuels. From the prior arts it is found that adding little quantity of hydrogen with the conventional fuels offers better heat release rate, stable lean mixture formation and improved combustion efficiency. Further it shortens the delay period and offers peak pressure attainment close to top dead center (TDC). The cycle-to-cycle variation of the engine operating behavior was also reduced with the addition of hydrogen with gasoline. On the emission side significant reduction in CO and HC emission was noticed; with some penalty on NOx emission, but particulate emission in the direct injection gasoline has consistent reduction with addition of hydrogen. The implementation of direct fuel injection technology in SI engine is one of the advancements that pushes the limits of SI engine in terms of its thermal efficiency, power performance, emission, and lean operating limits [2]. The gasoline direct injection (GDI) engines are getting more robust since the research advancement was towards various combustion modes, alternate fuels, dual spark ignitions, plasma ignition, dilution techniques to treat emission, in-cylinder water injection, fuel injector study, dual fuel injection, combustion diagnosis and furthermore [3]. The Gasoline Direct Injection (GDI) Engine is known for its economical fuel consumption, improved thermal efficiency and better torque characteristic. Application of GDI technology for small bore engine increases the operating limits of the engine for the light commercial vehicles (LCV) and two-wheeler segment; where this percentage of vehicles in Indian roads are higher in meeting the daily commutation. The GDI technology and the usage of Hydrogen as the primary/secondary fuel paves the path towards the lean combustion technology, wherein the real problems associated with the driving condition will be addressed [4]. On roads most of the engines are operated only at the partial load conditions, wherein the actual efficiency of the engine is poor due to the poor load characteristic, throttling effect and traffic conditions (start and stop). Leaning the gasoline by operating the engine under lean conditions leads to other technical issues like overheating engine misfire and unstable combustion [5].

Addition of hydrogen for the lean operating condition of GDI engine provides more stable combustion and significant reduction in the cycle-to-cycle variations will be attained. After accessing the prior literature, the author aims for hydrogen-gasoline lean burn combustion for small bore GDI engine, with the performance, emission evaluation. The effect of lean burn combustion with addition of hydrogen in gasoline and the lean limit estimation with stable combustion is also investigated.

2. EXPERIMENTAL APPARATUS AND METHODS

2.1 Experimental Apparatus

The engine used for the present investigation is the 390 cm3 small bore single cylinder air cooled GDI engine. The layout of the experimental setup is shown in Fig. 1. The engine was originally available as the carburetor engine, Honda make; it was later modified to direct injection gasoline engine. The engine head was modified to support the GDI injector, throttle control was replaced with the electronic actuator and to control the spark and injection timing, an Electronic Control Unit (ECU) was fitted. To make the close-loop system CAM and crankshaft position (CKP) sensors were additionally fitted with fuel rail pressure control. The modification details of the engine were not included since it is beyond the scope of the article. The engine details are listed in the Table 1. The spark plug location in the engine is at the sides with hemispherical type combustion chamber. The piston head was not modified, production type flat piston head was maintained throughout the investigation. The spray guided fuel injector was used and it was fitted near the spark plug. The details of the fuel injector and pump are listed in the Table 2. The water cooled eddy current type dynamometer was used to load engine for operating conditions. To measure the inlet air HFM (Hot Film) Type T-MAF Sensor was employed and the gravimetric type fuel flow measuring system was used to calculate the fuel consumption by the engine. Contact type encoder was coupled with the crankshaft, this was utilized to trigger the data acquisition system to record the various sensor data. Piezoelectric pressure transducer with the resolution of 0.1 crank angle degree (CAD) was employed to record the in-cylinder pressure data. Wideband Lambda sensor (from Bosch) LSU 4.9 was used to monitor the air fuel ratio and the exhaust gas temperature was monitored by K-type thermocouple. Di-gas analyser 444 (from AVL) was used to record the engine out emission.

2.2 Experimental Methods

The test condition for the investigation is 3000 rpm with 100% throttle opening, where the maximum brake torque was obtained for the given spark timing. The engine operating conditions are listed in Table 3. The hydrogen flow rates are estimated with the energy balance of not exceeding 50% by hydrogen and the maximum limit was set to 8 LPM. For the equivalence ratio of 1, the hydrogen flow rate was varied from 8 to 1 LPM and similarly the equivalence ratio was increased to 1.02 and 1.08. For the consistent increment in the equivalence ratio the subsequent gasoline leaning will be carried out.

Table 1. Engine Details

Particulars	Details
Make	M/s. Honda
No. of Cylinders	1
No. of Valves	2
Type of CAM	Single Overhead
Ignition	Spark
Bore*Stroke (mm)	88*64
Displacement (cm^3)	390
Compression Ratio	8.2:1
Induction	Naturally Aspirated
Rated Torque	24 Nm @3000 rpm
Rated Power	8 hp @3600 rpm
Cooling system	Air

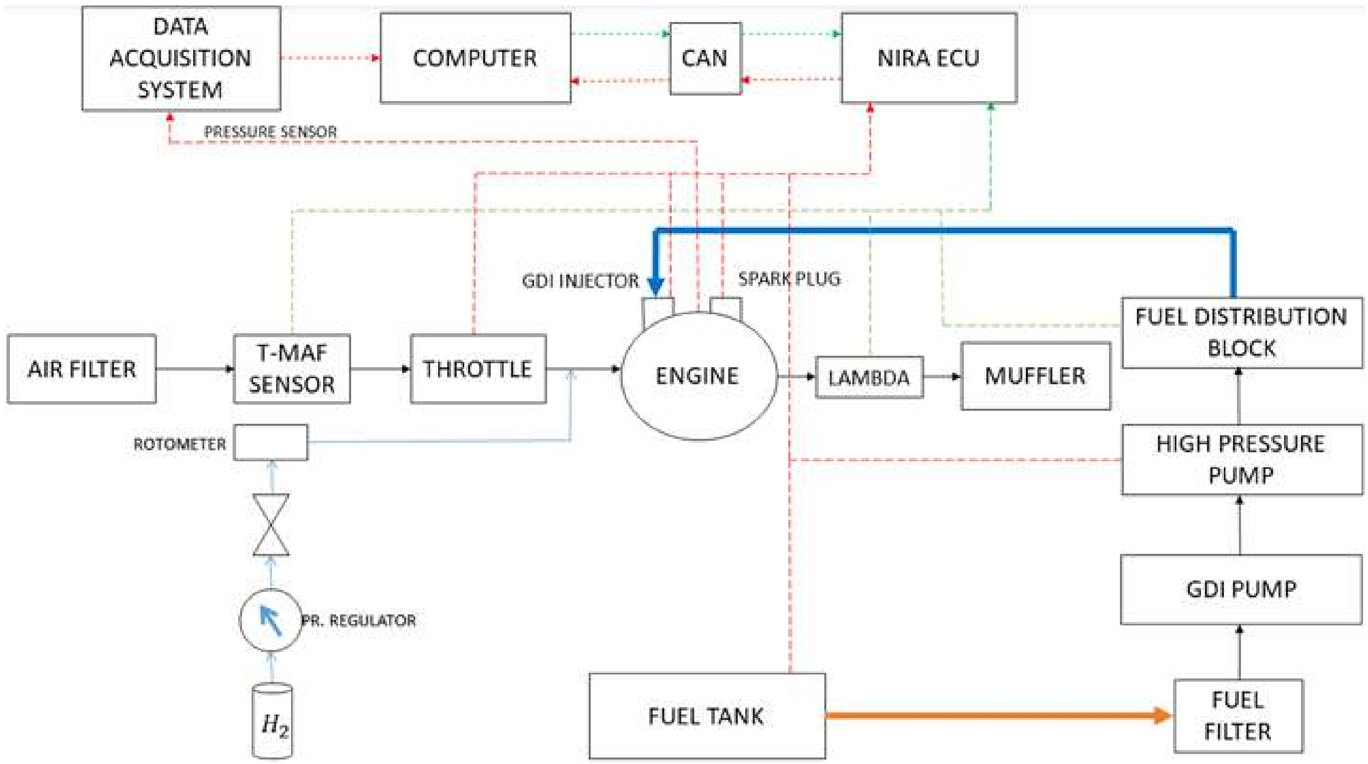

Fig. 1. Experimental Layout

Particulars	Details
Make	M/s. Bosch
No. of Nozzles	6
Configuration	Spray Guided
Operation	Peak & Hold- Solenoid
Make of pump and rail	M/s. Bosch
Pressure	180 bar

Table 2. Fuel Injector Details

Particulars	Details
Speed (rpm)	3000
Mode	Constant Speed Mode
Throttle position	100%
Fuel Injection Pressure	180 bar

3.CONCLUSIONS

1.The spark timing for the equivalence ratio for 1.08 was 33°CAD bTDC and it was advanced to 37°CAD bTDC, the peak pressure improved by 12%. Spark advancement beyond 37°CAD causes misfire in the engine.
2.The lean limit was engine was further increased to 1.22 with the air fuel ratio of 18 for the spark timing of 37°CAD bTDC.
3.Engine operation with 100% wide open throttle, equivalence ratio of 1, 1.02 & 1.08 and the varied hydrogen fraction of 1 to 8 LPM has the significant effect on the engine performance, combustion, and emission characteristic. As the hydrogen fraction increases for the equivalence ratio significant increment in thermal efficiency and indicated mean effective pressure

4.Engine operation with 100% wide open throttle, equivalence ratio of 1, 1.02 & 1.08 and with the increase in hydrogen fraction the combustion duration was shortened leading to peak pressure attained after TDC. Keeping the hydrogen fraction constant and increasing the equivalence ratio improves the heat release rate and consistent reduction in the delay period.
5.Engine operation with 100% wide open throttle, equivalence ratio of 1, 1.02 & 1.08 and with the increase in hydrogen fraction CO and HC emissions decreases and increment in NOx emissions.. Keeping the hydrogen fraction constant and increasing the equivalence ratio, CO emission significantly reduces and HC emission reduces initially and increases in the later part. The NOx emission has the adverse effect with the higher amount of hydrogen fractions.

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MACHINE LEARNING METHODS FOR THE PREDICTION OF CO2 EMISSIONS IN SPARK-IGNITION ENGINES

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ABSTRACT
The present study explores the prediction of carbon dioxide (CO2) emissions coming from gasoline-powered automotive engines operating at maximum capacity by employing ensemble machine-learning techniques. Given the significant impact of fossil fuel consumption on global warming, especially in relation to carbon dioxide emissions from automotive spark ignition engines, it is essential to accurately estimate and monitor these emissions. This is crucial for maintaining environmental sustainability and adhering to government regulations. The investigation applies ensemble-based machine learning models, Ensemble DT Bagging and Ensemble LS Boosting, combining multiple individual models to enhance predictive performance. Hyperparameters of these models were optimized using Bayesian optimization, a strategy that aids in determining the best parameters while reducing model training time. The results of the study indicate that the ensemble Least Squares (LS) Boosting method outperformed the other model tested. Specifically, this method achieved a test score of .9727 for the R2 (coefficient of determination) and a Root Mean Square Error (RMSE) of 0.0085, suggesting a high level of predictive accuracy and minimal error. Therefore, the LS Boosting model offers a valuable tool for managing CO2 emissions from automotive gasoline engines.
Keywords: Machine Learning, Spark Ignition Engines, CO2 emissions, Ensemble DT Bagging, Ensemble LS Boosting.

1. INTRODUCTION
The annual increase in the global vehicle population is accompanied by a corresponding rise in the emissions generated by these vehicles. The aforementioned emissions not only contribute to air pollution but also have adverse impacts on human health [1]. The emission of carbon dioxide (CO2) from automobiles is frequently disregarded due to its lack of direct impact on human beings [2]. Nevertheless, it is a significant factor in the phenomenon of global warming, which results in an accelerated rise in the Earth's temperature [3]. This situation underscores the urgent need for alternative and renewable energy sources for use in the automotive industry. Several scholars have conducted experiments to tackle this challenge by utilising alternative liquid and gaseous fuels in automotive engines [4,5]. Ensemble learning methodologies have the potential to enhance the accuracy of predictive models. Ensemble learning algorithms such as decision tree forest and decision tree boost were utilised to forecast urban air quality [6]. The study conducted a comparison between ensemble learning techniques and SVM, utilising RMSE performance metrics. The results indicated that the former exhibited lower error rates compared to the latter. The boosted decision tree algorithm [7] was utilised to forecast the mean effective pressure in a natural gas engine. The findings indicate that the predictions exhibited a high degree of accuracy, with minimal deviation from the experimental outcomes. An ensemble-boosted regression tree [8] was utilised to forecast the emissions in a dual-fuelled engine that runs on biogas-biodiesel. The evaluation utilised performance indicators such as the R2 value and the RMSE. A comparative analysis was also conducted to assess the distinctions between the ensemble-boosted regression tree and the artificial neural network. The ensemble-boosted regression tree exhibited superior performance compared to the artificial neural network model, as indicated by all statistical parameters. The use of ensemble learning to predict CO2, NOx, smoke, BTE, and HC emissions from engines was investigated by Femilda et al. [9]. Several ensemble learning techniques, including XGBoost, LGBM, CatBoost, and Random Forest, were utilised. The superior accuracy of CatBoost outperformed the XGBoost, RF, and LightGBM models. Hichem et al. [10] examined how ensemble models, bootstrap aggregates (Bag), and least-squares boosting (LS Boost), improve decision trees. DT, DT_Bag, and DT_LS Boost models used physicochemical parameters, including organic matter. DT_LS Boost model predictions and observed organic matter concentrations correlated in the range of 0.99 in the validation dataset. DT_LS Boost outperformed DT_Bag and DT_DT models with better mean root-mean-square errors. Prabhakar et al. [11] used boosted regression trees to assess the efficiency and adverse environmental effects of a compression ratio combustion engine powered by waste-derived biofuel and biogas. Compression, load, and injection of fuel time were model inputs. Models estimated BFR, BTE, NOx, CO, and radicals of hydroxyl from trials. BRT outperformed ANNs in all statistical measures under identical operational settings. The present study employs ensemble learning algorithms to forecast the CO2 emission characteristics of spark ignition engines as per the outcome of the survey of the literature. Ensemble learning techniques, such as Ensemble DT Bag and Ensemble LS Boost, were utilised for making predictions of CO2. The former employs a bagging approach, while the latter utilises a boosting technique.

The process of hyperparameter tuning was undertaken to determine the optimal parameters for constructing a highly accurate CO2 prediction model. The implementation of cross-validation was conducted in order to mitigate the possibility of overfitting the model, which has the potential to yield imprecise forecasts when applied to the test dataset. A comparative analysis was conducted among the algorithms, utilising R2 value, RMSE, MAE, and MSE as the metrics for evaluating performance.

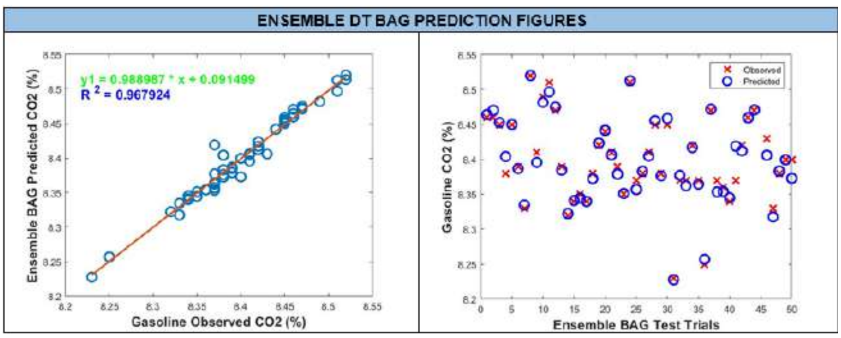
2. MACHINE LEARNING METHODS

Ensemble DT Bagging: Ensemble learning is a popular machine learning method that trains numerous models and integrates their predictions to improve model accuracy and robustness. Bagging is a specialised ensemble technique that trains many models on different parts of the training data and then averages their regression predictions. Random sampling replaces training datasets in bagging. Bagged decision tree models incorporate the results of many decision trees to avoid overfitting and improve efficiency. Ensemble learning bagging was implemented for CO2 prediction as follows. Neat gasoline datasets were split into training and testing datasets. The predictors to sample were BSFC, Pmax and HRRmax. The testing dataset was used to evaluate the optimised ensemble bagging model, whereas the training dataset was used for training. The hyperparameters were adjusted using k-fold cross-validation with a k factor of 5. Each ensemble model was trained using the decision tree as the basic learning technique. The model was iteratively trained with the basic learning method using a random subset of training data for each model in the ensemble. The average of the predictions was utilized to do engine regression analysis. Bagging ensemble model efficiency was tested using the testing set.

Ensemble LS Boosting: Boosting, a supervised learning ensemble technique sequentially trains models to fix the previous model's mistakes. The final model is a weighted combination of all models. The Least Squares Boosting ensemble method uses a small number of weak learners and a meta-learner to weigh and sum their predictions. Voting improves regression prediction in this method. The approach sequentially trains weak learners as decision trees and fits the residual of the errors to improve performance. Ensemble LS Boost uses least squares for loss. Training and test sets were created from neat gasoline datasets. The training set trained ensemble models and the testing set tested the final model. The predictors to sample were BSFC, Pmax and HRRmax. Each round of boosting used the training data to build a new model. In each boosting round, the training data was used to construct a new model, with the increased weight assigned to instances that were incorrectly predicted by the previous model. The training data's performance determined the current model's weight. Blending the models included averaging their projections. The validation used k-fold cross-validation with a k factor of 5. The boosted ensemble model was evaluated on the test data set.

3. RESULTS AND DISCUSSION

Ensemble DT-Bagging-Based Model for CO2 Prediction: Ensemble DT Bagging was used to predict the characteristics of a gasoline-powered SI engine. Fig 1. depicts the predicted engine CO2 emissions and 3 also compares the model-predicted and actual values for all test data points for gasoline. Predicted and observed values were in good agreement. The Ensemble method enables a quick understanding of parameters like specific fuel consumption, Peak In-cylinder Pressure, and Peak Heat Release. It provides insights into their respective positive and negative impacts at maximum load, which substantially influence CO2 emissions. According to Table 3, for the Ensemble DT bag model, the gasoline test fuel had an R2 value of 0.9679 for CO2. The Ensemble DT Bag model's precision can be seen by its R2 value approaching unity. The model reasonably predicted the values. Table 3 displays various error coefficients, such as CO2's RMSE of 0.0102, which had a strong correlation with reduced RMSE values.



. Fig.1. Ensemble DT Bag Model Prediction Vs Observed for CO2 Gasoline.

Ensemble LS-Boosting-Based Model for CO2 Prediction: Fig. 2 depicts a comparison between experimentally observed CO2 vs predicted Ensemble LS Boost CO2 values and also the estimated and observed values for all test data points, demonstrating a strong correlation. The outcome of analysing the relationship between CO2 using the Ensemble LS Boost algorithm is depicted in Table 3, i.e., the R2 value for CO2 was 0.9727 for the prediction of gasoline. The Ensemble LS Boost method yielded results with an R2 coefficient of determination for CO2 engine emission parameters that was extremely close to 1

Comparative Analysis of Machine Learning Models for Predicting CO2 Emissions in Gasoline Engines: The two models Ensemble DT Bagging and Ensemble LS Boosting were analysed and compared. Figures 1 and 2 depict the values of the coefficient of determination (R2) and the predicted results for each model. The R2 values and numerous statistical error indicators, including RMSE, MSE, and MAE, suggest that Ensemble LS Boosting demonstrated slightly superior performance and generalisation compared to Ensemble DT Bagging. The Ensemble LS Boosting R2 value for the CO2 emissions parameter was 0.9727. Table 3. demonstrate that the Ensemble LS Boosting model outperformed the other models in terms of statistical error metrics. For CO2 emissions, the model's root-mean-squared error (RMSE) was 0.0085. Upon comparing the two models, Ensemble DT Bagging and Ensemble LS Boosting, it can be concluded that although both models yield similar results in terms of the coefficient of determination and display notable effectiveness based on the statistical error, the Ensemble LS Boosting model stands out as the more robust and superior option, outperforming the Ensemble DT Bagging model developed in this study.

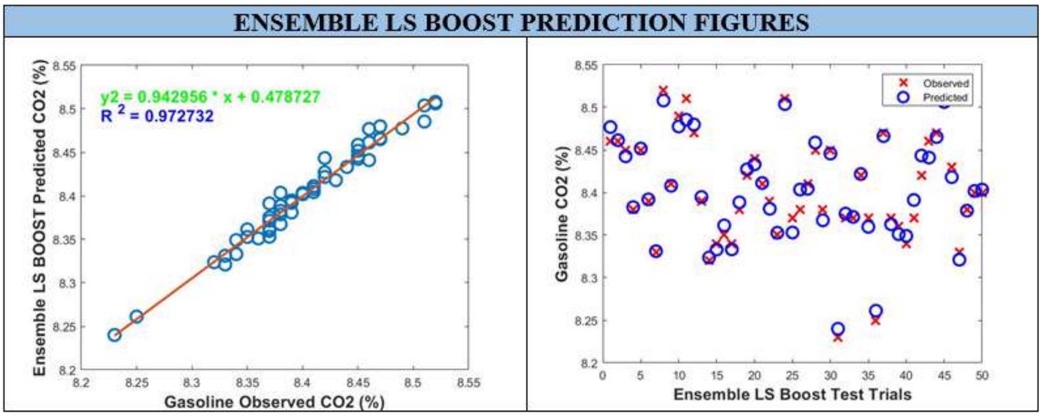


Fig. 2 Comparison between experimentally observed CO2 vs predicted Ensemble LS Boost CO2 values

4. CONCLUSIONS

To conclude, the assessment of Ensemble DT Bagging and Ensemble LS Boosting models in predicting CO2 emissions from gasoline engines indicates that both models yield similar almost outcomes in relation to the coefficient of determination and exhibit substantial efficacy, taking into account the statistical error. The study has established the Ensemble LS Boosting model as the preferred model due to its superior robustness and performance. The results indicate that the utilisation of Ensemble LS Boosting exhibits the potential for enhanced precision and dependability in predicting CO2 emissions. This is of utmost importance in tackling environmental issues associated with vehicular emissions. Subsequent investigations could potentially endeavour to more precisely refine this model or investigate alternative machine learning methodologies in order to augment prognostic precision and efficacy.

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SUSTAINABILITY: TECHNOLOGICAL DEVELOPMENT, GROWTH AND ENVIRONMENTAL POLLUTION

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ABSTRACT
The relationship between technological development, growth, and pollution is analyzed using optimal control theory and the phase diagrammatic analysis of the necessary conditions. The results of the analysis show that consumption is the main reason for environmental degradation. Technology on the other hand is only an input to the production process and does not cause pollution. It can improve efficiency in production to enable higher consumption level with lower rate of extraction of natural resources. Emphasis on policies concerning environmental degradation should be on reducing consumption and the keeping the population of the World at a reasonable rate.
Keywords: Technological Development, Growth, Pollution

1.INTRODUCTION
All countries try to grow to increase the wellbeing of their population and reduce unemployment. However, the almost insatiable desire for growth (more consumption) and the increasing population are already straining the resources of the world including energy, clean air, and water. Climate change and related catastrophic events are almost everyday occurrences. The world's population has increased from 3 billion to 6.9 billion between 1960 and 2012 (World Bank, 2012) and it is expected to reach over 9 billion by 2050 (Meadows, 2004, p28).
Consumption of five important metals is increasing at an accelerating rate (Meadows, 2004, p101). Consumption of steel exhibits the same behavior (Meadows, 2004, p101). Estimates of life expectancy of identified reserves of major metals are presented in Meadows (2004, p105). They range from 20 years for zinc to 81 years for aluminum.
The problem of climate change, now visible to residents of the earth, is summed up by 6 Nobel laureates (Meadows, 2004, p115-117) as "the balance of evidence suggests a discernible human influence on global climate. As economists, we believe that global climate change carries with it significant environmental, economic, social, and geopolitical risks, and that preventive steps are justified". Meadows et al. (2004, p115) showed that carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons emissions have increased very sharply in the past few decades. Rising temperature of the earth and the economic losses from weather related disasters are shown to be drastic in Meadows (2004, p116-117).
Fresh water problem is already an important problem. A UN Report (1997) states "…current pathways for freshwater use are often not sustainable… water degradation is weakening one of the resource bases on which human society is built". Forests, lungs of the earth, are like water, is already a problem also especially in the light of air pollution problem. World Commission on Forests and Sustainable Development in their report (1999) concludes that "…a trend toward a massive loss of forested areas… and all is threatened".

Decrease in the amount of cultivable land, clean air (air pollution), extinction of some members of fauna and flora are other important losses that human consumption is causing.
All these problems on which some data are provided clearly raise the question of sustainability of the current economic system based on increasing consumption.
Akan (2006) showed that the sustainability (defined as the existence and the stability of an equilibrium point) of the current economic system was only possible if the population remained constant and or technology advanced at a rapid rate. However, pollution was omitted in his study.

In this paper pollution (a generalized word representing degradation of all useful resources) is added as a factor which effects utility negatively where pollution is assumed to be a cumulative variable (state variable) which increase as a function of consumption but has a natural rate of cleansing.

2.DYNAMIC MODELLING
The objective of society is to maximize the sum of its discounted utility over an infinite horizon where the utility of consuming an amount $c(t)$ at time t is represented by $u(c(t))$. The discount factor is represented by $e^{-\rho t}$ where the letter ρ is the social discount factor.

The productive base is split into two because of the differences in their dynamics. The natural resource base R(t) decreases by the extraction rate z(t), increases by the new discoveries of reserves and renewable sources made possible by technology base, T(t).
Mathematically (skipping the variable t in the related variables):

$$R' = -z + \eta T^{\mu} \qquad (1)$$

$$R(0) = R_0$$

which denotes the starting reserve level of natural resources. The parameters μ and η represent the positive impact of technology on natural resource base. The Labor, as the other resource base, behaves differently than natural resource base. It is assumed to increase at a constant exponential rate g. i.e.:

$$L(t) = L(0)e^{gt} \qquad (2)$$

The manufactured capital is a product of technology, natural resources, and labor i.e., an intermediary product where:

K(t) = f(T(t),z(t),L(t)) (3)

The production function of the society which can be generally written as a function of manufactured capital K, labor L, resource extraction z and the technology base T as:

Y = F(K(t),L(t),z(t),T(t)) (4)

which can be rewritten as:

Y = F(T(t),z(t),L(t)) (5)

Given the above definitions and dynamics of natural resources and labor, the other most important productive base component is technology. The dynamics related to technology is given as:

$$T' = T^{\alpha} z^{\gamma} L^{\beta} - L_0 c e^{gt} - kT = T^{\alpha} z^{\gamma} (L_0 e^{gt})^{\beta} - L_0 c e^{gt} - kT \qquad 6)$$

$T(0) = T_0$ which denotes the level of technology at t=0. Notice here that technology is a general word which represents all knowledge and expertise employed in production and not just the new technology. The first term on the right hand side of this equality shows the total production of the society as a combination labor, technology, and natural resources (a Cobb Douglas type of production function is assumed).The total production is allocated to consumption (the second term on the right hand side of the equation) and improving the level of technology as a productive base (T'), and technological obsolescence represented by K(t) term where k represents the exponential rate of obsolescence rate of technology. The dynamics of pollution is represented by the following first order differential equation:

P'=dP/dt= G(c)-bP (7)

where the first term on the right of Eq. (7) represents an increase in pollution as a function of consumption whereas the last term represents the natural cleansing of pollution where: G (0) =0

G'>0, G'>=0, c>0. For ease of calculation, we will assume that:
G(C)=eC where e>0.

Then, the model in an optimal control theoretic format is:

$$Max \int_0^{\infty} e^{-\rho t} e^{gt} L_0 \, u(c,P) dt \qquad (8)$$

Subject to constraints in Eq. (1) -(7). Where the concave utility function is assumed to have the functional form of: $u(c,P)$ where:

$$U_c > 0, U_{cc} < 0, c > 0$$
$$U_P < 0, U_{PP} < 0, P > 0$$
$$U_{cc}U_{PP} - U^2{}_{cP} \geq 0 \quad (9)$$

Assuming population remains constant the Current Value Hamiltonian (viewing ρ as a discount factor) of the system is: $H = u(c,P) + m_1(-z + \eta T^{\mu}) + m_2(T^{\alpha} z^{\gamma} - c - kT) + m_3(G(C) - bP)$ (10)

However, one control and three state variables are very hard to solve.

3.RESULTS AND DISCUSSION

We will attempt to solve the problem in two stages. In the first stage, we will assume that the utility curve is additive, and the objective is to maximize present value of utility over and infinite horizon subject to the constraint which will us the optimal consumption path and the pollution path in Eq. (7). In the second stage we will find the optimal technological path to produce the goods and services to support the optimal consumption.

In the first stage the problem posed by Kamien and Schwartz (1981, p172) as:

$$Max \int_0^T e^{-rt}(U(C) + M(P)dt$$
$$P' = G(C) - bP,$$
$$P(0) = P_0$$
$$0 \leq$$
$$C \leq \bar{C}$$

The hamiltonian for this problem is:

$$H = U(C) + M(P) + m(G(C) - bP)$$

The necessary conditions are:

$$H_C = U'(c) + M'(P) + m(G'(C) - bP)$$
$$m' = m(b + r) - mM'(P)$$

The analysis of these conditions by phase diagrammatic methodology of these shows that there is an equilibrium (Cs, Ps) and it is stable.

If P0<Ps optimal solution is that the pollution increases toward the equilibrium level while the consumption decreases. Otherwise, the reverse occurs. It is not possible to solve this equation since the exact form of some functions used in the model are not known. Theoretically, the solution would give the optimal consumption time path and the optimal pollution path.

C*(t)=F(t, and parameters of the system) and P*=N(t, parameters of the system).These equations are used in the second stage of the problem:

The problem in second stage is finding the optimal technology path given the optimal level of consumption assuming that the inputs to the production to support that consumption are technology(T), Labor(constant), and natural resources(z) since the capital(K) commonly used n functions are themselves produced by labor, natural resources, and technology and hence they are not included in the production function. Then the problem is maximizing the total production over a finite time to satisfy the required demand with technology and natural resources given that they are limited.

$$Max \int_0^T F(T,z)\,dt$$
$$T' = F(T,z) - C*(t) - kT, T(0) = \bar{T}$$
$$R' = -z$$
$$R(0) = \bar{R}, \mathrm{R}(T)=\underline{\mathrm{R}}$$

The Hamiltonian for this problem is:

$$H = F(T,z) + \lambda_1(F(T,z) - C* - kT) - \lambda_2 z$$

$$Hz = F_z(T,z) + \lambda_1 F_z(T,z) - \lambda_2 = 0$$

$$\lambda_1{}' = \lambda_1(k) - F_T(T,z) - \lambda_1 F_T(T,z)$$

$\lambda_2{}' = 0$ implying λ_2=Z is a constant

With

$$R' = -z$$

$$T' = F(T,z) - C(t) * -kT$$

And relevant end point conditions. Differentiating Eq. (13) totally with respect to time and using equations (13-15) in resulting equation we get:

z'=Y(T,z) =
$$z' = (((B - F_z)k - BF_T) - BF_{zT}(F(T,z) - C^* - kT)/F_z)F_z/BF_{zz}$$

Then equations (17) and (18) form a system of nonlinear nonhomogeneous differential equations in (T, z) space to characterize the solution for optimal z and T. Analysis of the phase diagram represented by this system shows that natural resource should be used heavily at early stages to produce suitable quantity of goods to support the consumption, and increase investment in technology, gradually reducing it at later stages.

The interrelationship between pollution (environmental degradation), consumption, technology (productive knowledge), and natural resource use is studied. In the first stage we showed that if P. (current level of pollution) <Ps(equilibrium level of pollution) optimal solution is that the pollution increase toward the equilibrium level while the consumption decreases. Otherwise, the reverse occurs. We then use this optimal path of consumption and the pollution paths to determine the optimal technology path. In that case the results are that Natural resource should be used heavily at early stages to produce suitable quantity of goods to support the consumption, and increase investment in technology, gradually reducing it at later stages to keep the pollution level defined in stage 1.

4. CONCLUSION

Consumption is the main reason for environmental degradation. Technology on the other hand is an input to the production process and does not cause pollution. It can improve efficiency in production to enable higher consumption level. Therefore, the real effort should be concentrated on controlling consumption levels, to increase technology not to increase consumption but to reduce the use level of natural resources supporting production. Technology. It also should be advanced to increase the level of reserves of natural resources. Encouraging consumption is the real reason that exerts negative pressure on environmental degradation.

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RETROFIT SCENARIOS FOR OVERHEATING PROBLEM OF A STUDIO-TYPE HOUSING IN THE MEDITERRANEAN CLIMATE

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ABSTRACT
Thermal comfort is an essential design factor for an individual's peace and productivity. The housing sector is responsible for a large part of the energy consumption worldwide due to active heating and cooling demands for better thermal comfort conditions. High cooling loads and CO2 release, and thermal discomfort are observed due to overheating, especially in regions where humid and hot weather conditions prevail, such as the Mediterranean climate. High energy demand and increasing carbon emissions cause environmental problems such as global warming and climate change. While modern housing cannot adequately meet thermal comfort standards, with the increase in temperatures due to climate change and global warming in the coming years, thermal discomfort, energy consumption, and carbon emissions will become a bigger problem. This study aims to investigate the effect of retrofit scenarios on thermal comfort, cooling load, and carbon emissions by considering a studio-type housing built in 2019, located in the province of Izmir within the Mediterranean climatic zone. In three different scenarios, the shading element, the thermal transmittance coefficient of the glass, and the ratio of the glass facade are considered variables. It has been determined that the annual cooling load, annual carbon emissions, and comfort dissatisfaction rates in summer months due to overheating have decreased for all three scenarios compared to the current situation. The scenario with the highest effect on thermal comfort, carbon emissions, and cooling load is the scenario using the shading element.
Keywords: overheating, thermal comfort, cooling load, retrofit scenarios, carbon emissions

1. INTRODUCTION
Buildings cause around 39% of global carbon emissions, meaning that they play a key role in reducing carbon emissions (Adams et al., 2019). Especially the housing sector causes 17% of the total carbon emissions worldwide (Nejat et al., 2015). An average annual increase of 2% has been observed in this rate in the last 20 years, and it is estimated that this rate will increase further in the coming years with the increasing population, urbanization, and housing production (Chen et al., 2017). According to the International Energy Agency, the housing sector causes approximately 25% of energy consumption worldwide (Delmastro et al., 2021). A large part of this energy consumption consists of the ever-increasing demand for heating and cooling to attain thermally better conditions (Wan et al., 2011). Due to the worldwide pandemic especially in the last two years, education and work being carried out remotely, preference to provide needs and various activities remotely, has caused people to spend more time in the home environment. Spending energy to keep thermal comfort neutral in residential buildings has become even more essential. While modern housing cannot adequately meet thermal comfort standards, thermal discomfort, and energy consumption will become a bigger problem with the increase in temperatures due to climate change and global warming in coming years. Consequently, retrofit scenarios should be planned for residential buildings. In the literature, there are limited studies dealing with thermal comfort, cooling load, carbon emissions, and overheating problems of modern housing. This study will contribute to the literature by concerning studio-type housing with a high glass-facade ratio, exemplifying a current modern housing type in the Mediterranean climate. It is of great importance to this study within the framework of evaluating and improving thermal comfort and reducing cooling load and carbon emissions in modern housing, especially after the corona pandemic, with the increase in time spent at home. The following research questions are formed due to these shortcomings identified in the literature review:
- How does overheating affect thermal comfort, cooling load, and carbon emissions in modern housing?
- What is the effect of using shading element on the south facade for thermal comfort levels, cooling load, and carbon emissions?
- How does the improvement of double clear glass, which is often used in large facades of modern housing, affect thermal comfort, cooling load, and carbon emissions?
- How much would change in the glass-to-facade ratio on the south facade to improve thermal comfort and reduce cooling load and carbon emissions?

In line with the research questions, this study aims to investigate the effect of retrofit scenarios on thermal comfort, cooling load, and carbon emissions by considering a studio-type housing built in 2019, located in the province of Izmir within the Mediterranean climatic zone. The 2+1 studio-type flat located on the fourth floor of the apartment block is approximately 45 m². The facade of the flat, which has a single facade, deviates 34 degrees from south to east. The case room is 11.5 m².

2. MATERIAL AND METHODS

In the study, the shading element, thermal conductivity coefficient of glass, and glass-to-facade ratio are considered variables. The effect of these variables on thermal comfort, cooling load, and carbon emissions are evaluated with simulation results obtained from the model created on the dynamic building energy performance software, DesignBuilder v7.0 (DesignBuilder, 2023). Firstly, dataloggers were placed to analyze the existing situation. Temperature and relative humidity values were recorded every ten minutes with indoor and outdoor dataloggers between April 1st, at 01:00, and April 30th, 2022, at 01:00. The heating and cooling systems are passive during the monitoring period. The case room where the indoor datalogger locates is closed during the thirty-day monitoring period; the door of the room has never been used, and there is no device that can provide heat gain in the room. Hourly weather data is prepared with the data obtained. The simulation model is created by entering the size and material information of the building to be examined. The model is calibrated according to hourly monitored indoor temperature, guided by the ASHRAE Guideline-14 (2014). Three scenarios are examined to improve thermal comfort conditions and reduce cooling load and carbon emissions. In the first scenario, a situation with an outer louver on the 2.0x2.3m window on the south facade of the case room is targeted. The material of louver blades is selected as steel, with a thickness of 0.002m. There are four blades whose depth is 0.2m, and there is a distance of 0.30m between each blade. The angle of the blades is 15°. In the second scenario, it is planned to decrease the glass-facade ratio on the facade of the case room from 60% to 40%. The existing glass two meters wide and 2.30 meters high is reduced by ninety centimeters from the ground to form a glass two meters wide and 1.40 meters height. Thus the glass ratio on the south facade is decreased to 40%. In the third scenario, the heat transmittance coefficient of glass on the south facade of the case room is changed. While the U value and total solar transmission were 2.816 W/m²K and 0.763 respectively, in the base condition (clear double glass), it became 1.628 W/m²K and 0.421 in the scenario-2 condition (low-e double glass). All scenarios are implemented just for the case room.

3. RESULTS AND DISCUSSION

Findings from the monitoring period indicate that outside temperature varies between 5.85°C and 28.6°C, and inside temperature between 22.30°C and 30.99°C. Outdoor relative humidity values vary between 23.0% and 100.0%, and indoor relative humidity values are between 24.5% and 49.5%. The model is accepted as calibrated according to the limits of two statistical error indices defined by ASHRAE Guideline-14: the root mean squared error (RMSE) is calculated as 7.29%, while the mean bias error (MBE) is reduced to 1.83%. The simulation output is taken through DesignBuilder for the base case. Two thermal comfort indices, hourly PMV (predicted mean vote), and PPD (dissatisfaction rate) values are generated for one year. PMV values are analyzed as the percentages under three categories: values defined below -1 are cool or cold; above +1 are hot or warm; between -1 and +1 are slightly cool, neutral, or slightly warm. For the base case, hourly PMV values for the whole year between -1 and +1 constitute 32.82%, values defined as warm or hot are 47.88%, and 19.3% are defined as cool or cold. Very high PPD and cooling loads occur due to overheating especially in summer and spring. The total cooling load and carbon emissions of the case room for one year are 70.71 kWh/m² and 48 $kgCO_2e/m^2$, respectively. For the first scenario, which predicts that a steel louver is attached to the outside of the window on the south facade of the case room, the percentage of hours defined as warm and hot decreases by 10.48% compared to the base case. In the base case, the months with the highest PPD are July and August. In the first scenario, even if the internal temperature values in the summer months decrease, the decrease in PPD values is very minor. The total cooling load of the case room for one year is 43 kWh/m², with a decrease of 39.22% compared to the base case, while carbon emissions are 32.75 $kgCO_2e/m^2$ with a decrease of 31.76%. In the second scenario, the reduction in the ratio of glass on the south facade from 60% to 40% resulted in an increase in the hours that felt cool and cold slightly. The total cooling load and carbon emissions for one year are 49.62 kWh/m² and 36.21 $kgCO_2e/m^2$, with a decrease of 29.82% and 24.56%, respectively. The third scenario, it is aimed to minimize the solar gain due to the direct sunlight coming from window during the year by improving the U value of glass and total solar transmission rate. This situation decreases the ratio of warm and hot hours. The total cooling load for one year is 48.62 kWh/m², a decrease of 31.24% compared to the base case. The carbon emissions of the case room for one year is 35.29 $kgCO_2em^2$. When the PPD values for the base case and scenario conditions are compared, it is observed that while a decrease is observed especially in May, September, and October, there is an increase in the winter months. Even if the PPD values for summer months decrease by a small margin, it is seen that the percentage of dissatisfaction is still high in scenario situations. In Table 1, cooling load and carbon emissions for the base case and scenario conditions, and the percentage of decrease of these values compared to the base case are given. Table 2 and Table 3 indicate the distribution of PMV and PPD percentages for the current situation and scenarios.

Table 1. Comparison of base case and scenario results with cooling load and carbon emissions

	Base Case	Scenario-1	Scenario-2	Scenario-3
Cooling load (kWh/m²)	70.72	42.98	49.63	48.62
%		-39.22%	-29.82%	-31.24%
Carbon emissions (kgCO₂e/m²)	48.00	32.75	36.21	35.29
%		-31.76%	-24.56%	-26.47%

Table 2. Comparison of PMV percentages for the base case and scenarios

	Base Case	Scenario-1	Scenario-2	Scenario-3
Warm, hot	47.88%	37.40%	40.17%	40.37%
Slightly warm, neutral, slightly cool	32.82%	32.43%	32.36%	32.72%
Cool, cold	19.30%	30.17%	27.47%	26.92%

Table 3. Comparison of PPD for the base case and scenarios

	Base Case	Scenario-1	Scenario-2	Scenario-3
January	77.73%	85.34%	85.09%	84.64%
February	34.59%	48.74%	45.86%	45.43%
March	40.77%	68.41%	59.97%	58.84%
April	26.90%	31.26%	25.06%	24.30%
May	51.56%	29.66%	33.78%	34.16%
June	99.80%	94.11%	98.24%	98.36%
July	99.99%	99.73%	99.97%	99.97%
August	99.99%	99.91%	99.99%	99.99%
September	92.96%	73.50%	83.03%	83.53%
October	42.87%	19.70%	26.07%	26.40%
November	16.77%	19.59%	17.22%	16.78%
December	21.84%	33.20%	30.41%	29.53%

4. CONCLUSIONS

This study investigated the effect of some retrofit scenarios on thermal comfort, carbon emissions, and cooling load in a studio-type house in the Mediterranean climatic zone with the help of calibrated simulation model based on monitored data obtained for thirty days in 2022. Conducting a long-term follow-up for a year including summer, winter, spring, and autumn terms will provide more accurate results. Three scenarios, designed in line with the shading element applied on the opening on the south facade, changing the glass-facade ratio of the case room, and changing the U value of the window glass, provided the reduction in the cooling loads and carbon emissions compared to the base case. PMV results show a decrease in warm and hot hours, with an increase in cool and cold hours. PPD values are still not acceptable in summer in all three scenarios, but it is observed that there is a decrease in indoor temperatures. It is indicated that the most influential scenario to improve thermal comfort and reduce carbon emissions and cooling load is the first scenario where a shading element is used. The scenario with the least effect is the second scenario where the glass-to-facade ratio is changed.

It can be summarized that retrofit scenarios for south-facing studio-type flat yielded positive results against overheating. In practice, it is seen that the 1+0, 1+1, and 2+1 flat types are designed without considering the directions. The openings of flats of the same type are designed similarly in all directions, resulting in increased thermal discomfort. This early-design approach can be improved with solutions defined specifically for each direction, such as retrofit scenarios examined in this study.

NOMENCLATURE

CO2e Carbon dioxide equivalent
MBE Mean bias error
PMV Predicted mean vote
PPD Percentage of dissatisfied people
RMSE Root mean squared error

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Environmental Effects of Pretreatment Processes Applied to Cotton Fabrics

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ABSTRACT
Cotton is the most important raw material of the textile industry. The production processes of cotton fiber with high production volumes and the environmental side effects consumed during production are factors that cannot be ignored. The pre-treatment processes applied to cotton textile surfaces are examined under five main headings: desizing, singeing, alkaline process, bleaching and mercerization. These processes are extractive processes that cause weight loss in the product by preparing the textile product for subsequent processes in the finishing process. During the pre-treatment processes of cotton textile products, high energy, water and chemical consumption occurs. High pH, salt and toxicity occur in the wastes generated due to the chemicals used as a result of the pretreatment processes. In addition, many environmental damage is caused due to air pollution due to high energy consumption (Benli & Bahtiyari, 2015).
In this literature study, the pre-treatment processes of cotton products were examined and the harms of these processes to the environment were mentioned. At the same time, more environmentally friendly pretreatment processes were mentioned.
Keywords: Environment, Bleaching, Mercerization, Chemicals

1. INTRODUCTION
With the increasing awareness in the world about protecting the environment, traditional pretreatment methods that require high costs for textile products and cause serious environmental pollution cannot meet the green and sustainable development requirements in the textile industry. Therefore, in order to overcome these disadvantages, it is of great importance to apply environmentally friendly innovative processes instead of conventional pretreatment processes.
Cotton fiber is one of the most typical and ancient natural fibers, which provides the final products with numerous advantages such as comfortable wearing feeling, stable thermal insulation, satisfactory moisture retention and good washability. Various garments made of cotton are widely preferred by people and therefore annual cotton production always remains in the leading position among all natural fibers (Zheng, et al., 2021). However, cotton as a typical natural fiber, apart from cellulose; contains 4-10% natural impurities such as cottonseed hulls, pectin, waxy substances, ashes, nitrogen-containing substances, lignins, natural oils (Abdel-Halim, 2012a; Abdel-Halim, 2012b; El Shafie et al., 2009). Also, the yellowish or brown color of cotton fiber is related to protoplasmic residues of protein and flavone pigments of cotton flowers (Abdel-Halim, 2012b).
A series of processes that are made to make the fabric ready for dyeing and printing processes from its raw state are called pre-treatment processes. With these processes, the surface roughness of textile products is removed, the sizing agent given during weaving is removed, the impurities on the cotton are removed, better adhesion of the dye or printing pattern to the fabric and more vivid colors are obtained. Pre-treatment process in textiles also ensures the fabric's size remains constant, so there is no issue of size change after washing or use.
Water, air, and soil pollution occurs due to pretreatment processes. Therefore, many alternative options are being developed to reduce the environmental impact in pretreatment processes. One of these options is the reuse of wastewater. It is possible to reduce environmental impacts by recycling and reusing the wastewater generated in pretreatment stages or by optimal use of process chemicals before discharging the used wastewater. Thus, an economic solution can be produced that reduces the need for fresh water intake and provides energy savings in pretreatment processes (Harane & Adivarekar, 2017). In this review study, the environmental impacts of the chemicals used in the pretreatment processes of cotton, the effects of dry processes such as burning on the environment, and the environmental impacts of other pretreatment processes have been discussed, and solutions have been examined.

2. THE ENVIRONMENTAL IMPACT OF SINGEING PROCESS

The process of singeing is the removal of the fiber fuzz on the surface of woven or knitted fabric by burning. The main purpose of this process is to provide a smoother and more shiny appearance on the surface of the fabric. It is also done to prevent one color from contaminating another in the transition between patterns during printing.

During the singeing process, carbon dioxide and other greenhouse gases released can have atmospheric effects. Singeing, especially when done through traditional methods, can have significant environmental impacts. However, with modern technologies, it is possible to minimize these effects. For example, closed-loop singeing processes, gas recycling, and filtration systems can be used to minimize environmental impacts. Minimizing harmful substances within the exhaust gas released into the atmosphere depends on the type of fuel and burning method. Therefore, careful monitoring of the exhaust gas waste and necessary improvements must be made (Güngör et al., 2009).

Enzymes are large biological molecules responsible for thousands of metabolic processes that sustain life. Removing the fuzz on fabric using enzymes is a more environmentally friendly method compared to burning. The type of enzyme used for this process is cellulose (Roy Choudhury, 2014). It has been observed in studies that enzymes are used to remove the fuzz on the fabric surface (Aly et al., 2004; Eyüpoğlu & Merdan, 2020). Therefore, it is considered more environmentally friendly to use enzymes instead of the burning process for removing lint from the fabric surface.

3. THE ENVIRONMENTAL IMPACT OF DESIZING PROCESS

Sizing is the process of applying chemicals to yarns in order to increase their slipperiness and strength, thus preventing breakage during weaving in cotton woven fabrics. This process is carried out by applying chemicals such as polyvinyl alcohol, carboxymethyl cellulose, starch, and polycyclic acids (Madhav et al., 2018; Davulcu, 2008). Starch and its derivatives make up approximately 75% of the sizing agents used in the textile industry (Opwis et al., 1999). The process of removing these sizing agents applied to warp yarns from the fabric during pre-treatment is called desizing. The desizing process contributes to approximately 50% of the total wastewater volume with a high biological oxygen demand (BOD). Additionally, sizing agents used in textile mills lead to high chemical oxygen demand (COD) consumption in wastewater ranging from 30-70% when removed through desizing (Davulcu, 2008).

In the starching of cotton, the amount of starch absorbed by the warp yarns is generally higher compared to other natural or synthetic sizing materials (Davulcu, 2008). Starch is broken down aerobically (consuming oxygen) by enzymes and bacteria. Therefore, it is desirable for wastewater to be biologically degraded before being discharged into channels or seas. Although this may seem disadvantageous for starch at first glance, it is advantageous compared to synthetic desizing agents that do not easily degrade biologically. The application of enzymes that degrade starch to simple ethanol instead of complex anhydroglucose can solve this problem. An oxidative desizing process such as hydrogen peroxide (H2O2) can also be used to complete the dissolution of starch into carbon dioxide (CO2) and water (H2O) (Madhav et al., 2018). Enzymatic methods are also advantageous in terms of ecology and economy. Enzymes can be used in catalytic amounts and under physiological conditions, i.e., at ambient temperatures, resulting in low energy consumption (Opwis et al., 1999).

4. ENVIRONMENTAL IMPACTS OF SCOURING PROCESSES

Scouring is the process of removing natural substances such as oil, wax, pectin, and hemicellulose from cotton. If this process is carried out with the help of an alkali, the fatty acids in the cotton combine with the alkali to form compounds in the structure of soap, allowing the waxes to dissolve in the solution as an emulsion. Sodium hydroxide (NaOH) is mainly used in the hydrophilization process (Chung et al., 2004). Waste sodium hydroxide can increase the concentration of hydroxyl ions in the aqueous medium, leading to high pH levels that can be toxic to aquatic organisms. Additionally, waste sodium hydroxide can increase the solubility of metal ions in the aqueous medium, causing toxic metal ions to be released into the water. If sodium hydroxide is released into the soil, it can cause neutralization reactions and prevent plant growth in acidic ecosystems. Therefore, waste sodium hydroxide can cause significant environmental damage in aquatic and soil environments.

Today, hydrophilization can be achieved with various enzymes at lower temperatures. The use of enzymes has significantly increased nowadays with the aim of reducing quality losses, decreasing the amount of chemicals used, and developing an environmentally friendly alternative method. Pectinase enzyme is the main enzyme used in this process, while protease, cellulase, and lipase enzymes are also used (Özgen, 2018; Şahinbaşkan, 2010). Pectinase enzymes are used to hydrophilize cotton products before bleaching, to enzymatically soften plant fibers such as flax, hemp, ramie, and jute, and to remove pectin in cotton structures. In recent years, the use of pectinase enzyme to hydrophilize cotton by removing pectin has increased (Sancar et al., 2012; Stanescu et al., 2010).

5. ENVIRONMENTAL IMPACTS OF BLEACHING PROCESSES

The bleaching process aims to degrade and decolorize the natural color of cotton fibers by using oxidizing agents such as sodium hypochlorite, sodium perborate, sodium chlorite, or hydrogen peroxide (Kılık, 2014; Tamtürk, 2007).
Hydrogen peroxide is preferred in textile wet processing due to its oxidizing properties and environmental friendliness. Stabilizers, which are made up of organic compounds, are used to reduce self-decomposition of hydrogen peroxide during the bleaching process and stabilize the textile material (Şahinbaşkan, 2010).
A study was conducted in which swelling was performed on cotton raw materials with an environmentally friendly ethanol-water mixture without scouring and bleaching. Then, dyeing was carried out without the addition of salt using the ethanol-water mixture. The results showed that the applied method had higher dye uptake and more color fastness compared to the conventional method. Furthermore, it has been concluded that the ethanol-water mixture used for the swelling process can be reused up to 5 times. This study has provided energy and chemical waste savings by eliminating hydrophilization and bleaching processes. Additionally, it has been observed that the use of salt during the dyeing process has been eliminated, reducing the waste burden (Xia et al., 2021).
In the whitening of cotton fabrics, ozone bleaching, which is a more environmentally friendly method that does not contain harmful chemicals, requires very little water and provides bleaching at room temperature in a very short time without requiring any heating or cooling energy, can be used instead of conventional bleaching chemicals (Perincek, 2007). Another environmentally friendly method is bleaching with ultrasound. This method offers shorter reaction cycles, cheaper reactants, less detailed physical conditions, and is a cheaper method (Vajnhandl & Majcen Le Marechal, 2005; Mistik & Yükseloğlu, 2005).

6. ENVIRONMENTAL IMPACTS OF MERCERIZATION PROCESS

The mercerization process, which was discovered by a British chemist named John Mercer in 1844, gives a silky texture to the fabric. This process is based on the treatment of cotton fabrics or threads with a concentrated solution of sodium hydroxide (NaOH). After the mercerization process, cotton fabrics have improved properties such as increased brightness, dyeability, absorbency, and strength (Bayar, 2015).
Most of the caustic used in mercerization processes is disposed of as waste. This results in increased chemical consumption, costs, the chemical load carried by wastewater, and treatment costs in textile facilities (Tanaçan, 2015). The waste solution generated during the mercerization process is highly alkaline, and its recovery by evaporation technique is among the recommended environmentally friendly techniques for the textile industry (Bayar, 2015).

7. CONCLUSIONS

Cotton fiber is a raw material that has been and still is the cornerstone of the textile industry, both in the past and present. Approximately 800,000 tons of cotton fiber are produced annually in Turkey, and cotton fiber constitutes about 35% of the country's exports (Cevheri & Şahin, 2020). In this study, the definition of pre-treatment processes (singeing, desizing, scouring, bleaching and mercerization) applied to cotton fabrics, their harmful effects on the environment, and the processes followed to reduce these effects were examined through a literature review method.
As a result of the literature research, it is suggested to use enzymes to remove fiber fuzz and remove the sizing agents from the fabric instead of conventional methods to reduce the environmental impact of singeing and desizing processes. Sodium hydroxide is the most commonly used chemical for cotton hydrophilization, but it is a chemical that can be harmful to the environment in soil and aquatic environments. Therefore, the use of enzymes in the scouring process is recommended in many studies. In addition, environmentally friendly swelling with ethanol-water mixture, as well as scouring-bleaching with ozone and ultrasound methods, which require less energy and chemicals, are recommended instead of conventional methods. Furthermore, the evaporation and recovery of sodium hydroxide used in mercerization applied to cotton textile surfaces are one of the recommended environmentally friendly pre-treatment methods.

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INVESTIGATION OF HYDROGEN PRODUCTION POTENTIAL BASED ON AN OCEAN THERMAL ENERGY CONVERSION PLANT; THERMODYNAMIC PERFORMANCE ANALYSIS

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ABSTRACT:
In this study, a thermodynamic performance investigation of the ocean thermal energy conversion system including carbon dioxide working fluid is conducted and examined for power and hydrogen generation. In the study, the thermal energy is met by 35 °C hot seawater and the system is designed according to this temperature. The detailed thermodynamic analysis is carried out with the method of energy and exergy efficiencies. Parametric studies are also carried out to examine the effect of changes in some prominent parameters. The net electricity production of the system is calculated as 273.14 kW, and the energy and exergy efficiency of the OTEC system is also calculated as 4.26% and 66.35%.
Keywords: Energy, exergy, OTEC, hydrogen, power

1. INTRODUCTION
Today, fossil-based (carbon-based) use still has a large proportion in meeting energy need worldwide. If it is known to everyone, fossil-based fuels cause environmental problems such as global warming. For this reason, it is accepted as an essential solution based on renewable energy at the point of switching to carbon-free fuels worldwide. Currently, the main precursors of renewable energy sources can be expressed as solar, wind, and biomass. Looking at the other hand, ocean energy conversion (OTEC) plants have attracted attention in recent years (Hasan and Dincer, 2020). Because the ocean of the world almost covers %70 of the world's earth's surface and that is making it significant in several countries (Neill and Hashemi 2018).
OTEC systems can be expressed as energy conversion systems that can be operated at low pressures and temperatures that can produce electricity between the hot flow at the surface and the cold flow at the deep depending on the different depths at sea level. These systems have gained importance at the point of examination with the advanced technologies in recent years. Some academic studies in 2023 show that the interest in the OTEC plant has increased. Zhang et al. (2023) proposed and examined a thermodynamic performance analysis of an OTEC using ammonia. Their developed study generates 30 kW of power. Geng and Gao (2023) evaluated a thermodynamic and exergoeconomic analysis of the OTEC for producing cooling, desalination, and power. They computed the thermal efficiency of the combined system as 449.32% and exergy efficiency as 50.08%, respectively. In some studies, it is aimed to obtain more useful outputs by integrating the OTEC system with renewable energy sources such as solar energy and increasing it to higher temperatures. Temiz and Dincer (2022) proposed a new design system that includes OTEC and solar energy-based multigeneration plants for Arctic communities. They investigated the energy and exergy efficiency of the entire plant and found 16.28% energy efficiency and 36.35% exergy efficiency for the entire system. Yamada et al. (2009) examined a performance investigation of the solar energy-based OTEC system. Yilmaz (2019) examined an energy, exergy, and economic analysis of a hybrid OTEC system for beneficial products.
The main purpose of this study is to compare the use of CO2 fluid in the OTEC system and electricity and hydrogen production. It has been examined how the efficiency of the system changes if the produced electricity is completely preferred in hydrogen production. In addition, the variation of parameters, which have important effects on the system, has been examined. For the entire plant, thermodynamic performance investigation is examined with energy and exergy approaches.

2. SYSTEM DESIGN AND ANALYSIS
The proposed system consists of a hot and cold seawater cycle, a turbine, an evaporator, a condenser, and a pump. This power generation system same is the ideal Rankine cycle. The developed system's schematic diagram is presented in Fig. 1. The thermal energy required for the modeled system to operate meets the warm seawater cycle. The OTEC system basically consists of a turbine, a pump, a condenser, and an evaporator. The seawater temperature is accepted as 35°C the cold water at 5°C Moreover, the necessary assumptions and parameters for the system design are presented in Table 1.

Table 1. System inputs and assumptions

Parameters	Value
Turbine isentropic efficiency (%)	82
Sea water pump isentropic efficiency (%)	85
Warm Sea water inlet temperature (°C)	35
Cold seawater inlet temperature (°C)	5
Sea water mass flow rate (kgs^{-1})	100
OTEC working fluid	Carbon dioxide
Turbine inlet pressure (kPa)	6000
Turbine outlet pressure (kPa)	4000
Pinch point temperature (°C)	8
Reference temperature (°C)	15
Reference pressure (kPa)	101.325

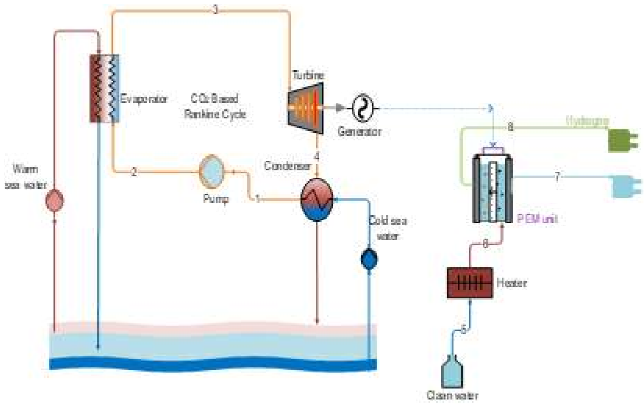

Fig.1 Proposed OTEC system with hydrogen generation

In thermal system design, which is energy and exergy efficiencies methods, generally, thermodynamic laws are taken into account and these formulations consist of mass, energy, entropy, and exergy balance equations and can be modeled as (Kotas; Cengel and Boles; Dincer, 2020);

$$\dot{m}_i = \dot{m}_e \tag{1}$$

$$\dot{Q}_i + \dot{W}_i + \sum \dot{m}_i h_i = \dot{Q}_e + \dot{W}_e + \sum \dot{m}_e h_e \tag{2}$$

$$\sum \left(\frac{\dot{Q}}{T}\right)_i + \sum \dot{m}_i s_i + \dot{S}_{gen} = \sum \left(\frac{\dot{Q}}{T}\right)_e + \sum \dot{m}_e s_e \tag{3}$$

$$\dot{Ex}^{\dot{Q}_i} + \dot{Ex}^{\dot{W}_i} + \sum \dot{m}_i ex_i = \dot{Ex}^{\dot{Q}_e} + \dot{Ex}^{\dot{W}_e} + \sum \dot{m}_e ex_e + \dot{Ex}_D \tag{4}$$

Herein, i and e subscripts define the inlet and exit of the system components. The energy and exergy efficiency of the developed OTEC and overall system can be formulated as:

$$\eta_{OTEC} = \frac{\dot{W}_{net}}{\dot{Q}_{in}} \tag{5}$$

$$\psi_{OTEC} = \frac{\dot{W}_{net}}{\dot{Ex}_{in}^{\dot{Q}}} \tag{6}$$

$$\eta_{sys} = \frac{\dot{m}_{H_2} LHV_{H_2}}{\dot{Q}_{in}} \tag{7}$$

$$\psi_{sys} = \frac{\dot{Ex}_{H_2}}{\dot{Ex}_{in}^{\dot{Q}}} \tag{8}$$

LHV is the lower heating value of the hydrogen and is computed in the EES program (Klein, 2021).

3. RESULTS AND DISCUSSION

The designed system is to investigate a detailed thermodynamic performance analysis using energy and exergy efficiency methods. Analysis results of the developed plant are tabulated in Table 2.

Table 2. Thermodynamic analysis results of the developed OTEC system

W_{net}	273.14 (kW)
$\dot{m}_{H2}$	0.001368 (kgs^{-1})
η_{OTEC}	4.26 (%)
ψ_{OTEC}	66.35 (%)
η_{sys}	2.566 (%)
ψ_{sys}	38.91 (%)
Total exergy destruction rate	667.5 (kW)

Also, Fig. 2 and Fig. 3 illustrate the proposed system energy and exergy efficiency and also the exergy destruction rate of the system's components, respectively. The highest reversibility among all system elements was observed in PEM electrolysis with 273.6 kW. The overall system's total irreversibility is 667.5 kW.

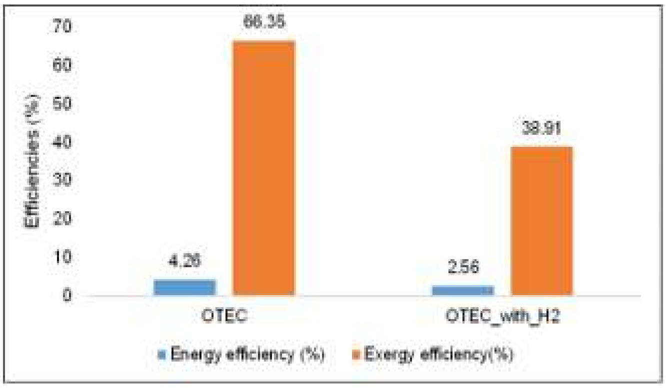

Fig. 2. Energy and exergy efficiency of the proposed systems

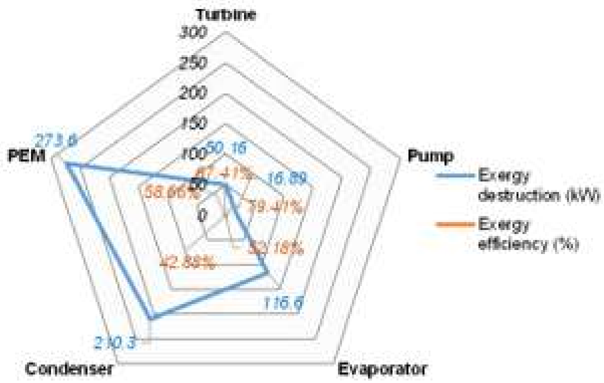

Fig. 3. Exergy efficiency and exergy destruction rates of the proposed systems components

Parametric analysis is carried out in Fig. 4 and Fig. 5 to examine the effect on seawater, i.e., source temperature change, system performance, and the power and hydrogen amount obtained from the developed model. As the sea water temperature rises between 28 °C and 38 °C, net electricity generation increases from approximately 200 kW to 290 kW. Here, the increase in source temperature has a positive effect on the system.

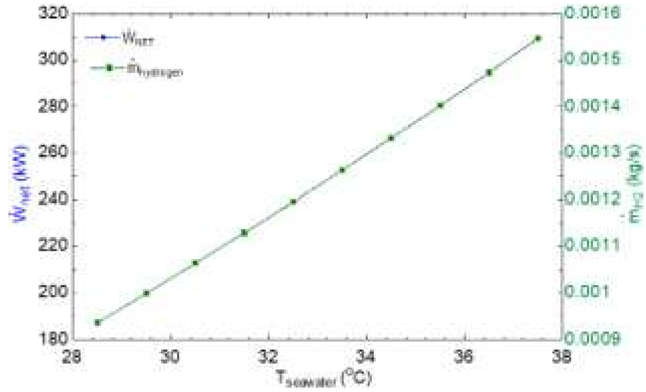

Fig.4. Effect of seawater temperature on power and hydrogen production rate

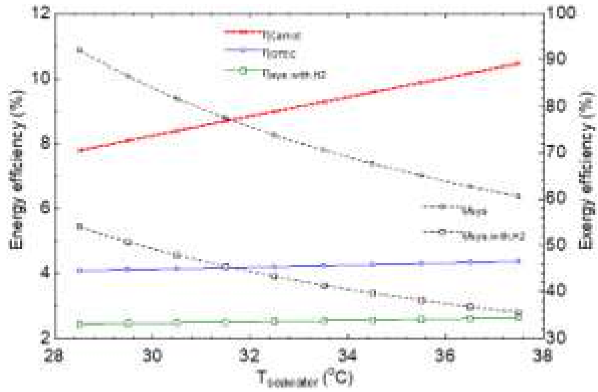

Fig.5. Impact of seawater temperature on performance ratio of the developed system

Another parametric analysis is to examine the change in turbine inlet pressure. Fig. 6 and Fig. 7 illustrate the increase in turbine inlet pressure with the increase in system efficiency and produced outputs. The increase in turbine inlet pressure increases the amount of power obtained from the system.

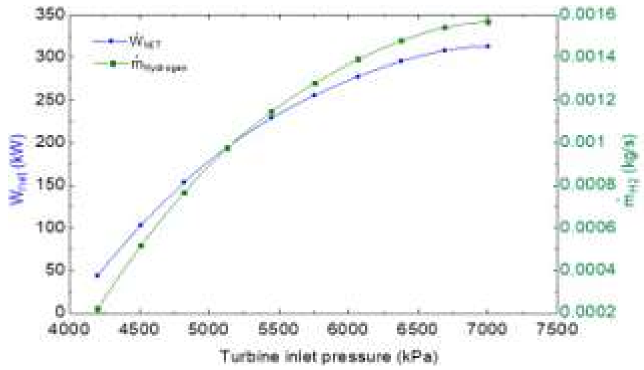

Fig.6. Hydrogen and power production rate vs turbine inlet pressure

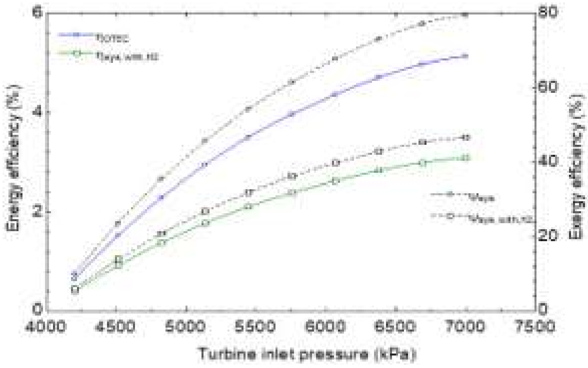

Fig.7. Performance ratio of the developed system vs different turbine inlet pressure

The last figure, Fig. 8, shows the effect of evaporator pinch point temperature (PPT) change on the developed system. As the temperature of the PPT increases and the temperature of the fluid going to the OTEC turbine decreases, the power and hydrogen amount obtained from the system change in the negative direction.

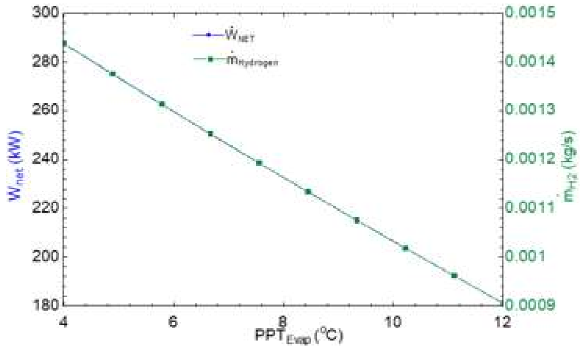

Fig. 8. Performance ratio of the developed system vs different turbine inlet pressure

4. CONCLUSION

In this designed study, the thermodynamic analysis of the ocean thermal energy conversion system with a source temperature of 35°C is investigated using energy and exergy efficiency methods. The CO2 fluid is selected as the working fluid in this OTEC system. The deep cold-water inlet is assumed as 5 °C. In addition, hydrogen production with the electricity obtained from the system is analyzed. According to the results of the analysis, the power generation capacity of the system is calculated as 273.14 kW, while the energy and exergy efficiency (for electricity) is determined as 4.26% and 66.35%. In response to this value obtained from the system, 0.001368 kg/s hydrogen is produced. Furthermore, looking at parametric analysis results, increment in the seawater temperature and turbine inlet pressure leads to a rise in the system performance and produced products. Finally, rise in the PPT of the evaporator, decreasing the system performance.

It concluded that the OTEC systems have gained more importance in the coming year, especially in low-temperature applications. Additionally, the integration of other renewable energy, i.e., solar energy, can reach higher temperatures and this is meaning more power generation.

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PERFORMANCE ANALYSIS OF A BIOMASS-BASED BRAYTON AND SUPERCRITICAL- CO2 INTEGRATED POWER PLANT

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ABSTRACT:
In the developed this study, a biomass (olive pits) driven integrated power plant that includes a Brayton cycle, a supercritical CO2-based Brayton cycle), (sCO2-BC) and a thermoelectric generator (TEG) is proposed, designed, and analyzed for clean power generation. To conduct thermodyanmşc analysis, the energy and exergy efficiencies methods are applied to this integrated plant. Also, in order to determine some significant factors on the system's performance, a parametric examination is fulfilled. After that, based on the analysis results, the developed system can generate 4338 kW net power. Moreover, the energy and exergy efficiencies of this examined plant are 19.45% and % 14.6%, respectively.
Keywords: Biomass, energy, exergy, power, CO2

1. INTRODUCTION
With the development of technologic and the increase in the human population in parallel, the need for energy is increasing worldwide. Carbon-based fossil fuels occupy a large place in meeting this increasing energy need. At this point, the key problem is dealing with energy generation with fossil-based fuels which is the great challenge that must be addressed (Dincer and Aydin, 2023). Because, for the year 2022, according to the IEA's report, CO2 emissions will increase by 300 million tons in 2022 and reach 33.8 billion tons (IEA, 2022). In this regard, the increase in environmental problems still continues and to prevent this, renewable energy-supported systems should be adopted. Furthermore, energy efficiency methods are also used to combat environmental challenges. It can be stated that biomass is one of the most known renewable energy sources as well as solar, wind, and geothermal.
When investigating the open literature, there are many papers about biomass-based multigeneration plants that use both renewable sources and energy-effective methods. Ahmadi et al. (2013) proposed a new biomass based combined plant for multi purposes. Their developed model includes different subsystem and they conducted a energy and exergy performance analysis. After conducting the mathematical analysis, exergy efficiency of their study is 22.20%. In Another paper, for the production of multigeneration and hydrogen, a multigeneration plant driven by biomass source is developed and analyzed by Safari and Dincer (2019). The result of their analysis shows that the more CH4 molar fraction in biogas, the higher the energetic and exergetic performances. In 2023, Kamari et al. (2023) examined the thermodynamic and environmental analysis of a biomass-assisted combined plant. They investigated and compared different biomass sources and found that the lowest CO2 emission occurs in the switchgrass. Here, some authors, biomass-assisted combined systems, studies in the last year are collected (Cao et al. 2022; Hashemian et al. 2022; Eldeib et al. 2023; Wang et al. 2023).
The main aim and motivation of this developed study is the design and development of the biomass-based combined plant. As a biomass source, dry olive pits are used. The proposed system consists of a Brayton cycle, sCO2-BC a and a TEG. A comprehensive thermodynamic analysis is also conducted to determine the system proposed system performance. For this reason, energy and exergy efficiency methods are addressed.

2. SYSTEM DESCRIPTION and MODELING
As indicated in Fig.1, which is the process flow diagram, the developed integrated power plant is illustrated. In addition, some assumptions and design values for thermodynamic analysis application can be found in Table 1 is also pictured.In this study, the exit temperature of the combustion chamber, that is, point 4, is assumed to be 1100 °C The waste heat from point 6 enters the heat exchanger 1 (HEX1) where it transfers its heat to the lower cycle sCO2-BC. It then provides the necessary thermal energy to HEX 2 at point 7 and from there to TEG. In sCO2-BC a recovery device is used to increase heat recovery and system performance.

Fig. 1. Process flow chart of the developed power plant

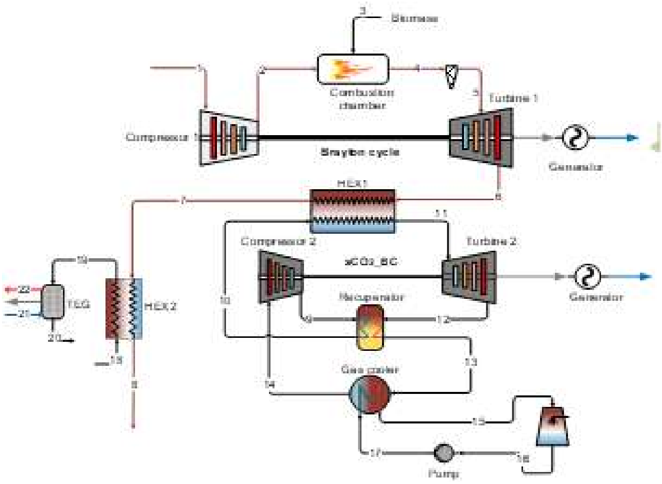

Table 1. System design criterias

Parameters	Value
Biomass mass flow rate	2 kg/s
Cumbustion chamber outlet temperature	1100 °C
Air compressor compression rate	8
Turbine 2 inlet pressure	23100 kPa
Turbine 2 outlet pressure	7700 kPa
Turbine and compressors isentropic efficiency	85 %
ZTM	0.8
Reference temperature	25 °C
Reference pressure	101.325 kPa

Basically, energy and exergy efficiencies methods, generally, thermodynamic laws are taken into account and these formulations consist of mass, energy, entropy, and exergy balance equations and can be modeled. Moreover, to look at the details, the following mature references can be overlooked. (Kotas; Cengel and Boles; Dincer, 2020). After the detailed formulation, the energy and exergy efficiency of the system and subsystems can be written as follows;

$$\eta_{BC} = \frac{\dot{W}_{T_1} - \dot{W}_{com_1}}{\dot{m}_{fuel} * LHV} \quad (1)$$

$$\psi_{BC} = \frac{\dot{W}_{T_1} - \dot{W}_{com_1}}{\dot{m}_{fule} * exf} \quad (2)$$

$$\eta_{sCO_2-BC} = \frac{\dot{W}_{T_2} - \dot{W}_{com_2}}{\dot{m}_{10} * (h_{11} - h_{10})} \quad (3)$$

$$\psi_{sCO_2-BC} = \frac{\dot{W}_{T_2} - \dot{W}_{com_2}}{\dot{m}_{10} * (ex_{11} - ex_{10}} \quad (4)$$

$$\eta_{overall} = \frac{\dot{W}_{net}}{\dot{m}_{fuel} * LHV} \quad (5)$$

$$\psi_{overall} = \frac{\dot{W}_{net}}{\dot{m}_{fule} * exf} \quad (6)$$

LHV is the lower heating value of the biomas and is computed in the EES program (Klein, 2021).

3. RESULTS AND DISCUSSION

In this subsection, the results of the analysis and the consequence of the parametric evaluation are presented briefly. The energy and exergy efficiencies of the system and subsystems at 1100 °C combustion chamber exit temperature are presented in Figure 2. Also, Figure 3 shows the exergy destruction rates in the system elements. Here, the energy efficiency of the whole system was calculated as 19.45% and the exergy efficiency as 14.60% , while the highest exergy destruction rate was seen in the combustion chamber with 25611 kW, as expected.

Fig. 2. Energy and exergy efficiency of proposed system and subsystems

Fig. 3. Exergy destruction rates for the overall system components

Fig. 4 illustrates the variation of the energy and exergy efficiency of the sCO2-BC and overall system for different reference temperatures. As indicated that increasing the reference temperature, the energy efficiency is nearly no change, however the exergy efficiency increase.

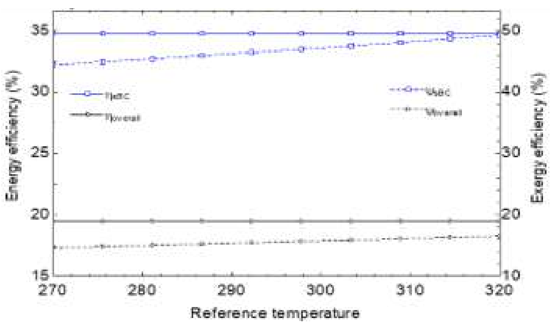

Fig. 4. Variation of efficiencies of overall system and sBC for various reference temperature

Figs.5 and 6 prove that increasing the compressor compression rate leads to an increase in the power generation (Fig.5) and efficiencies of the BC and overall system (Fig.6). As the compression ratio increases, the system rises to higher pressure, and the compressor work takes precedence over the turbine's work, and the net power production deteriorates.

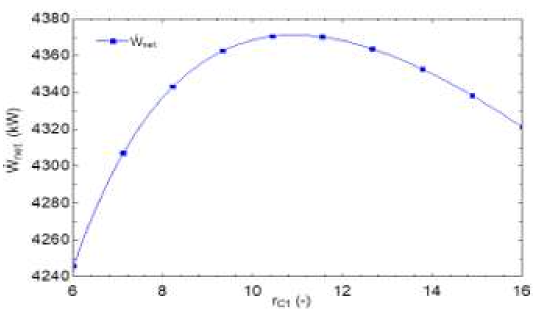

Fig. 5. Effect of the air compressor compression rate on the power generation

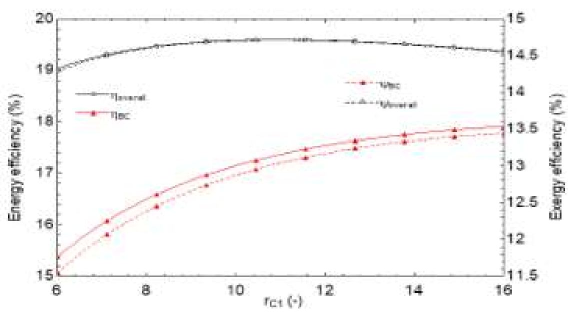

Fig. 6. Effect of the air compressor compression rate on Brayton cycle and overall plant

Also, Fig. 7 shows the impact of the compression ratio on the sCO2-BC. Here, too, this increase caused a decrease in performance in sCO2-BC. The reason for this situation is that as a result of the increase in temperature to the subsystems, the mass flow in the system decreases and the net work obtained is decreased. The effect of turbine 1 (T1) isentropic efficiency on the performance rate of the overall system and BC is examined and presented in Fig. 8. As shown in here, clearly, T1 isentropic efficiency increasing gives rise to system performance.

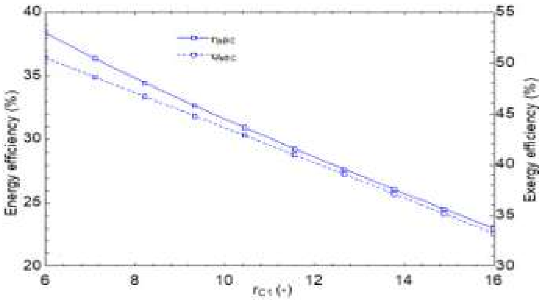

Fig. 7. Impact of the air compressor compression rate on sCO2-BC' performance

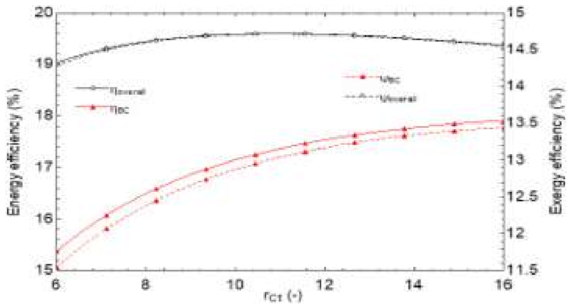

Fig. 8. Varioation of the performance rate of overall system and BC versus T1 isentropic efficiency

With the increase of the turbine inlet temperature, that is, the combustion chamber outlet temperature, the energy and exergy efficiencies of this designed operation and subsystems have clearly increased, and this is shown in Fig. 9 and Fig. 10. Increasing the temperature to the turbine means more electrical power and also higher efficiency.

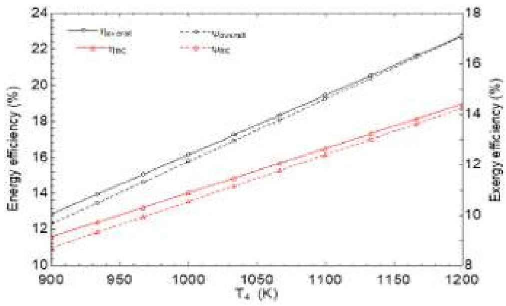

Fig. 9. Energy and exergy efficiency of the overall system and BC with various T1 inlet temperature

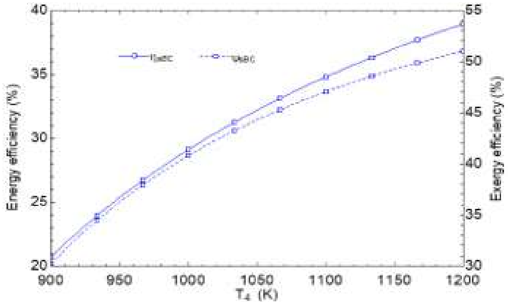

Fig. 10. Energy and exergy efficiency of the sCO2-BC with various T1 inlet temperature

4. CONCLUSION

In the developed study, a biomass-based Brayton cycle and sCO2-BC combination is proposed and analyzed. Also, TEG is integrated to get more electrical power with energy recovery. To define the system performance, detailed energy and exergy efficiency approaches are fulfilled with using the parametric assesmnet. The main analysis results can be sum up as below;

- The proposed plant can be produced a 4338 kW net power rate.

- The exergy destruction rate is 32433 kW, for the overall system.

- The energy efficiency of the Brayton cycle and sCO2-BC is determined as 16.5% and 34.79%. On the other hand, these systems' exergy efficiencies are computed as 12.39% and 47.04%.

- The energy and exergy efficiency of the whole plant is computed as 19.45% and 12.39%, respectively.

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WATER FOOTPRINTS IN DENIM PRODUCTION

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ABSTRACT

The textile sector is one of the sectors with the highest water consumption. Especially in denim production, water consumption is quite high because the raw material is cotton and due to processes, such as dyeing, finishing, and washing. Dyeing and finishing/washing processes are the main causes of wastewater pollution in denim production, and the resulting wastewater contains a large amount of harmful dyestuffs and alkaline chemicals. It is clear that the denim industry has a production that consumes intense water and causes environmental damage. Therefore, today the denim industry seeks sustainable, less water consumption and environmentally friendly denim production processes to overcome these environmental and energy problems. In this study, water consumption, which has a great place in denim production, the concept of water footprint, the types and calculation of water footprints, the existence of water footprints in denim production, the recent developments in denim water management and in denim industry's efforts toward sustainability were evaluated.

Keywords: Denim, water footprint, sustainability

1. INTRODUCTION

Water is a basic need for all living organisms on earth. It occupies most of the volume on our planet, and about 71% of Earth's total surface is made up of water. Water is the main consumption item in various industrial production stages such as agriculture, construction, thermal power generation, textile production, paper, and pulp production (Kumar et al, 2021). Compared to other manufacturing industries, the textile industry is one of the most water using and polluting industries in the world. Denim is a popular material that is universal in the textile industry.

The most basic raw material used in denim is cotton, which is a water-intensive product and is responsible for the high-water footprint of denim. About 70% of the water consumed during the life cycle of jeans is used only during cotton farming (Strauss et al, 1951). The use of fertilizers and pesticides containing large amounts of water for cotton production also affects the health of the people living in these regions. The amount of water footprint calculated to produce denim trousers depends on the location produced, the irrigation technology used in cotton production, the water saving measures of the farmers, the raw material content used and the denim production technologies. For this reason, in the denim industry, cotton creates a water footprint from growing in the field to denim production (Pal et al, 2017). In this period from raw cotton to finished denim production, water footprint formation takes place in many stages such as ginning, yarn production, weaving preparation, indigo dyeing, weaving, clothing production and finishing processes. Determining the environmental impact, evaluation criteria and related parameters at these stages will enable the evaluation of water footprint formation (Luo et al, 2022).

2. WATER FOOTPRINT

The term 'Water Footprint' was first coined by Arjen Hoekstra at UNESCO-IHE in 2002. (Hoekstra et al., 2011). Water footprint is defined as the total amount of fresh water used directly and indirectly by an individual, community or country over a period. A geographic indicator showing the amount of water used or polluted by a group in a particular location. (Pal et al, 2017). As an indicator, the water footprint (WF) measures the allocation of water resources by human activities by assessing water consumption and its impact on water quality (Chico et al, 2013). Water footprint; It is the total amount of clean water resources used for the production of goods and services consumed by the individual or society or used by the producer for the production of goods and services (10). The water footprint shows not only the volume of water, but also the type of water used (green, blue, gray), when and where it was used. In this respect, the water footprint of a product is a multidimensional indicator (Turan, 2017).

2.1. Types of Water Footprint

The water footprint consists of three main components: blue, green, and gray water footprints. Blue WF is expressed as the volume of water withdrawn from the ground or surface water system minus the volume of water returned to the system (Li et al., 2021). In the case of textiles, this would include the water used to grow cotton or other fibers, as well as the water used in textile manufacturing processes such as dyeing and finishing. The second water footprint component, the green water footprint (green WF) component is closely related to crop production and is expressed by the volume of rainwater used in the cultivation of an agricultural product (Hoekstra,2014). WF gray, the final water footprint component, is an indicator of water pollution (Wang et al., 2013) and represents the volume of fresh water required to reduce the pollution load according to current water quality standards (Hossain et al.,2017).

Blue and gray water footprints are the most widely used in the textile industry. In their study, Hossain et al. concluded that the blue water footprint can be reduced by recycling process water, while the gray water footprint can be reduced by appropriate water treatment, zero hazardous chemical discharge and cleaner production approach (Hossain et al.,2017).

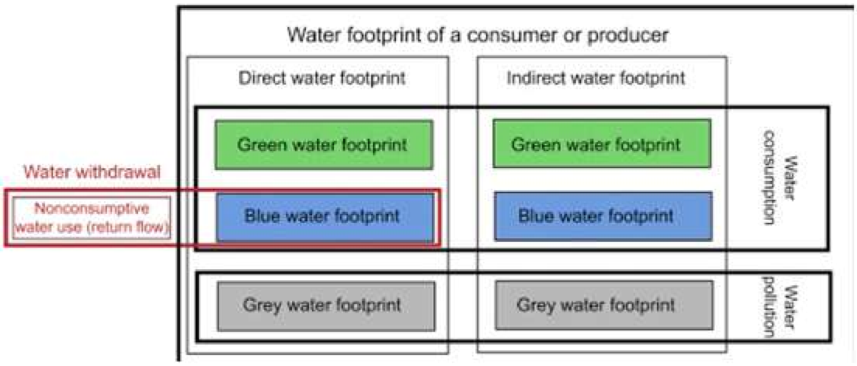

Fig. 1. Components of water footprints. (Pal et al, 2017)

2.2 Assessment of Water footprint

To understand the magnitude of water consumption and wastewater generation in denim production, comprehensive water footprint assessments have been conducted. These assessments consider both direct water use within the production facilities and indirect water use associated with the supply chain, including cotton cultivation and chemical production. Water footprint evaluation stages consist of four stages: determining the purpose and scope, calculating the water footprint, assessing the sustainability of the water footprint, and developing a response to the water footprint. (Hoekstra et al., 2011). Geographical location is an important factor in calculating the water footprint. An average of 11,000 liters of water is consumed to produce 1 kg of cotton fabric. When examined geographically, the amount of water consumed is 6,000 L in China, 8,100 L in America, 22,500 L in India, 9,600 L in Pakistan and 9,200 liters in Uzbekistan (Alper, 2015). The water footprint calculation of textile products is carried out by two methods, the WFN method and the ISO 14046 method (Luo et al., 2021). WF original (WFori, gray) and WF residuary (WFres, grey), which is an indicator for assessing the degree of water pollution, is calculated in two categories. Originally produced wastewater is much more concentrated than the discharged treated wastewater. Impacts on the environment from the original wastewater can be reduced by using pretreatment WF blue is calculated with totalization Blue Water Evaporation, Blue Water Incorporation and Lost Return Flow (Wang et al., 2015).

2.3 Denim Water footprint

The water footprint of a denim product is defined as the total volume of fresh water consumed directly and indirectly to produce a particular denim product, measured throughout the entire supply chain (Hoekstra et al., 2011). To produce a denim trousers, the cotton must first be grown, the fibers ginned and spun. After being turned into yarn, the fabric goes through weaving, sewing, and finishing processes. All these steps have a direct water footprint and an indirect water footprint. Calculating the water footprint of the denim industry, which includes all processes in denim production, will show the effect of denim on freshwater resources (Water footprint, 2023).

The highest water consumption in denim production is in the dyeing and finishing/washing stages. The most used dye types in denim dyeing are Indigo, sulfur, reactive and vat dyes, which cause high water consumption. Denim products usually go through several stages that consume a lot of water and energy, including dyeing, desizing, stone/enzyme washing, finishing, and softening. Highly alkaline chemicals are used in dyeing processes, and these chemicals are harmful to the environment and human health (Ibrahim et al., 2008). Dyeing and finishing wastewater from denim production contains many suspended solids (SS), dispersants, salts and trace metals. The resulting polluted wastewater can cause great environmental damage by creating high color content, large amount of SS and high chemical oxygen demand (Uzal, 2015).

Apart from the production of denim pants, consumer use after production is also a remarkable issue in the water footprint. Research has shown that in 2017, people around the world washed their jeans after two uses. In the last 20 years, the French have used approximately 619 L of water to wash their jeans, while American consumers have used 1049 L of water. Every year, 260 million pairs of denim products are produced and sold worldwide. If each denim product is washed after wearing it 10 times, water consumption can be reduced by 75% (Brenot et al.,2019).

3. Recent Developments in Denim Water Footprint

Many studies are carried out for the treatment of textile wastewater and water footprint management by reducing the amount of wastewater. The first of these studies is considered as the preference of new and less polluting chemicals and technologies in production processes. The second study is the recycling and reuse of wastewater. It is then recommended to effectively treat heavy colored wastewater containing high salt concentrations to meet the specified discharge requirements (Ramesh et al.,2007) In production processes, laser an ozone technology has gained popularity in denim finishing processes as it enables precise fading and distressing effects without the need for water-intensive techniques like stone washing. Waterless systems in denim production are becoming is most popular day by day. Employ various methods, such as mechanical abrasion, to create the desired distressed and worn-out look without using water or chemicals. Waterless washing not only eliminates water usage but also reduces energy consumption and chemical waste. In another work could be seen digital design and virtual sampling technologies have gained momentum in the denim industry. By creating virtual prototypes and utilizing 3D simulations, designers can visualize denim finishes and effects accurately without the need for physical samples. This approach reduces water usage by eliminating the need for multiple sample iterations and associated washing processes. In addition, to promote sustainable practices in the denim industry, governments and regulatory bodies have introduced policies and regulations addressing water resource management. This includes setting standards for wastewater discharge, enforcing water reuse requirements, and incentivizing the adoption of sustainable technologies. Recent developments in policy frameworks aim to create a favorable environment for the implementation of sustainable water management practices across the denim supply chain. Collaborative initiatives and partnerships aim to share best practices, exchange knowledge, and develop industry-wide sustainability guidelines. Moreover, certifications such as the Jeans Redesign by the Ellen MacArthur Foundation and the Sustainable Apparel Coalition's Higg Index encourage brands to adopt sustainable practices, including water footprint reduction, throughout their supply chains.

4. CONCLUSIONS

While significant progress has been made, further advancements are required to achieve a truly sustainable denim industry. Future research and development efforts should focus on improving the efficiency of water treatment technologies, exploring alternative dyeing, and finishing methods, and fostering innovation in sustainable materials. It is necessary for the denim industry to adopt sustainable approaches such as the use of organic cotton, the reduction of dyes and chemicals, and less wastewater production. Environmentally friendly practices such as electrochemical reduction, minimum application technologies and reduced water washing production processes should be used. In addition to these, it is very important to raise awareness among consumers in order to ensure post-production sustainability. Apart from these, the legal regulations of the governments to reduce the blue and gray water footprint components will affect the water footprint formation.

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INVESTIGATION OF LIFE CYCLE ASSESMENT FOR RURAL WASTEWATER TREATMANT PLANTS

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ABSTRACT
Sustainability has a significant impact on the field of environmental engineering and management. Life Cycle Assessment (LCA) is a useful method that evaluates the environmental impact of a product, service or process during its lifecycle. LCA is quantitative and helps in selecting strategies that solve environmental problems instead of just transferring them. It is a suitable technology for evaluating the sustainability and design of wastewater treatment. In this study, the LCA approach was used to compare alternative wastewater treatment systems for small and decentralized areas. The focus was on the constructed wetland (CW) of the WWT system in the limits and scope of the three parts of wetlands - construction, operation, and dismantling. The study assessed the impact of different environmental categories like abiotic depletion, global warming, ozone layer depletion, human toxicity, freshwater aquatic ecotoxicity, marine aquatic ecotoxicity, terrestrial ecotoxicity, photochemical oxidation, acidification, and eutrophication according to LCA standards. The study showed that natural WWT has a lower environmental impact than other systems, as it requires fewer resources. However, most of the impact categories have been due to construction stage of the CW (>90%). The most important impact category has determined as marine aquatic ecotoxicity while ozone layer depletion potential was minimum value.
Keywords: Wastewater, Sustainability, Constructed wetland, Dismantling, Green deal

1. INTRODUCTION
Indeed, human activities generate environmental impacts that should be minimized in the context of environmental sustainability to protect environmental quality (EQ) (Visvanathan., 2006). Therefore, it is important to preserve and protect ecosystems and the environment and to optimize the use of natural resources (Behm et al,2022). In this context, the LCA estimates the environmental impact of many systems such as products, processes, and activities from “cradle” to “grave” approach (Zampori et al ,2016). The products of life cycle matarial could be such as a manufacturing products, transportation, use of products and finally to disposal or recycling (Chordia et al , 2022; Szulc et al , 2021; Tabesh et al, 2018). The ISO 14040 (ISO,1997) was the basis for the implementation of LCA studies, which contain as general and methodological principles (Dewalkar et al, 2021).
Although WWTP has been planned to reduce organic contaminants in order to minimize negative effect on aquatic environment, determination of their environmental impacts throughout of the life cycle is also important in respect of green deals. The wastewater treatment in rural areas requires decentralised systems such as constructed wetland (CW) with different options and technologies are available for this type of purpose (Gallego & Tarpani, 2019; Machado, 2006). There is some literature focused on life cycle inventory and environmental impact assessment of CW presenting different results (Alam et al 2023; Lourenço & Nunes 2021; Flores et al ,2019; Corominas et al, 2013; Machado et al, 2007). The fundamental objectives of this study are; firstly to determine the avarage inventory data by using the data in previous researches particularly with regard to the construction, operation and maintenance for CW and secondly to investigate environmental impact assessment of CW by using average inventory data.

2. METHODOLOGY
The environmental impacts of a constructed wetland treatment plant were investigated through the main LCA stages of construction, operation, and dismantling processes. The inventory data of the constructed wetland (CW), including construction, operation, and maintenance, were obtained from literature and average values were recorded in Table 1. However, data have been given as different units in literature were converted to suitable units such as kg, m3 and MJ. Flow rates and hydrolic retention times were used to convert kg/m3 to the desired unit, if it necessary. Web-based software called Mobius (Ecochain, Amsterdam, Netherland) was used to characterize the respective emissions and environmental impacts. The data was analyzed and normalized using Mobius - openlca, lcia v2.04, 2019, and the CML-IA baseline method. Mobius follows the guidelines of ISO 14000 and considers various impact categories such as global warming (GW), abiotic depletion (AD), human toxicity (HT), O3 layer depletion potential (ODP), marine aquatic ecotoxicity (MAE), freshwater aquatic ecotoxicity (FWA), photochemical oxidation (PO), terrestrial ecotoxicity (TE), eutrophication (E), and acidification (A). It is important to mention that the software includes different emission databases and methods for characterizing emissions. (Gmünder &Dettling, 2020).

3. RESULTS AND DISCUSSION

The inventory data which included some stages with a "cradle to grave" approach were collected from various sources related to the CW process in small and decentralized communities, and were analyzed and presenten in Table 1. The inventory data presented in Table 1 includes detailed information on construction, operation, and dismantling stages. The information was used to evaluate the performance of five small and decentralized wastewater treatment plants through a life cycle assessment (LCA) study. However, conducting an LCA study can be very time-consuming, especially when there is a lot of data needed. Therefore, insufficient or inadequate data collection may result in an unreliable study outcome. Furthermore, communicating the results of an LCA study, which involves four different components, namely scoping, quantitative data compilation on materials, energy consumption, and waste emissions, impact assessment, and study results improvement, can be challenging (Ecoil, 2006). The emission factors which have used to convert the inventory data to environmental impacts were also evaluated for various impact categories.
The materials used in construction were selected to be sufficient for the entire life cycle of the system, and no alternatives were considered. The remaining organics as COD, the amounts of phosphorus and nitrogen from the effluent of the treatment process was used as emissions to water. It is noteworthy that the construction phase have been found as the most important stage of the LCA inventory.

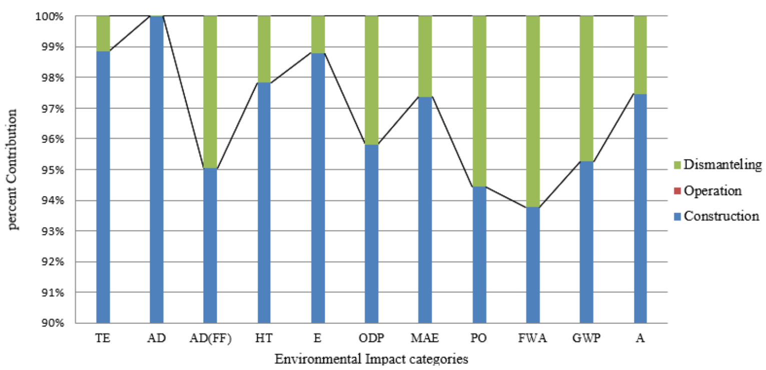
Table.1 presented the inventory results of wastewater treatment in various constructed wetlands

Inventory Data	Unit	[a]CW1	[b]CW2	[c]CW3	[d]CW4	[e]CW5	Max	Min	Average	SD*
Construction phase			CW-VF							
Concrete	m3	0.043	0.198	0.04	0.02	0.34	0.34	0.02	0.13	0.14
Gravel	ton	10.8	0.045	10.80	0.01	8.26	10.80	0.01	5.98	5.54
Sand	kg	0.2	46.9	0.04	48.31	912.91	912.91	0.04	201.67	398.31
Steel	kg	–	18.2	x	1.69	30.92	30.92	1.69	16.94	14.66
Iron/cast iron	kg	0.3	661.7	0.06	18.08	10.64	661.70	0.06	138.16	292.76
PVC	kg	0.003	0.137	3.17	0.46	8.94	8.94	0.00	2.54	3.80
PE/HDPE	kg		0.008	0.01	-	-	0.01	0.01	0.01	0.00
Fossil fuel	kg	1.600	1.600	0.95	-	-	1.60	0.95	1.38	0.37
Aluminum	kg	-	-	0.03	-	-	0.03	0.03	0.03	
Polypropylene(PP)	kg	0.643	0.008	0.64	-	-	0.64	0.01	0.43	0.37
Operation										
Emissions to water (COD)	kg	254.4	311.4	68.50	0.077	175.0	311.40	0.08	161.88	128.44
Emissions to water (TN)	kg	76.3	77.4	0.03	0.006	21.0	77.40	0.01	34.95	39.20
Emissions to water (TP)	kg	60.7	36.6	0.00	0.001	2.8	60.70	0.00	20.02	27.51
Electricity	MJ	3940.0	6340.0	-	0.00	1116.9	6340.00	0.00	2849.21	2857.42
Dismantling										
Construction waste	kg	0.0	312.0	0.00	-	-	312.00	0.00	104.00	180.13
General waste	kg	1.3	0.1	1.31	-	-	1.31	0.12	0.91	0.69
Total fossil fuel	kg	0.9	2.1	0.95	-	-	2.13	0.92	1.34	0.69

*SD: standard deviation; [a](Machado et al, 2007), [b](Lourenço & Nunes 2021),[C&d](Alam et al 2023), [e](Flores et al ,2019)

The construction and installation phase was found to have the highest impacts in constructed wetlands, which is the first phase of the plant's life cycle. MAE was determined as the maximum value amongst environmental impact categories while ODP was minimum value. The main inventory elements that affecting impact categories were obtained as gravel and sand because of their high usage. Dismantling stage had also a significant impact on the environmental performance of the CW.

Figure1.Contribution of life cycle phases of constructed wetland to environmental impact categories



CONCLUSIONS

LCA is a powerful tool for certifying and ensuring the environmental sustainability of various assessments, including wastewater management. In this study, life cycle inventory data were used to calculate into various impact categories to describe environmental effects. Currently, LCA is expected to gain importance as a decision-making tool for planners and operators of municipal wastewater systems. In general, it follows a "cradle to grave" approach. This study shows that the LCA approach can be used as a determination tool and method in design studies. In this case, the LCA quantification identified CW parts as appropriate technologies in small communities and rural areas to certify economic and sociocultural aspects of sustainability.

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SUSTAINABLE FORMIC ACID PRODUCTION FROM CO2: A LIFE CYCLE ASSESSMENT ANALYSIS

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ABSTRACT
Formic acid (HCOOH) can be produced using CO2 via electrochemical reduction. This has the potential to mitigate increasing greenhouse gas emissions by utilizing captured CO2 from other processes. This paper presents a life cycle assessment of the electrochemical reduction of CO2 process to produce formic acid. A lab-scale conventional H-type cell is constructed with a Nafion 117 membrane. The electrodes are synthesized using drop-casting method with lead particles. The LCA is carried out based on ISO14040 standards using GaBi software. The LCA analysis consists of the goal and scope definition, inventory analysis, impact assessment and interpretation. To understand the overall environmental impacts, the energy and material flows into and out of the system are analyzed. The system boundary is set to be cradle-to-gate and the raw material extraction, transportation, membrane production, electrode production and cell operation are studied. The impact assessment methodology used to assess the environmental impacts is ReCiPe 1.08 Midpoint indicator. The environmental impacts were found to be 5.94 kg CO2 eq, 4.05 x 10-7 kg CFC-11, 5.94 kg 1,4 DB eq, 1.12 x10-2 kg SO2 eq and 0.418 x 10-4 kg 1,4-DB eq for the climate change, ozone depletion, human toxicity, terrestrial acidification and terrestrial ecotoxicity for 1 kg formic acid produced, respectively. Overall, the cell operation electricity and water in the electrolyte had the highest impact on climate change, human toxicity, acidification and ecotoxicity. The membrane and electrode in the cell had an insignificant impact on all the categories except the ozone layer depletion, where the membrane accounts for 83% of the impact. The findings from this study can help researchers, policy makers and industrial stakeholders make critical decisions regarding material selection and optimization to increase the sustainability of the process.
Keywords: Carbon Management, CO2 Electrochemical Reduction, Carbon Capture and Utilization

1. INTRODUCTION
The rising levels of Carbon dioxide (CO2) in the atmosphere is leading to global warming. There is an urgent need to reduce emissions in order to mitigate climate change. The Paris Agreement intends to slow down climate change and maintain global temperature increases below 2 °C, ideally 1.5 °C, compared to the pre-industrial levels (UNFCC, 2015). CO2 can be reduced by using CO2 capture technologies. Carbon capture and utilization (CCU) is a promising pathway to convert waste CO2 into valuable products and fuels. One such technology is the production of formic acid (FA) using electrochemical reduction of CO2. FA is a valuable fuel that can be used for various applications.
Life cycle assessment (LCA) is a comprehensive tool for assessing the environmental effects of a product, process, or technology over the course of its full life cycle. The environmental consequences associated with each stage of the electrochemical reduction process for FA generation can be assessed by doing a LCA. This aids in finding potential areas for process improvement. Kang et al. (2021) performed a LCA on FA production and found that electricity input had the greatest environmental impact. Switching to a renewable energy source or lowering the amount of electricity required can help reduce this impact. In another study, Ai et al. (2022) compared the effects of the ECR technique to the standard FA production process. The conventional process was shown to have a lesser environmental impact. To have a comparable impact with the traditional process, more improvement of the ECR technology in areas such as catalyst performance, product yield and reactor design will be required. The study presents a comprehensive cradle-to-gate LCA, considering the extraction of raw materials, manufacturing of electrochemical cells and catalysts, operation and maintenance of the electrochemical cell based on experimental studies.

2. SYSTEM DESCRIPTION
A conventional H-type cell is constructed with Nafion 117 membrane. The electrodes are synthesized using drop-casting method. A lead catalyst is mixed with the Nafion 117 solution and ethanol and loaded on a tin electrode. Fig. 1 shows a schematic representation of the electrochemical cell.

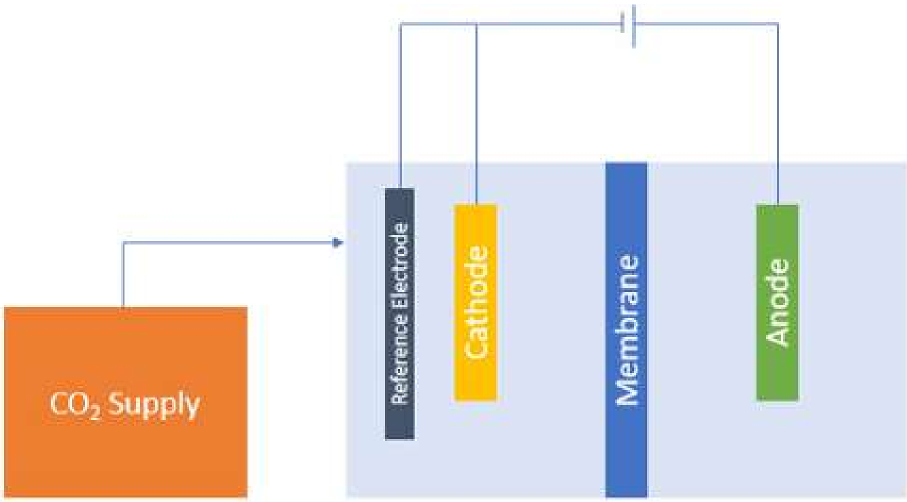

Fig. 1. Schematic representation of the electrochemical cell

3. GOAL AND SCOPE

This study aims to systematically assess the environmental impacts and overall environmental sustainability of producing FA from electrochemical reduction of CO2. Experimental data from a lab-scale electrochemical cell is used an iterative and non-linear procedure is followed using GaBi software (Sphera, 2023) to carry out the LCA analysis. The study is based on the international organisation for standardisation (ISO14040) guidelines shown in Fig. 2. The LCA includes the following steps: goal and scope definition, inventory analysis, impact assessment, and interpretation.

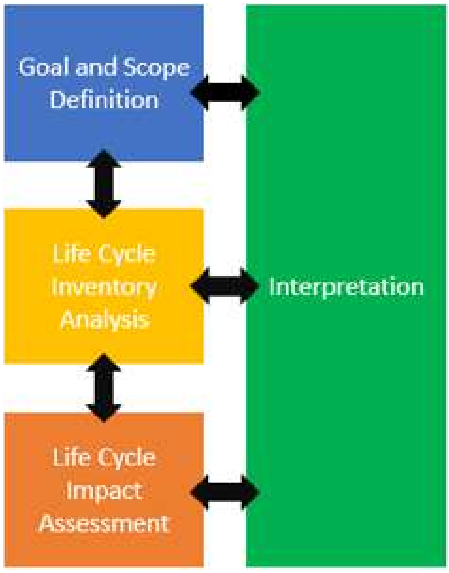

Fig. 2. LCA framework based on ISO 14040 and 14044 (ISO, 2006)

The LCA boundary is set to be cradle-to-gate where the raw material extraction, production and operation is included. The functional unit is set to be 1 kg of FA produced, and the life cycle impact assessment methodology used is ReCiPe 1.08 Midpoint indicator. The impacts analysed in this study are climate change, ozone depletion, human toxicity, terrestrial acidification and terrestrial ecotoxicity.

4. INVENTORY ANALYSIS

Table 1 shows the inventory data for the operation and production in the electrochemical reduction of CO2. This includes the material and energy flows into the system based on a lifetime of 10 years. The inventory data is collected from the experimental investigation and the values are adjusted relative to the functional unit of 1 kg FA produced.

Table 1. Inventory table for process

Materials	Quantity	Units
Membrane	0.0558	g/kg FA
Electrode material inputs	0.0777	g/kg FA
Electricity for electrode production	0.00054	kWh/kg FA
CO_2 flow	13800	g/kg FA
Electrolyte (potassium bicarbonate)	1.14	g/kg FA
Electrolyte (water)	123000	g/kg FA
Electricity for cell operation	5.32	kWh/kg FA

5. IMPACT ASSESSMENT

The impact assessment is carried out using GaBi software (Sphera, 2023) where the environmental impacts are investigated based on the inventory analysis using ReCiPe 1.08 Midpoint indicator. The environmental impacts were found to be 5.94 kg CO2 eq, 4.05 x 10-7 kg CFC-11, 5.94 kg 1,4 DB eq, 1.12 x10-2 kg SO2 eq and 0.418 x 10-4 kg 1,4-DB eq for the climate change, ozone depletion, human toxicity, terrestrial acidification and terrestrial ecotoxicity for 1 kg FA produced, respectively. Fig. 3 shows the impact assessment results with the percentage distribution of factors affecting the environmental impact categories. The required electricity input for cell operation and water in the electrolyte has the most significant effect on climate change, human toxicity, acidification and ecotoxicity. Therefore, incorporating renewable sources of electricity and water would make the process of converting CO2 into FA via electrochemical reduction more sustainable.

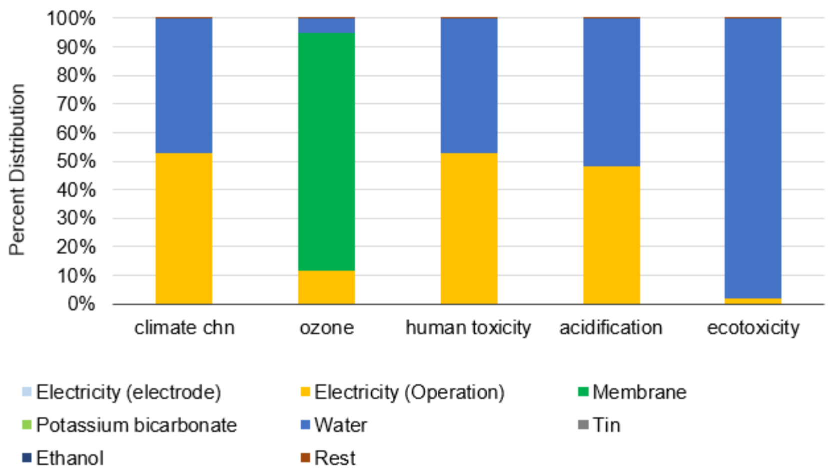

Fig. 3. Impact Assessment Results

6.CONCLUSION

A comprehensive LCA was conducted on the CO2 electrochemical reduction process to analyse the impacts on the environment. Climate change, ozone depletion, human toxicity, terrestrial acidification, and terrestrial ecotoxicity were found to be 5.94 kg CO2 eq, 4.05 x 10-7 kg CFC-11, 5.94 kg 1,4 DB eq, 1.12 x10-2 kg SO2 eq, and 0.418 x 10-4 kg 1,4-DB eq for 1 kg FA produced, respectively. Overall, the impact of cell operation electricity and water in the electrolyte on climate change, human toxicity, acidification, and ecotoxicity was the greatest. Except for ozone layer depletion, where the membrane accounted for 83% of the impact, the membrane and electrode in the cell had no effect on any of the categories. The findings of this study can assist researchers, policymakers, and industry stakeholders in making key decisions about material selection and optimization in order to improve the sustainability of the process. Future work includes sensitivity analysis and comparison of the impact with conventional fuel production process.

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REMOTE SENSING TECHNOLOGIES FOR RENEWABLE ENERGY MANAGEMENT

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ABSTRACT
The energy industry is undergoing rapid change. As a result of efforts to reduce greenhouse gas emissions and safeguard the planet for future generations, electricity generation and consumption are changing. Renewable energy sources, such as wind and solar, are expected to contribute nearly 70% of global electricity production by 2050. Digital technology is facilitating these dramatic changes to the energy system. An essential digital technology in the energy sector is remote sensing. Remote sensing is used for energy management and information collection. For instance, remote sensing can be used to determine the optimal location for the construction of hydroelectric, solar, and wind power plants. Asset planning, management, and risk management can be supported by using remote sensing technologies. Using this technology reduces the need for human inspections and facilitates advanced decision support and risk management. In conjunction with geospatial analytics, satellite-based remote sensing can supplement or replace traditional methods that require expensive and labour-intensive. In addition, several types of assets can be managed, including power plants, transmission and distribution grids, pipeline infrastructure, wind farms, power lines, pipeline infrastructure, and asset condition monitoring. In this paper, a variety of energy management applications are examined using remote sensing technologies.
Keywords: Energy Management, Remote Sensing, Digitalization, Renewable Energy

1. INTRODUCTION
The energy industry is undergoing rapid change. As we strive to reduce carbon emissions and protect the environment for future generations, the way we produce and consume electricity is changing. With the move away from fossil fuels, renewable energy sources, such as wind and solar, are growing exponentially. In 2050, they are expected to account for nearly 70% of all global electricity production. Our energy system is experiencing dramatic changes as a result of advances in digital technology. In order for the energy transition to be successful, digitalization is a crucial tool (EU Action Plan, 2021). AI/Machine learning, data visualization, cloud computing, drones, remote sensing, and digital twins are among the major digital technologies in the energy industry. A variety of applications for remote sensing can be found in a variety of industries as a means of gathering information (Ishak, 20017). Remote sensing can be used in the energy industry to determine the best location for the construction of infrastructure, including hydroelectric, solar, and wind power stations. Remotely sensed images are gathered by special cameras, which enable researchers to gain a better understanding of the Earth. The use of remote sensing allows us to monitor and map temperature changes in the ocean, forest fires, tracking clouds to predict the weather, the erupting of volcanoes, the growth of cities, and the changes in farmland or forests over time (Energy Education). Depending on the signal source used to explore an object, active or passive remote sensing is the two main types of remote sensing. A passive remote sensing instrument relies on reflected light, whereas active remote sensing instruments emit their own light. Each active sensor in remote sensing directs its signal to the object and then checks the response – the received quantity. In active remote sensing, different techniques transmit different signals (light or waves) and determine different parameters (e.g., distance, height, atmospheric conditions, etc.). Radar is a sensor assisting in ranging with radio signals. A distinctive feature of this antenna is that it emits impulses. A Lidar, a laser altimeter, and a scatterometer are instruments that are used for active remote sensing. The passive sensors in remote sensing do not transmit their own energy to the object or surface being researched. The passive remote sensing method relies on the bounce back of natural energy (sun rays) from the target (Leslie, 2018). Due to this reason, it is only applicable when there is adequate sunlight, as otherwise nothing can be reflected. Multispectral or hyperspectral sensors are used in passive remote sensing to measure a quantity using a combination of multiple band frequencies. Combinations of these wavelengths differ in terms of the number of channels (two wavelengths and more). This group of bands includes wavelengths within and beyond the range of human vision (visible, infrared, near-infrared, thermal, and microwave). A remote sensing approach can be advantageous in the energy industry when it comes to finding the best sites for building infrastructure, such as hydropower stations, solar power plants, and wind power stations. A variety of applications of remote sensing can be found in the energy sector. For example, remote sensing can be used to identify the best locations for the placement of solar photovoltaics and wind turbines, in order to maximize their efficiency and minimize their environmental impact (Jafarbiglu & Pourreza, 2022). A variety of active sensors can be used to measure wind resources or for the creation of local elevation models (NASA, 2018,Merrett, 2009). In order to locate potential offshore wind farm sites, wind measurements can be used (Merrett, 2009). Hydroelectric plants or areas that have fewer obstructions for wind turbines or power transmission lines can be planned using elevation models (NASA, 2018,Merrett, 2009, Wikimedia, 2009).

A passive, space borne instrument provides images of the surface that can be used to identify areas of potential crude oil or natural gas reserves (Ishak,2017). The purpose of this paper is to provide state-of-the-art tools in energy management using remote sensing techniques.

2. RENEWABLE ENERGY MANAGEMENT

A renewable energy source consists of solar energy, wind energy, geothermal energy, and wave energy, which exist naturally and are continually renewed (Wikimedia,2009). Obtaining energy from these sources and converting it into electrical energy is one of the important topics that researchers and scientists pursue. Solar and wind energy have a distinguished place among these types of energy. In addition to obtaining the energy, the objective is to convert the energy into appropriate values, manage the existent energy, and terminate the harmonics. It is important to consider lowering the cost of the system at every step of the process while managing all these factors. Energy storage systems must be designed efficiently so that solar energy can be utilized to its full potential in order to reduce the cost of solar energy systems. Managing energy assets is the process of monitoring and controlling them to minimize consumption and maximize efficiency (Meliani et. al., 2021). This includes optimizing energy use to achieve the best possible economic and environmental outcomes, as well as conserving energy. By optimizing energy use, businesses can lower their operating costs and reduce their carbon footprint. Moreover, energy management can enhance the safety and reliability of energy systems, as well as improve the performance of energy-consuming equipment. As part of the process, an organization is also proactively prepared for the production and future storage of energy in order to achieve environmentally sustainable operations, or even "net Zero operations. As a result of their ability to reduce the need for on-site maintenance and upkeep, energy management systems and solutions provide full control over remote locations and energy assets. Sustainability or renewable energy management refers to the process of using alternative, renewable energy sources to meet the organization's energy needs. While actively monitoring energy assets, this ensures that they are operating at peak efficiency and with the least amount of energy waste (Gennitsaris, 2023). Since RESs are generally installed in remote areas or offshore, a reliable condition monitoring and control system has become imperative for managing such valuable assets over long distances. In order to ensure the safe operation of renewable energy sources and the reliability of the electricity generated, monitoring and control systems are necessary. Using the information gathered from these systems, energy producers are able to determine how much energy is being produced and consumed as well as identify potential problems or inefficiencies. Access to this data also allows companies to accurately report their renewable energy production, ensuring that their renewable energy disclosure is accurate and reliable. In the following sections, a comprehensive review of relevant literature is presented which demonstrates how remote sensing technology has been applied to the development of renewable energy sources such as solar, wind, hydro, and biomass (Benbouzid et. al., 2021).

3. RESULTS AND DISCUSSION

In combination with GIS, remote sensing is useful for mapping both spatial and temporal scales of RE resources (Ishak, 2017, Benbouzid et al., 2021). Furthermore, they are capable of generating models based on which cost-effective and optimal energy-generating sites can be evaluated. There is a huge potential for solar energy, and its use is gaining traction in many countries around the globe. Solar thermal and photovoltaic systems are the most common technologies for utilizing the sun's energy (Ishak, 2017, Khan &Rathi, 2014). Remote sensing technologies, such as satellites equipped with solar radiation meters, can measure the amount of sunlight that reaches different areas of the earth. These data, including sunlight availability and land characteristics, can be very valuable in identifying optimal locations for new solar farms. Increasing the lifespan of solar installations and optimizing energy efficiency are the results of using this technology in early detection of potential issues that can disrupt the efficiency of panels. This information allows power producers to quickly identify and deal with such problems. When developing solar energy infrastructure and projects, it is important to analyze the availability and potential contribution of photovoltaics to energy needs. There has been a great deal of discussion about the critical role that remote sensing technology plays in this regard. In forested and hilly settings, as well as in complex mountainous terrains around the world, wind turbines are increasingly being installed to supply renewable energy. The use of remote sensing technologies in wind energy has recently expanded into more quantitative and accurate applications, including the propagation of light and sound waves and backscatter detection-based instruments, including light detection and ranging (lidar), sound detection and ranging (SOdar), as well as satellite-based scatterometry of sea surface waves.(Pena et. al,2021, Ishak,2017,Kumar et. al., 2015). Wind energy production is highly dependent on accurate wind speed and direction data at different altitudes. The traditional instrument can only measure wind conditions at a single height and location. However, LIDAR (light detection and ranging) and SODAR (sonic detection and ranging) which are remote sensing devices, can be measured the wind speed and direction at wide range and in different altitudes. Wind speed and direction can be assessed using Lidar by probing the atmospheric wind flow from a ground-based instrument with laser beams; satellite remote sensing consists of the combination of synthetic aperture radar (SAR) and microwave scatterometry on the sea surface.

Remote sensing in biomass energy can track plant growth and provide information on suitable biomass sites and the availability of biomass power plants. This technology can help planners accurately estimate energy production by providing insights into seasonal changes in biomass.
The use of biomass for energy generation dates back millennia and continues to be a vital component of the global quest for sustainable energy solutions. According to Kumar et al., (2015) quantification, mapping, and monitoring of biomass potentials in specific geographic areas are important considerations when using biomass as a renewable energy source (Patenaude et.al, 2005). It has been demonstrated that traditional methods of estimating biomass are highly time-consuming, expensive, and limited to small geographic settings with small sample sizes of trees. It has been demonstrated that remote sensing offers the best method for obtaining detailed information about abundance, distribution, and quality of biomass. In addition, it provides a rapid and cost-effective method of assessing biomass over relatively large tracts of land and across a variety of land cover classes (Patenaude et.al, 2015, Shi et.al, 2008). Across vast expanses of land there are pipelines and electrical corridors, solar farms the size of small cities, and supply chains that require ever-increasing security. Monitoring energy infrastructure is becoming increasingly important in order to address the most pressing challenges facing the energy sector. Near-real-time monitoring of both broad areas and specific locations is increasingly important for analysing the markets as a whole and responding to potentially detrimental events. Satellite imagery with very high resolution (VHR) can be an essential tool for monitoring critical infrastructure like oil pipelines since it can provide recurrent information at both a local and global level. Data sources can be combined with artificial intelligence and machine learning to provide further insights autonomously and more quickly. In addition to assessing oil inventories, mapping, monitoring, and tracking activities at production facilities, determining the height of floating roofs, allowing crude oil volume calculations to be simplified, remote sensing technologies are also used in protecting pipelines, monitoring oil pipelines, and understanding failures (Energy Management, 2022).

4. CONCLUSIONS

Remote sensing capabilities are critical in detecting and mapping surface and subsurface temperatures to identify potential geothermal energy sites. Also, by remote sensing technology, land surface deformation changes that are specifically related to geothermal reservoirs. This information can be very effective in finding the most suitable places for exploration and exploitation of geothermal energy. Information about soil quality and water availability is another area where this technology can have a significant impact. This information is one of the important factors in identifying and choosing suitable land for the cultivation of energy crops. In addition to the important role of remote sensing in the planning and operational stages, this technology can be used in the maintenance of renewable energy infrastructure. The use of remote sensing in the energy sector is an essential digital technology. In this paper, a review of the applications of remote sensing technologies in renewable energy development is presented. Remote sensing technologies can be used to support asset planning, asset management, and risk management. A key benefit of this technology is the ability to facilitate advanced decision support and risk management while reducing the need for human inspections. By combining satellite-based remote sensing with geospatial analytics, traditional methods that are labor-intensive and expensive may be supplemented or replaced. In comparison with traditional ground-based monitoring systems, commercial satellites offer a number of advantages. Commercial satellites are capable of reducing the costs associated with the management of infrastructure as well as facilitating the use of remote sensing from space. Satellites are also being used to improve infrastructure planning. Furthermore, satellites are being used to monitor infrastructure in real time by providing detailed topographical information. New infrastructure routes can be identified by satellite in a cost-effective and efficient manner. Through the use of satellites, infrastructure can be viewed 24/7, enabling problems to be detected and resolved as quickly as possible. Reduced maintenance costs and reduced catastrophic failures can be achieved.

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COMPARISON OF TRADITIONAL AND INNOVATIVE THERMAL INSULATION MATERIALS IN TERMS OF ENERGY EFFICIENCY

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ABSTRACT
The buildings were built in ancient times with the search for protection and shelter of mankind. Today, structures have been shaped and developed with the need for energy, safety, comfort and healthy living. The structures that meet people's protection and security requirements also need protection over time. While ensuring the protection of the structures we live in, it is also necessary to protect nature and our world. To ensure this, insulation and insulation materials are encountered. The insulation of the structures also has a large share in the energy consumed. Insulation material applications are made according to TS 825 (Thermal insulation rules standard in buildings) in our country. With this application, heat losses are reduced. On the other hand, energy saving is achieved. The materials used in insulation will be introduced by being divided into two groups as traditional and innovative materials. It has been determined in the researches that an average of 40% energy savings is achieved with the proper use of appropriate materials. Thus, the environment and nature are protected and carbon dioxide emissions are reduced. Problems in insulation are directly related to energy, earthquake, fire, environmental health, human health and safety. Due to the increasing energy consumption and decreasing energy source, new materials have been started to be searched for in insulation works and thermal insulation. In this article, the thermal conductivity values of traditional insulation materials were compared by specifying the importance of thermal insulation materials in energy saving and discussed the properties of innovative materials.
Keywords: Thermal insulation, energy saving, ecology

1. INTRODUCTION
All manufacturing and procedures made for ensuring comfort in structures and that people can maintain safe and healthy lives increase energy consumption day by day, bringing environmental pollution together. It is once more understood how important the materials used in insulation elements for protecting the structures are. Compulsory heat insulation came into force on January 1, 2011 with the Energy Efficiency Law No. 5627. Pursuant to this law, it is required to issue an Energy Identity Certificate in buildings with a construction diameter of 50 m2 or more. With the right insulation material and the right application, the energy consumption in the buildings and the emission of CO2 (carbon dioxide) gas will decrease by a high rate. The thermal insulation material must also have other properties. Features of thermal insulation materials such as non-flammability, durability and ease of application must be taken into account in selection of materials. For a good thermal insulation, materials, which majorly have these features must be produced. Thus, the multi-featured materials found with the researches will solve the problems in insulation and be the solution for the future by solving the problems in insulation. While energy resources (especially fossil) are decreasing day by day, energy saving is becoming requisite due to the continuous increase in energy need. For this reason, new searches have started in many countries for the prevention of heat loss and the efficient use of energy. Many of the European Union member states have revised their legal regulations on thermal insulation and researches have been made for structures that consume less energy. However, the search for innovative insulation materials has started instead of traditional insulation materials. In Europe, Puret with air purification feature, which was found with the help of NASA aeronautical scientists material was also a subject of research recently (URL, 2022). For this purpose, new generation insulation materials such as Silica aerogel felts, Vacuum insulation panels, Isonaturelle organic plaster have started to be used in Turkey. Objectives such as conservation of natural resources, reduction of heat loss, protection of human health and nature have increased the need for thermal insulation materials. In order to provide a successful thermal insulation, it is necessary to pay attention to features such as being long-lasting, low-cost, fire-resistant, easy-to-apply and thermal conductivity value when choosing the material.

2. INSULATION MATERIALS

2.1. Conventional (commonly used) Insulation Materials (Fig.1.)

Mineral Wools (MW): Mineral wool thermal insulation materials are used as blankets and sheets, as well as filling material sometimes. It is also called by the names of glass wool and rock wool from place to place and purpose of use (Eren, 2009).
Rock Wool: Rock wool is produced by turning the inorganic raw material basalt stone into fibre at 1350-1400 oC. It is a non-flammable thermal insulation material. According to the physical properties of stone wool, it can be used in terraces, roofs, stairs, elevator shafts, internal insulation of interior walls, in adjacent walls, and behind granite, marble, etc. claddings on interiors for heat and sound insulation (Isbilir, 2009).
Glass wool: Glass wool consists of quartz sand, dolomite, calcium and sodium carbonate. Waste glass can also be used in its production. It is a light, flexible, economical and fireproof thermal insulation material. It is not affected by heat and humidity. It is also used as a sound insulation material. It is a long-lasting, corrosion-resistant, corrosion-proof and rust-proof material. Areas of use of glass wool: It is used in thermal insulation in all kinds of insulation in roofs and attics (Ozer et.al., 2019).
Expanded polystyrene foam (EPS): Expanded polystyrene foam is a material used as thermal insulation in building walls, floors, ceilings and terrace roofs. It is produced as a result of the pentane gas contained in the polystyrene raw material expanding as a result of contact with water vapour and becoming large blocks, followed by being cut with hot wire (Eren, 2009). It is non-resistant to fire.
Extruded polystyrene foam (XPS): Extruded polystyrene foam is a heat insulation material obtained by spraying polystyrene raw material under high pressure). The pressure value of XPS is quite high. Gases (HCFC) released in the production of XPS give harm to the ozone layer (Eren, 2009). XPS is flammable and it emits suffocating gas. This insulation material is highly resistant to water and load. XPS is used in pitched roofs, flooring and sandwich walls.
Cellulose: Cellulose is an organic material that forms the cell wall of plant cells and consists of carbon, hydrogen and oxygen atoms in its structure. Cellulose is the most abundant organic polymer in the world. The raw material of cellulose used in the production of recycled paper consists of materials such as wood, straw and cotton. This material is used for heat, sound and fire insulation in walls and roofs (Eren, 2009).
Expanded cork board (ICB): Cork is a granular thermal insulation material obtained from oak cork grown in the Mediterranean climate. It is not resistant to fire (Arslan, 2015). It is used as thermal insulation material in roofs, walls, floors and ceilings in private and public buildings. It is used in the insulation of cooling rooms, storage tanks and pipes in industrial buildings.
Polyurethane rigid foam board (PUR): Polyurethane is a type of rigid foam formed by the reaction of isocyanates and polyols. It is a flammable material (Arslan, 2015). It is used in flat roofs, pitched roofs and flooring.

Fig.1. Conventional Insulation Materials

2.2.Comparison of Conventional Materials in terms of Thermal Insulation and Energy Saving

The materials with low thermal conductivity also have high thermal insulation. Materials with high thermal insulation properties also increase energy efficiency. In our day, mineral wools such as EPS (Polystyrene Rigid Foam), XPS (Polyurethane Foam), glass wool and rock wool are the most commonly used materials in insulation. In the selection of these materials, their properties of being fireproof and water resistant are important. In addition, insulation materials must be used in the most appropriate thickness. Thus, the desired goal can be achieved in terms of environment, human health and energy saving. The waterproofing of glass wool and rock wool materials is higher than the waterproofing of EPS, XPS and polyurethane. XPS, cork, cellulose, polyurethane are flammable, while rock wool and glass wool are non-flammable materials. When polyurethane is burned, cyanide is released, which is harmful to health.

Table 1. Thermal conductivity values of insulation materials

Insulation Materials	Thermal conductivity values (W/mK)
Glass wool	0.04
Rock wool	0.04
Polystyrene Rigid Foam (EPS)	0.04
Polyurethane Foam (XPS)	0.028 - 0.031
Polyurethane (PUR)	0.020
Cork Board (ICB)	0.040 - 0.055
Cellulose	0.037

In comparison of the thermal conductivity values of the insulation materials seen in Table 1, it is seen that the material with the lowest thermal conductivity is Polyurethane. Due to the fact that its thermal insulation property is high, its energy efficiency also increases. According to the data of the Ministry of Energy and Natural Resources, the amount of energy consumed per person per hour in Turkey is 250kWh. It is stated that it is 50-70 kWh in Germany and 20kWh in Austria (Sen, 2006). As can be seen here, higher importance must be given to thermal insulation in order for Turkey to reach the level of the other countries in energy saving. Fire resistance is required as a feature in thermal insulation materials, in addition to thermal conductivity. Glass wool is one of the thermal insulation materials with the highest fire resistance.

2.3.Innovative Insulation Materials (Fig.2.)

A major part of the energy consumption happens in residential and commercial buildings. Traditional insulation materials have adverse impacts on energy efficiency due to their thermal conductivity, fire resistance and carbon gas emissions into the air. These materials were produced and started to be used between 1950 and 1973. Due to the reasons such as many of these materials cause problems in practice, threaten health, and insufficiency of energy efficiency in terms of increasing energy demand in the future, the need for efficient, healthy, sustainable and environmentally friendly insulation materials has arisen. Due to these requirements, new materials have been developed. Innovative (new generation) materials have emerged as a result of materials that can replace materials including carbon gases and that are likely to damage the ozone layer. In Europe, the fact that 25% of the energy losses being in the insulation of the buildings incited new studies to start, and as a result of these studies, the nature-friendly insulation material Puret has been started to be produced. New generation insulation materials prevent heat transfer by means of their low heat transfer coefficient and having a thinner structure (Senkal, 2005; Kuk, 2019).

Fig.2. Innovative Insulation Materials

Puret: This material cleans the air around it by keeping the free radicals, other pollutants and surfaces in contact with the photocatalytic surface clean. Laboratory tests demonstrate that Puret reduces the level of harmful oxides. It is planned to use Puret in the European ISCAPE project designed to solve the environmental problems in the future. As a step taken in the fight against climate change, it is estimated that 700 trees will be provided with air purification capacity with this project.

Vacuum Insulation Panels (VIP): Porous interior vacuum insulation panels are highly efficient insulation materials compared to many common insulation materials. They have 10 times more insulation properties than conventional insulation materials. Its disadvantage is that it loses the performance of insulation during cutting and drilling while being applied, in addition to its production cost. Vacuum insulation panels are used in facade cladding, roof and floor insulation and internal insulation of buildings. Their insulation performance is high. They are used in the insulation of buildings due to its long service life and high energy efficiency. However, it is not preferred in Turkey due to its high production cost (Bostancıoğlu, 2010).

Aerogels: Aerogel is a smart material used as insulation material. It is formed by polymer being combined with a solvent to form a gel, and then by removing the liquid in this gel and replacing it with air. It provides good insulation against fire. It is also used as a good sound insulation material due to the air molecules trapped in its structure. Blankets used in the structure demonstrate excellent thermal insulation properties (Ozer et al., 2019). Thanks to these features, they contribute to energy efficiency. It can be used in windows, facades and roofs. Due to its energy-retaining feature, it is a superior material that is environmentally and nature-friendly.
Isonaturelle: Isonaturelle is a powder mixture used as a multi-purpose insulation material that insulates heat, sound and fire, and also has properties of moisture repellency. It consists of 12 natural materials such as super white cement, silicate sand, polymer and binders. It provides 40% heat saving in buildings. It is a material that does not lose its environmental friendliness and does not harm human health during production and after application. Besides being a fireproof class A insulation material, it does not emit harmful gases to the environment in fire. It is a long-lasting and recyclable material.
Vacuum Insulation Panels (VIP): Porous interior vacuum insulation panels are highly efficient insulation materials compared to many common insulation materials. They have 10 times more insulation properties than conventional insulation materials. Its disadvantage is that it loses the performance of insulation during cutting and drilling while being applied, in addition to its production cost. Vacuum insulation panels are used in facade cladding, roof and floor insulation and internal insulation of buildings. Their insulation performance is high. They provide long service life.
Expanded Perlite Sheets: Expanded perlite sheets consist of silica and aluminium components. It is a material with a glassy structure that contains water within its composition. They are used in building cavities in high thermal insulation applications.
ss-PCM (Shape Stabilized Phase Change Material): The research team consisting of scientists from Martin Luther University Halle-Württemberg (MLU) and Leipzig University in Germany developed a new heat storage material named ss-PCM. The importance of this new material is that it retains more heat and that it is made of environmentally friendly fatty acids found in lime peels. In composition of the material, environmentally friendly fatty acids found in rice hulls were used.

3. CONCLUSIONS

This study emphasises how important the application of heat insulation and the selection of the material used in insulation. Thermal insulation reduces energy consumption. It has been determined in the researches that an average of 40% energy savings is achieved with the proper use of appropriate material. Thus, the environment and nature will be protected. When Turkey was compared with other countries in the world, it is seen that it is far behind in thermal insulation. Other countries must be taken as example by the studies on energy saving being followed and implemented in Turkey, and action must be taken as soon as possible in terms of climate change, reduction of resources and air pollution. For reducing heat losses, it is necessary to raise awareness of humanity on the importance of insulation, and to minimise the damage to nature by increasing the number of insulated buildings. As a result of this, our limited sources can be conserved while contributing to the country's economy.

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BUTYRATE GENERATION DURING THE FERMENTATION OF BIO-HYDROGEN AS A GREEN CHEMICAL

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ABSTRACT
Trace element addition was optimized for hydrogen and butyric acid production using a three-level Box Behnken Design of the response surface methodology. With sodium chloride, sodium thiosulphate, and minerals (Fe, Zn, Cu, and Ni) as variables, seventeen runs were planned. The model has a high R2 of 96% and a P value of 0.03 and fits a cubic model. The generation of butyrate was significantly impacted by certain of the interacting variables. The maximal butyrate concentration produced by the lactose substrate when 10 g/L of lactose was used (4.64 g/L) was extremely close to the expected value. The greatest BA/AA ratio (2,65) found from the experimental setup resulted in a cumulative hydrogen formation of 178.8 mL, a Yp/s of 3.6 mmolH2/mmol lactose, and an HPR of 2.4 mL/g/h.
Keywords: Bio-hydrogen, Dark Fermentation, Butyric acid, Clostridium aceotobutylicum, Box-Behnken Design

1. INTRODUCTION
Biohydrogen is an important eco-friendly energy carrier that is produced via biomass valorization (Özmıhçı et al., 2022). Besides biofuel organic acids such as butyric acid is produced as an end product after fermentation, these processes offer more than one helpful end products which is valuable in a new sustainable economy (Polettini et al., 2022). Hydrogen is a high-energy power source obtained mostly during primary fermentation through the production of acetate, and butyrate (Baeyens et al., 2020). Butyrate produced by dark fermentation from glucose produces 2 moles of H2 (Polettini et al., 2022). Butyrate is widely used in food, pharmaceutical, and cosmetics (Camara et al., 2021).
Organisms such as Clostridium acetobutylicum can be used for butyrate and biohydrogen fermentation. The operational conditions of these organisms depend on the temperature, the alkalinity, the retention time, and the operation mode (Alibardi et al., 2016).
In the literature, there are examples of butyrate-based hydrogen production studies using food waste, cheese whey (CW), and rice straw as substrates (Fu et al., 2019).
Trace element additions have to be made to increase the production efficiency of butyrate and hydrogen. Various studies have observed mineral addition such as iron, nickel, zinc, copper, sodium thiosulphate, and sodium chloride (Fu et al., 2019). The literature studies reveal (3-54) g/L butyric acid production with different substrates and organisms under dark fermentation conditions.

2. EXPERIMENTAL SET-UP AND PROCEDURE
The experiments were carried out with a constant concentration of 10 g/L lactose as a substrate and dark fermentation. It was executed in 250 mL Isolab-Germany Boro 3.3 serum bottles with a working volume of 150 mL. Using the Box-Behnken design, an experimental design was made with independent parameters of sodium chloride, sodium thiosulfate, and mineral concentrations at 17 runs. Variable concentrations are given in Table 1.
The fermentation medium contained 10 g/L peptone, 0.6 g/L yeast extract, 0.1 g/L L-cysteine, 2.8 g/L K2HPO4, 3.9 g/L KH2PO4, 0.25 g/L MgSO4, and 0.25 g/L KH2PO4 [1]. The fermentation process used ten days of mesophilic (37°C) conditions. Prior to fermentation, the experimental media's pH was adjusted to 7.2 using 10M NaOH, and the bottles underwent a 15-minute autoclave at 121°C. To establish anaerobic conditions, nitrogen gas was sparged over the top of the bottles. The bottles were then sealed with silicone and stoppers and caps to ensure gas tightness.

Table 1. Variables and experimental Box-Behnken design levels.

Variables		Experimental range			
Factors	Parameters	Units	Low (−1)	Middle (0)	High (+1)
X1	Sodium Chloride	g/L	0.1	2.55	5
X2	Sodium Thiosulfate	mg/L	0	100	200
X3	Minerals	mM	0	0.4	0.8

2.1. Organisms

The USDA National Center for Agricultural Utilization Research, Peoria, IL, USA, provided the Clostridium acetobutylicum-NRLL-B 527 (CAB) pure anaerobic culture. A medium containing 10 g/L lactose, 2.8 g/L K2HPO4, 3.9 g/L KH2PO4, 0.25 g/L MgSO4, 10 g/L peptone, 0.6 g/L yeast extract, and 0.1 g/L L-cysteine was inoculated with C. acetobutylicum [8]. Nitrogen gas was pumped through the bottle's top to create anaerobic conditions, and the organisms were then cultured for two days at 37°C with a starting pH of 7.2. At the conclusion of the second day, the organisms were injected into the fermentation media.

2.2. Analysis

Every day, 5 mL samples from the experimental bottles were taken and centrifuged at 8000 rpm for 15 minutes to analyze the fermentation media's liquid component. The generated clear supernatant underwent tests for total sugar concentration, pH, and total volatile fatty acid concentration. The total sugar concentration was determined using the acid-phenol spectrometry technique. Simple sugar and total volatile fatty acid concentrations were analyzed using high-purity liquid chromatography (Agilent 1100; Aminex HPX-84H column). 0.6 mL/min of 5 mM H2SO4 was used as the mobile phase. Each sample was drawn from the fermentation bottles using a gas-tight glass syringe for examination in the gas phase. Gas chromatography (Agilent 6890 N-GC) was used to calculate the concentration of hydrogen gas. Alltech, Hayesep D 80/100 (6 in. x 1/8 in. x 0.85 in.) was the type of column used in the GC. The carrier gas was nitrogen, flowing at a rate of 30 mL/min. Temperatures for the furnace, injection, detector, and filament were, respectively, 35°C, 120°C, 120°C, and 140°C. The water displacement method with 2% H2SO4 and 10% NaCl was used to calculate the total volume of gas generated [1].

3. RESULTS AND DISCUSSION

In this study, optimization was made with the Box-Behnken statistical method. The effects of sodium chloride, sodium thiosulfate, and mineral concentrations (Fe, Ni, Cu, Zn) on butyrate and biohydrogen production were investigated. Experiments were carried out with Clostridium acetobutylicum at 37°C for 10 days. Table 2. shows an analysis of variance for a cubic model of butyric acid with a three-factor Box-Behnken Design (BBD).

The model is very significant if the adjusted determination coefficient (adjusted R2= 0.8353) and determination coefficient (R2 = 0.9588) have high values. In the planned experiment, butyric acid concentrations ranged from 1.78 to 4.64 g/L. The model had a mean value of 2.98 g/L butyric acid concentration and a standard deviation of 0.2749. The model's significance is shown by P-values less than 0.05 [39–40]. A very significant model can be detected by a P-value of less than 0.01 [29], whereas an inconsequential model is shown by a P-value of more than 0.05 [39–40]. To be significant, the F value must be greater than the P-value. The model F-value (7.76) and P-value (0.03) indicate that the model is highly significant.

Table 2. ANOVA (Analysis of Variance) table for cubic model of butyric acid with three factor Box-Behnken Design.

Source	Sum of Squares	df	Mean Square	F-value	p-value
Model	7.04	12	0.5866	7.76	0.031
A-NaCl conc.	0.017	1	0.017	0.2255	0.6596
B-sodium thiosulfate	0.0905	1	0.0905	1.2	0.3351
C-Minerals	0.35	1	0.35	4.63	0.0977
AB	2.35	1	2.35	31.14	0.0051
AC	0.089	1	0.089	1.18	0.3389
BC	0.4271	1	0.4271	5.65	0.0762
A^2	0.0171	1	0.0171	0.2258	0.6595
B^2	0.6196	1	0.6196	8.2	0.0457
C^2	0.8847	1	0.8847	11.71	0.0267
A^2B	1.33	1	1.33	17.59	0.0138
A^2C	0.4693	1	0.4693	6.21	0.0673
AB^2	0.1441	1	0.1441	1,91	0.2394
Pure Error	0.3022	4	0.0755		
Cor Total	7.34	16			

The experimental data was found very close to the predicted ones. Response surface methodology (RSM) with interactive effects of sodium chloride and sodium thiosulfate on BA in Figure 1, sodium chloride and minerals on BA in Figure 2, and sodium thiosulphate and minerals on butyric acid production is given in Figure 3. According to the significant terms which were the interactions of AB, B2, C2, A2B, and A2C showed that low NaCl, high sodium thiosulphate, and high mineral concentrations favor both butyric acid and hydrogen production.

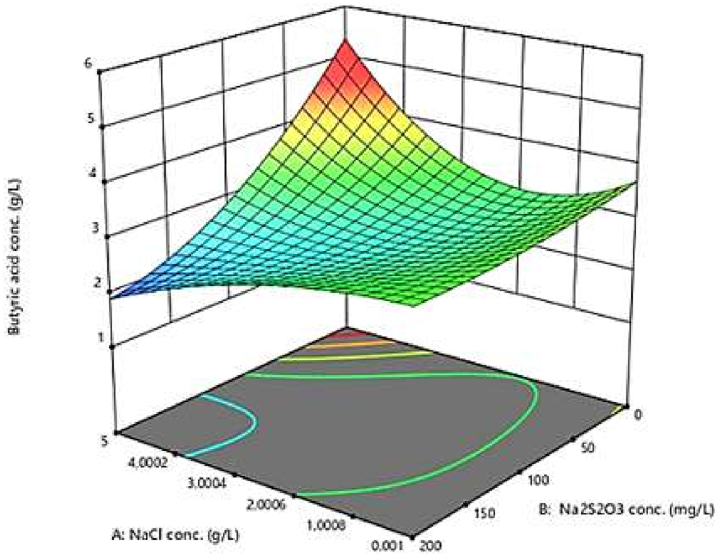

Figure 1. Response surface plot showing the effect of sodium chloride concentration (g/L) and sodium thiosulphate concentration (mg/L) on butyric acid production.

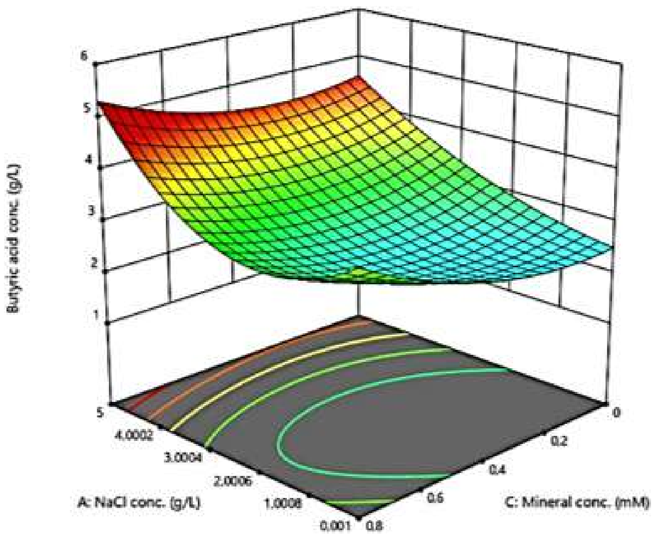

Figure 2. Response surface plot showing the effect of sodium chloride concentration (g/L) and mineral concentration (mM) on butyric acid production.

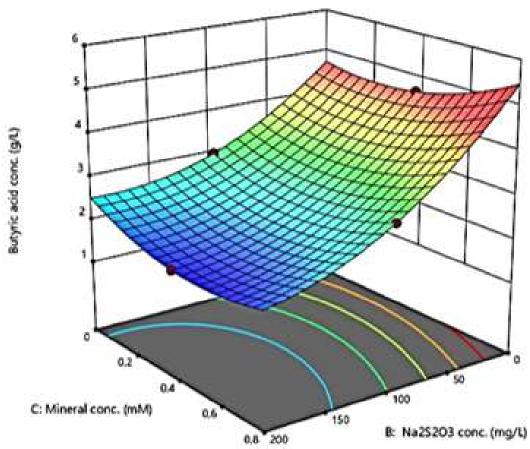

Figure 3. Response surface plot showing the effect of sodium thiosulphate concentration (mg/L) and mineral concentration (mM) on butyric acid production.

Table 3. Experimental Results of CHF, BA/AA, YP/S and HPR

Run	CHF (mL)	BA/AA (g/g)	$Y_{p/s}$ (mmol/mmol)	HPR (mL/g/h)
1	89.2	1.7	1.8	1.0
2	130.7	0.7	**2.4**	1.1
3	117.1	1.4	1.6	1.3
4	131.3	1.1	1.8	0.9
5	**190.2**	**2.2**	**2.3**	**2.6**
6	124.6	0.9	1.5	1.0
7	**178.8**	**2.6**	**3.6**	**2.4**
8	103.7	0.6	1.6	0.8
9	144.8	1.3	**3.7**	**2.5**
10	142.5	0.9	1.8	1.2
11	139.4	0.8	1.7	1.1
12	120.1	0.8	1.8	1.2
13	116	0.9	1.8	1.6
14	135.5	1.0	2.0	1.7
15	33.4	**2.4**	**3.0**	**2.5**
16	155.9	1.5	**2.6**	1.4
17	120.3	1.3	1.4	1.5

The test results of the butyric acid/acetic acid (BA/AA) ratio, hydrogen production efficiency (Yp/s), Cumulative Hydrogen Formation (CHF), and hydrogen production rate (HPR) for each run are given in Table 3. All these parameters were tested in the BBD model and the model with the highest R2, which was made according to the produced butyric acid concentrations, was selected. According to Table 3, it was concluded that the highest CHF, Yp/s, HPR, and BA/AA ratios were in the 5th, 7th, and 15th runes.

4. CONCLUSIONS

In this study, butyrate production was used as a proxy for the statistical optimization of biohydrogen generation. The results of the present investigation indicated that the butyric acid production model for the three components fit a cubic model with a high R2 of 96%, according to the ANOVA table. According to the significant terms which were the interactions of AB, B2, C2, A2B, and A2C showed that low NaCl, high sodium thiosulphate and high mineral concentrations favor both butyric acid, and hydrogen production. The model also demonstrated that the ratios of BA/AA, YP/S, and HPR increased when NaCl concentrations elevated. Meanwhile, it was found that the potential for producing hydrogen was adversely influenced by the rise in sodium thiosulfate and mineral concentrations. The research demonstrates that the technique can create butyrate, which is commercially available in addition to hydrogen, producing both green hydrogen and green chemicals. This dual output can help create an economy that is sustainable.

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THE EFFECTS OF CALSIUM CARBONATE ON HYDROGEN AND BUTYRATE PRODUCTION

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ABSTRACT
The effect of different calcium carbonate concentrations on butyric acid production with hydrogen production was investigated using cheese whey powder (CWP) as substrate (20 g/L). The study was carried out in dark fermentation using Clostridium acetobutylicum at 37°C for 10 days. As a result, 0.1 g/ L $CaCO_3$ significantly increased both hydrogen production, butyric acid production potential, and BA/AA ratios. The values enhancing butyrate along with hydrogen were observed as 138.25 mL H_2, 2.4 g/L butyric acid, 7.68 g/g BA/AA ratio, 0.17 g HBU/ g TS butyric acid production yield and 0.001 gHBU/ gTS h butyric acid production rate at 0.1 g/L calcium carbonate concentration.
Keywords: Bio-hydrogen, Butyric acid, Clostridium acetobutylicum, Calcium carbonate

1. INTRODUCTION
Green fuels and green chemicals produced from biomass is nowadays trend topic offering an eco-friendly and sustainable process while avoiding fossil fuel usage (Camara-Salim et al., 2021). Especially, waste sustrates can be converted into commercially useful products such as chemicals, biofuels and biofertilizer (Fu et al., 2019). Biohydrogen production as biofuel and their by-products as various organic acids, such as butyric and acetic acid, are seen as important outputs in the industry (Baeyens et al., 2020; Polettini et al., 2022).

Butyric acid is widely used in the food, pharmaceutical, and cosmetic industries as a flavor, fragrance, and aroma (Camara-Salim et al., 2021; Liu et al, 2018, Fu et al., 2017). It is used in hemoglobinopathies, cancer and gastrointestinal diseases, and vasoconstrictor drugs due to its anti-cancer effects (Camara-Salim et al., 2021; Atasoy and Cetecioglu, 2020). Butyric acid is one of the organic acids produced by bacterial fermentation of various substances (Zu et al., 2005). Sugarcane vinasse, food waste, dairy wastewater, straw, pulp and paper industry wastewater are some examples of these substrates. Cheese whey is a good waste substrate to be used for hydrogen and butyric acid production (Oh et al., 2019; Jang et al., 2014; Yang et al., 2013; Alibardi et al., 2016).

Additives such as iron, nickel, zinc, copper, sodium thiosulphate, sodium chloride, calcium carbonate increase the production efficiency of butyrate and hydrogen (Fu et al., 2019). In the literature, studies with different minerals reveal (3-54) g/L butyric acid production with different substrates and organisms under dark fermentation conditions (Oh et al., 2019; Jang et al., 2014; Yang et al., 2013; Alibardi et al., 2016).

In this study, the effect of different calcium carbonate concentrations (0, 0.1, 0.5, 1, 2, 3, 4 g/ L) on butyric acid production along with hydrogen production was investigated using cheese whey powder (CWP) as substrate (20 g/L).

2. EXPERIMENTAL SET-UP AND PROCEDURE

2.1 Experimental Set-up
The experiments were carried out with 20g/ L cheese whey powder (CWP) including 14.7 g/ L total sugar. 250 mL Isolab-Germany Boro 3.3 serum bottles with a working volume of 150 mL were used. The calcium carbonate concentrations were changed in the fermentation medium varying between 0-4 g/ L to enhance butyrate production. The fermentation medium contained 10 g/ L peptone, 0.6 g/ L yeast extract, 0.1 g/ L L-cysteine, 2.8 g/ L K_2HPO_4, 3.9 g/ L KH_2PO_4 and 0.25 g/ L $MgSO_4$. The pH was adjusted to 6.5 using 10M NaOH while the initial pH was 7.2. Fermentation was carried out in an incubator set to 37oC for 10 days. The experimental bottles were autoclaved for 15 min at 121oC before inoculation. Nitrogen gas was sparged over the top of the bottles to establish anaerobic conditions. Then they were sealed with silicone stoppers and caps to ensure gas tightness (Kargi et al., 2012).

2.2 Organisms
C.acetobutylicum-NRLL-B 527 (CAB) was obtained from the USDA National Center for Agricultural Utilization Research, Peoria, IL, USA. The organisms were prepared with the same procedure as the experminental bottles and were incubated for 2 days at 37°C. The organisms were inoculated into the fermentation media at the end of the 2nd day.

2.2. Analysis

5 mL liquid samples were taken from the experimental bottles and centrifuged at 8000 rpm for 15 minutes to analyze the fermentation media. The generated clear supernatant was used for total sugar concentration, pH, simple sugars and total volatile fatty acid concentration analysis. The total sugar concentration was determined using the acid-phenol spectrometry technique (Dubois, 1956). Simple sugar and total volatile fatty acid concentrations were analyzed using high-purity liquid chromatography (Agilent 1100; Aminex HPX-84H column). 0.6 mL/min of 5 mM H2SO4 was used as the mobile phase. Gas chromatography (Agilent 6890 N-GC) was used to calculate the concentration of hydrogen gas where samples were taken with a gas tight syringe from the headspace of the bottles. Alltech, Hayesep D 80/100 (6 in. x 1/8 in. x 0.85 in.) was the type of column used in the GC. The carrier gas was nitrogen, flowing at a rate of 30 mL/min. Temperatures for the furnace, injection, detector, and filament were, respectively, 35°C, 120°C, 120°C, and 140°C. The water displacement method with 2% H2SO4 and 10% NaCl was used to calculate the total volume of gas generated (Kargi et al. 2012).

3. RESULTS AND DISCUSSION

The effects of calcium carbonate (CaCO3:0-4 g/ L) on biohydrogen and butyric acid production was investigated with 20 g/ L cheese whey powder. Figure 1 shows the variation of cumulative hydrogen formation (CHF) and Fig 2 gives the changes of total sugar with time. Most of the total sugars were consumed in all tested bottles. The highest CHF was obtained with 0.1 g/ L CaCO3 concentration. The following concentration was 0.5 g/ L CaCO3 giving nearly 2/3 of the concentration obtained at 0.1 g/ L. It can be concluded from CHF that trace amounts of CaCO3 enhances hydrogen production however further increases decrease the CHF amounts.

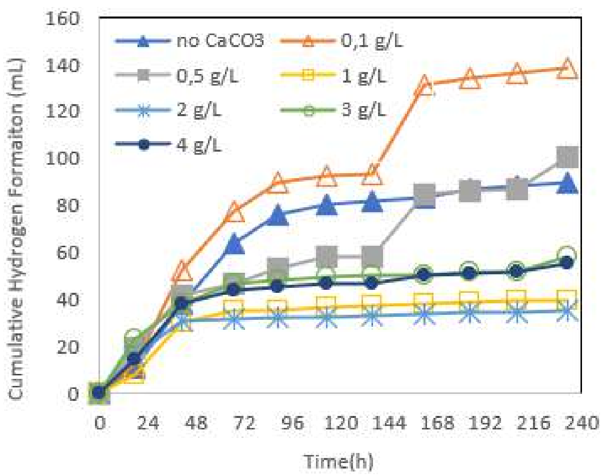

Figure 1. Variation of Cumulative hydrogen formation (CHF) with time

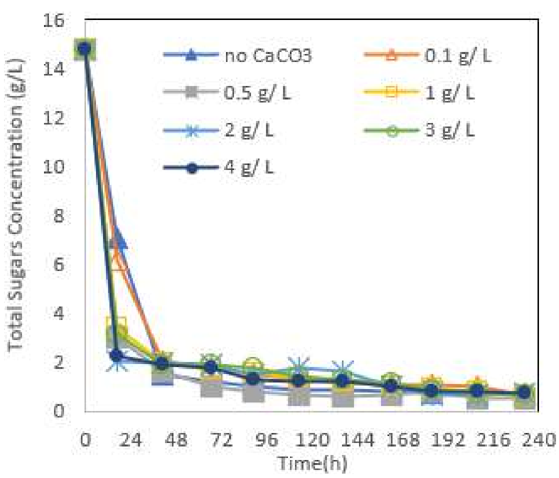

Figure 2. Variation of total sugar concentration with time

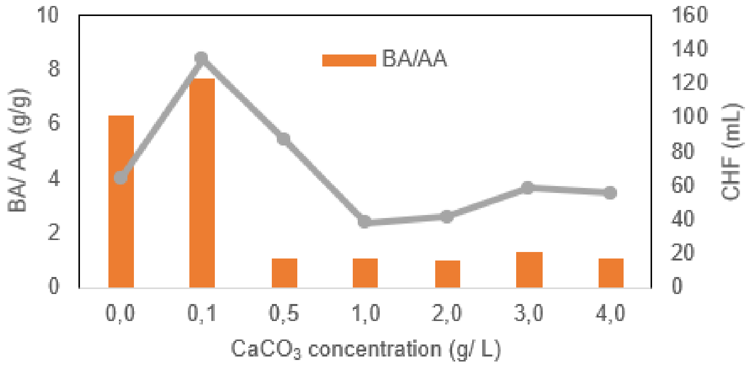

Figure 3. BA/AA rates (g/g) and Cumulative hydrogen formation (mL) with different CaCO3 concentrations

Figure 3 gives the Butyric acid/Acetic acid (BA/AA) ratios observed at the fermentation bottles with different CaCO3 concentrations. The same trend as CHF was observed with BA/AA ratios. 0.1 g/ L CaCO3 concentration increased BA/ AA ratios, where butyric acid production was favored. However, further increases caused to obtain approximately BA/ AA ratios of 1, where butyric and acetic acid concentrations were very close to each other.

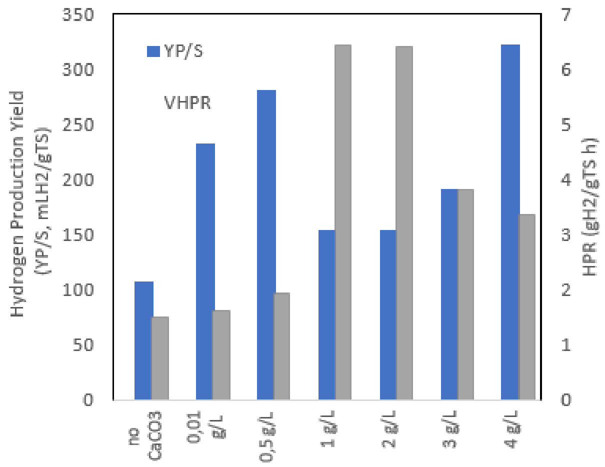

Figure 4. Hydrogen production yield and hydrogen production rates with different CaCO3 concentrations.

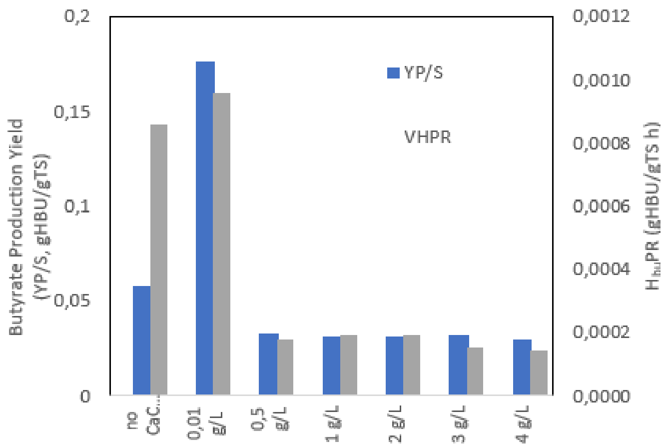

Figure 5. Butyrate production yield and butyrate production rates with different CaCo3 concentrations

Figure 4 depicts the hydrogen production yields and rates with CaCO3 concentrations. Hydrogen production yields increased with increasing CaCO3 concentrations. However, it decreased at 1 g/ L CaCO3 and then increased with further increases of CaCO3 concentrations. A metabolic shift to butyric acid production was observed untill 0.5 g/ L CaCO3 concentration. At 1 g/ L⩽ CaCO3 concentrations ⩾ 4 g/ L the fermentation media yielded lower hydrogen productions.

The BA/AA ratios at these values showed that the hydrogen production is due to acetic acid. However, the addtitive inhibited further acetic acid production. At 4 g/ L CaCO3 concentrations due to high total sugar conversion the hydrogen production yield was seen as the highest. Hydrogen Production yield was 322 mLH2/g TS at the highest tested CaCO3 concentration. Hydrogen production rates with different CaCO3 concentrations showed that rates increased with increasing CaCO3 amounts untill 2 g/L and decreased with further increases. It can be concluded that CaCO3 addition increased the rate of hydrogen production meaning that shortened the fermentation time. However, concentrations higher than 0.1 g/ L did not help to get higher hydrogen volumes.

Figure 5 shows the butyric acid production yields and rates with CaCO3 concentrations added to the fermentation media. It is clearly seen from the gragh that yield and rates increased with increasing CaCO3 concentrations until 0.1 g/ L CaCO3 concentration and than decreased rapidly. The yield and rate enhancing butyrate along with hydrogen were observed as 0.17 g HBU/ g TS and 0.001 gHBU/ gTS h, respectively.

4. CONCLUSIONS

The effects of calcium carbonate (CaCO3:0-4 g/ L) on biohydrogen and butyric acid production was investigated with 20 g/ L cheese whey powder. The highest CHF was obtained with 0.1 g/ L CaCO3 concentration. 0.1 g/ L CaCO3 concentration increased BA/AA ratios, where butyric acid production was favored. In further increases butyric and acetic acid concentrations were very close to each other. The highest butyric acid production yield and rate was obtained with 0.1 g/L CaCO3. Trace amounts of CaCO3 enhanced hydrogen production volumes, butyric acid concentrations however, further increases decrease the CHF, and butyric acid amounts. The values enhancing butyrate along with hydrogen were observed as 138.25 mL H2, 2.4 g/L butyric acid, and 7.68 g/g BA/AA ratio at 0.1 g/ L calcium carbonate concentration.

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Sustainable Thermal Desalination and Hydrogen Production: An Analysis of a Renewable-Based Energy System from a Thermodynamics Perspective

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ABSTRACT
To reduce the dependence of fossil fuel-based energy generation system which has many harmful effects including climate change, greenhouse gases (GHGs) and water pollution. The study is based on an energy system with multiple useful output in the form of electricity, potable water, hydrogen and oxygen. In this system concentrated solar parabolic trough (PTC) is used along with thermal energy storage (TES) to ensure nocturnal operations. The heat from the TES is used in the boiler of the organic Rankine Reheat cycle which uses "R600" as its working fluid and produces electricity as a useful output. The heat from the condenser unit is used to drive a multi-stage flash (MSF) desalination unit for the production of potable water. In addition, the freshwater from the desalination unit is used in the Proton exchange membrane electrolyser (PEM) to produce oxygen and hydrogen as useful output. To ensure stable PEM electrolyser operation an off grid solar power plant is utilized. To evaluate the overall performance of the system, a thorough thermodynamic analysis is carried out, encompassing mass, energy, entropy, as well as exergy balances. Additionally, energetic and exergetic efficiencies are calculated as part of the assessment. This comprehensive analysis provides a holistic understanding of the system's performance. The results show that approximately 1200.9 m3 of potable water is obtained daily, 4477.2 kg of Hydrogen and 35804.16 kg of Oxygen is produced by PEM electrolyser. The energy and exergy efficiencies for the desalination unit are 52% and 41%, respectively.
Keywords: Desalination, exergy, thermal energy storage, thermodynamic analysis, hydrogen, sustainable

1. INTRODUCTION
By 2050, the population of the world is going to rise by 26%, & subsequently, it will have a direct impact on energy, water, and food resources. Obtaining and utilizing these resources in a sustainable way is becoming more challenging, posing an increased threat to the ecosystem. During the last century, resource exploitation has been all-time high. The energy sector is witnessing the same, with an expected increasing trend, the energy consumption has increased by 28% between 2010 and 2040 (Luqman et al., 2019). So, it has compelled this generation of scientists and researchers to develop a more sustainable and greener resource utilization. Renewable energy with integrated systems design will adapt to the increasing energy demands in a sustainable way. But the intermittent nature of renewables has put forward a new challenge of better and more efficient energy storage technologies (M. Yekini Suberu et al., 2014)
In this study, a poly-generation system with multiple useful yields in form of electricity, fresh water, hydrogen, and oxygen has been carried out. The system is supported by Parabolic trough collectors (PTCs) with the inclusion of Thermal energy storage (TES) system for a continuous supply of heat and energy during night-time and unfavorable weather conditions (Ram and Ravi, 2021). The system also includes an Organic Rankine Reheat cycle for producing electrical power and a multistage flash (MSF) desalination system for producing freshwater. The system also integrates a proton exchange membrane (PEM) electrolyser for oxygen and hydrogen production. The PEM electrolyser is powered by a solar power plant and utilizes the potable water from the desalination unit. Desalination systems have several drawbacks. The proposed system unification is projected to reduce thermal losses caused by the high temperatures of the salt-water and brine departing the desalination system. The suggested desalination system is powered by the Organic Rankine Reheat cycle as opposed to systems that use fossil fuels, making it more ecologically friendly.
The specific objectives are the following:
1. The layout of a poly-generation renewable systems for electricity, hydrogen production, oxygen production, and potable water requirements.
2. To perform study of thermodynamic analysis on subsystems.
3. To perform energy and exergy efficiencies analysis of the subsystems.

2. SYSTEM OVERVIEW AND ANALYSIS
The suggested poly-generation system is shown in the Figure 1, and it uses PTCs with a (TES) system. The TES integrated system removes the intermittent nature of the renewables. The energy stored in the TES is utilized by the boiler of the Organic Rankine reheat cycle. Also, the heat from the condenser coils is utilized to run a multi-stage flash (MSF) desalination system for the production freshwater. The potable water from the desalination unit is used to run a PEM electrolyser, the electricity for electrolysis is provided by solar power plant. The PEM electrolyser is used to split water into hydrogen and oxygen.

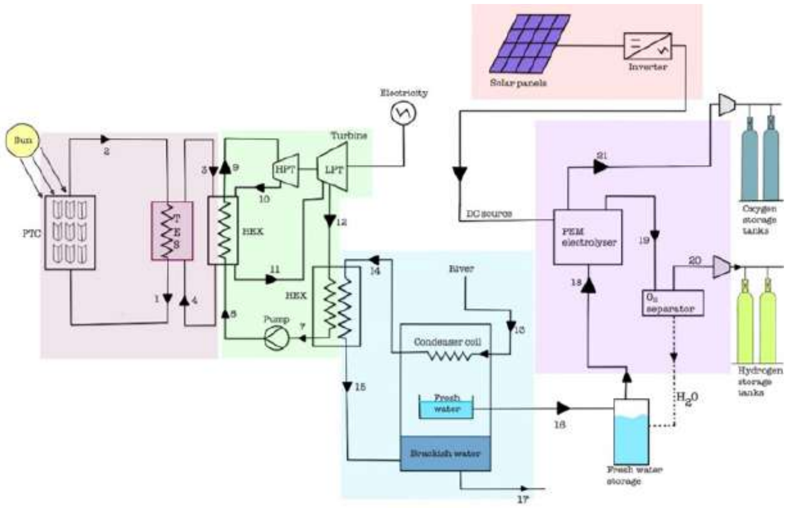

Fig.1. Schematic of the proposed Poly-generation system

The system explores applications of basic thermodynamic balances, including equations for mass, energy, entropy, and exergy. Each subsystem is individually balanced and the equations are integrated by providing the appropriate inputs to formulate a comprehensive thermodynamic model of the entire unit. Engineering equation solving (EES) is used to solve the balance equations. In addition, the energy and exergetic efficiency is calculated for each individual system.

The following assumptions have been made in this analysis:

- Steady state and processes are steady flow.
- The variation of kinetic and potential terms in energy and exergy balances are neglected
- The surrounding conditions are assumed as T [0] =25 [0C] and P [0] =101.3 [kPa]
- Input saline water concentration considered is 35 [g/L]
- The Organic Rankine reheat cycle uses "R600" as working fluid
- Water is used as the working fluid for both solar and TES unit.
- Heat exchanger work at constant pressure (isobaric).
- The fresh water from desalination plant is used in the PEM electrolyser unit

2.1 TES UNIT (CHARGING AND DISCHARGING CYCLE)

During charging of the TES cycle the mass balance is given by:

$$\dot{m}_2 = \dot{m}_1 \quad (1)$$

The charging cycle utilizes the energy balance equation as follows:

$$\dot{Q}_{gained,tes} = (\dot{m}_2 \cdot h_2) - (\dot{m}_1 \cdot h_1) - (\dot{Q}_{lost,tes,charging}) \quad (2)$$

$$\dot{Q}_{lost,tes,charging} = (1 - \eta_{tes,charging}) \cdot ((\dot{m}_2 \cdot h_2) - (\dot{m}_1 \cdot h_1)) \quad (3)$$

The entropy balance equation is:

$$\dot{S}_{gen,charging} = (\dot{m}_1 \cdot s_1) - (\dot{m}_2 \cdot s_2) + \left(\frac{\dot{Q}_{gained,tes}}{T_1}\right) + \left(\frac{\dot{Q}_{lost,tes,charging}}{T_0}\right) \quad (4)$$

The exergy balance equation is given as:

$$\dot{Ex}_{des,charging} = (\dot{m}_2 \cdot ex2) - (\dot{m}_1 \cdot ex1) - \left(\dot{Q}_{gained,tes} \cdot \left(1 - \frac{T_0}{T_1}\right)\right) - \left(\dot{Q}_{lost,tes,charging} \cdot \left(1 - \frac{T_0}{T_0}\right)\right) \quad (5)$$

Also, the mass balance during a discharging cycle is given by:

$$\dot{m}_3 = \dot{m}_4 \quad (6)$$

the discharging cycle has energy balance given by equation (7):

$$\dot{Q}_{disch,tes} = (\dot{m}_3 \cdot h_3) - (\dot{m}_4 \cdot h_4) \quad (7)$$

$$\eta_{tes,disch} = \dot{Q}_{needed,syst} / \dot{Q}_{disch,tes} \quad (8)$$

The entropy balance equation is:

$$\dot{S}_{gen,disch} = (\dot{m}_3 \cdot s_3) - (\dot{m}_4 \cdot s_4) - \left(\frac{\dot{Q}_{disch,tes}}{T_{TES}}\right) \quad (9)$$

The exergy balance equation is given as:

$$\dot{E}x_{des,disch} = (\dot{m}_4 \cdot ex4) - (\dot{m}_3 \cdot ex3) + \left(\dot{Q}_{disch,tes} \cdot \left(1 - \frac{T_0}{T_{TES}}\right)\right) \quad (10)$$

2.2. PEM ELECTROLYSER

The electrolysis reaction in PEM is given by:

$$H_2O_{(liquid)} \rightarrow H_{2(gas)} + \frac{1}{2}O_{2(gas)} \quad (11)$$

The mass balance is given by the molar flow rate determined by (Michael K.H. Leung et al. 2008):

$$\dot{N}_{H2,out} = \frac{J}{2F} \quad (12)$$

The voltage and electrolyser power demand are given by (Taheri et al., 2021)

$$Q_{electric} = J.V \quad (14)$$

$$V = V_o + \eta_{act,a} + \eta_{act,c} + \eta_{ohm} \quad (15)$$

3. RESULTS AND DISCUSSION

EES software was used to analyze the balance equation of mass, energy, entropy and exergy along with energy and exergy efficiency. The potable water accumulated from the desalination system is 1200.9 m3/day. The PEM electrolyser produces 4477.2 kg of Hydrogen and 35804.16 kg of Oxygen daily. The organic Rankine reheat cycle produces electricity equivalent to 83.9 kW. The energetic and exergetic efficiency of the PEM electrolyser are 56 % and 55 %, respectively. For desalination unit the energy and exergy efficiency are 52 % and 41 %, respectively. The organic Rankine reheat cycle has energy and exergy efficiency of 12.9 % and 14 %, respectively. Also, the cell potential vs current density is plotted as shown in Figure 2.

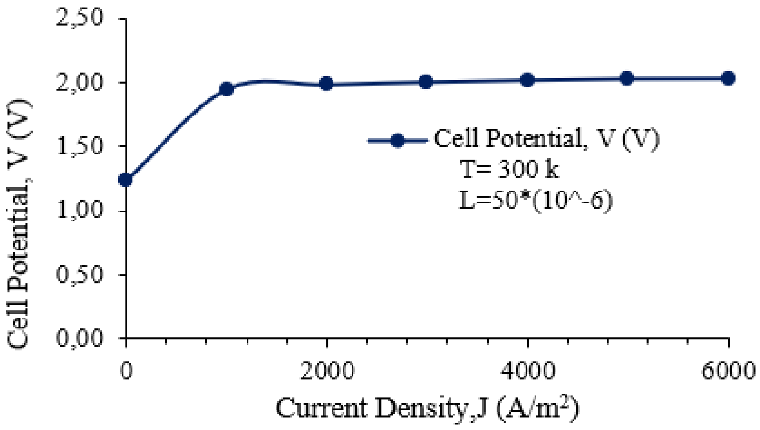

Figure 2. Current density and cell potential characteristics

4. CONCLUSIONS

The obtained results can be summarized as follows:

- The maximum energy and exergy efficiency of the PEM electrolyzer are 56% and 55%, respectively.
- The amount of electricity generated from the Organic Rankine reheat cycle is 83.9 kW.
- The energy and exergy efficiency of organic Rankine reheat cycle are 12.9 % and 14 %, respectively.
- The desalination unit produces 1200.9 m3 of potable water daily.
- The PEM electrolyser produces 4477.2 kg of Hydrogen and 35804.16 kg of Oxygen daily.

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DEVELOPMENT OF PHASE CHANGE MATERIAL MICROCAPSULES AND COMPOSITES USING A GREEN METHOD

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ABSTRACT
In this study we developed an innovative green method for microencapsulating phase change materials, avoiding the use of formaldehyde or any solvent. Nonadecane, a phase change material, was chosen as the core material, while humic acid was selected as the shell material for the capsules. The resulting microcapsules and composites were thoroughly evaluated in terms of their thermal and leakage properties. The analysis results indicated the promising potential of the produced nonadecane@humic acid microcapsules with green method as phase change materials for thermal energy storage applications.
Keywords: Phase change material, humic acid, microencapsulation, green method, composite

1. INTRODUCTION
Phase change materials (PCMs) are utilized as thermal energy storage materials to reduce heating and cooling loads. In recent years, there has been significant research focus in this area. The latent heat storage capability of PCMs allows for reduced energy consumption in heating and cooling applications, leading to a decrease in the use of fossil fuels and mitigating global warming. The behavior of PCMs during phase transitions is of great importance due to their latent heat storage or release characteristics. This study utilizes the solid-liquid transitions of PCMs. Microencapsulation and composite preparation play a vital role in preventing PCM leakage during phase change within the application environment. By encapsulating the PCM within a polymer shell or composite matrix, the phase transition occurs within defined boundaries, ensuring minimal direct interaction with the surrounding environment.

In this study, nonadecane (CH3(CH2)17CH3), with its suitable thermal properties including a melting point of 33°C and latent heat of approximately 190°C, was employed as the PCM. In recent studies, researchers have been focusing on the microencapsulation of nonadecane and the production of composites. Literature research shows that recent studies have been conducted by multiple researchers with a focus on the microencapsulation of nonadecane and the production of nonadecane composites. For example, Jin et al. (2010) prepared nonadecane@silica microcapsules containing 65% nonadecane using a one-step method. Zhang et al. (2014) and Moghaddam et al., (2015) prepared nonadecane microcapsules with a calcium carbonate and calcium alginate shell material respectively as thermal energy storage material. Kamali et al., (2015) prepared nonadecane microcapsules with alginate shell. In another studies, nonadecane microcapsules was prepared with in situ polymerization using urea–melamine–formaldehyde polymer as shells (Zhang et al., 2015), melamine-formaldehyde resin (Xie et al.,2015), poly (methyl methacrylate-co-butyl acrylate-co-methacrylic acid) (Naikwadi et al, 2021), poly(methyl methacrylate) (Sarı et al., 2014) and polystyrene (Sanchez et al., 2007).

Humic acid (HA) is a complex mixture of organic compounds that is commonly found in soil, coal, peat, and other natural environments. In this study HA, a naturally occurring substance that can be produced using cost-effective methods from lignite deposits in our country, was utilized for the first time in microencapsulation studies and the production of composite materials of PCMs

In this study, nonadecane microcapsules with humic acid shell material were synthesized using green method The analysis results demonstrate that nonadecane microcapsules were successfully prepared using a green method. The prepared microcapsules exhibit great potential as a promising candidate for an energy storage material in thermal energy storage applications.

2. MATERIAL AND METHODS
2.1. Materials and Methods
In this study, nonadecane was used as capsule core material and humic acid (Turkish Coal Enterprises (TKİ), Turkey) as shell material. HCl were used to control the pH. Tween 40 (Merck, Germany) was used as emulsifier during microcapsule synthesis.

The thermal properties of the microencapsulated phase-changing material were obtained by differential scanning calorimetry (DSC, PerkinElmer DSC 4000).

3. RESULTS AND DISCUSSION

The produced nonadecane/humic acid (HA) microcapsules and composites, as shown in Figure 1, exhibit a brown-black color attributed to the presence of HA.

Figure 1. Prepared nonadecane@HA microcapsules

To determine the leakage properties at the melting temperature of nonadecane, both the non-encapsulated nonadecane and the nonadecane-HA capsules were heated and maintained at 70°C for 60 minutes. The results are presented in Figure 2. As can be seen in this photo after thermal resistance test at 70 °C for 60 minutes prepared nonadecane microcapsules show good heat resistance.

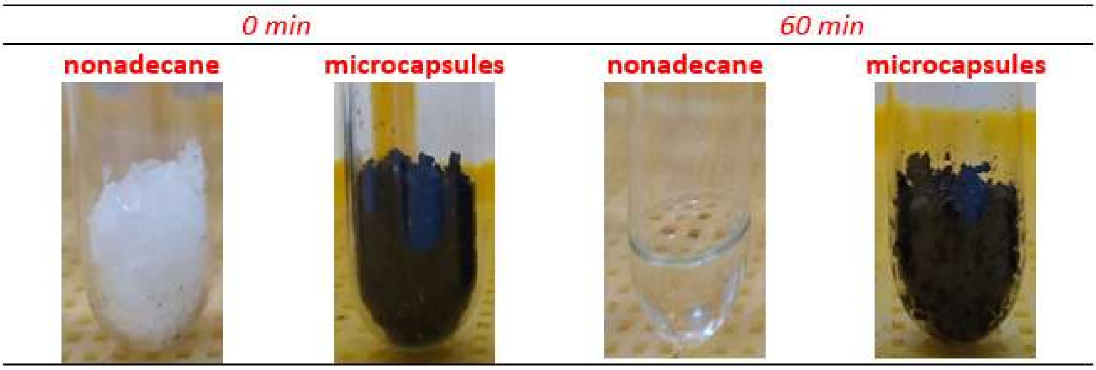

Figure 2. Lekage properties of nonadecane@HA microcapsules

The determination of thermal properties plays a crucial role as it directly impacts the efficiency of applications. In this study, the thermal properties of nonadecane and nonadecane-HA microcapsules were investigated using differential scanning calorimetry (DSC), and the results are summarized in Figure 3 and Figure 4. The analysis revealed that the melting and freezing temperatures were 33.23°C and 31.86°C, respectively, for nonadecane, and 28.87°C and 27.57°C, respectively, for nonadecane microcapsules. The latent heat of melting and freezing were determined to be 190.10 J/g and -201.41 J/g, respectively, for nonadecane, and 63.49 J/g and -66.71 J/g, respectively, for nonadecane microcapsules. These thermal properties demonstrate that the prepared microcapsules can be utilized as phase change materials (PCM) in thermal energy storage applications to reduce heating and cooling loads.

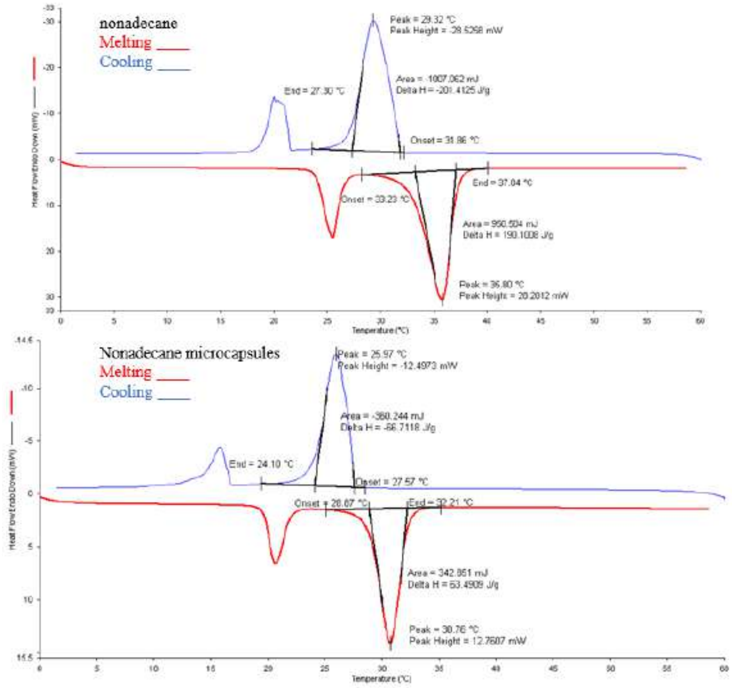

Figure 3. DSC Analyses of nonadecane and nonadecane@HA microcapsules

4. CONCLUSIONS

In this study, nonadecane@HA microcapsules and microcomposites were successfully prepared using an environmentally friendly method. The leakage test and differential scanning calorimetry (DSC) results confirm the successful fabrication of nonadecane microcapsules and microcomposites. Based on these findings, we highly recommend the utilization of encapsulated nonadecane, particularly in photovoltaic (PV) cooling applications.

Acknowledgements

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HUMIC ACID BASED PHASE CHANGE MATERIAL MICROCAPSULES FOR THERMAL ENERGY STORAGE

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ABSTRACT
In this study humic acid based lauric acid microcapsules were prepared for thermal energy storage applications as energy storage materials. The prepared microcapsules were thoroughly evaluated in terms of their thermal, chemical, and morphological properties. The analysis results indicated the promising potential of the produced microcapsules as phase change materials for thermal energy storage applications.
Keywords: Phase change material, humic acid, microencapsulation, composite

1. INTRODUCTION
The objective of this study is to explore the potential use of Humic Acid (HA), a naturally occurring biomacromolecule, as a supportive material for composite manufacturing and as shell material in the production of microcapsules containing Phase Change Materials (PCMs) for achieving thermal control in various applications.
Thermal energy storage using PCMs has proven to be beneficial in many heating and cooling applications. However, the practical use of PCMs is often limited by the transition to the liquid phase during phase change, which can result in leakage from the structure. To address this challenge, microencapsulation or composite preparation techniques are commonly employed prior to application. These methods provide protection to the active substance from the surrounding environment, increase the surface area, enable faster response to thermal changes, and facilitate easier storage.
This study aims to develop thermal energy storage composites and microcapsules doped with biomacromolecules such as HA. These materials can find applications in various sectors, particularly in thermal management of applications such as textiles, packaging, and greenhouse planting and photovoltaic panels.
HA, derived from lignite, serves as the monomer of capsule shell material. In this study lauric acid microcapsules were prepared. LA (Lauric Acid) is a preferred energy storage material in various Thermal Energy Storage (TES) application among organic PCMs. This preference stems from its favorable thermal properties and its economic, environmentally friendly characteristics, which are derived from plant and animal sources.
In recent times, there has been a growing interest in the microencapsulation of lauric acids as energy storage materials for thermal energy storage applications. Forexample; LA microcapsules wer prepared with titanium dioxide (TiO_2) (Chen et al, 2020), SiO_2 (Ishak et al, 2021), polystyrene (Sami et al., 2018), silica(Yang et al., 2021) and polystyrene with nanoparticles of MgO, TiO_2, and Graphite(Sami et al., 2021).
In this study, humic acid-formaldehyde based lauric acid microcapsules were synthesized using coacervation method. SEM, FTIR, and DSC techniques were employed to examine the physical, chemical, and heat-related characteristics of composites. The findings indicate the successful preparation of microcapsules, demonstrating their potential as effective materials for storing thermal energy in various applications.

2. MATERIAL AND METHODS
2.1. Materials and Methods
In this study, lauric acid was used as capsule core material and humic acid(Turkish Coal Enterprises (TKİ), Turkey) and formaldehyde as shell material. HCl were used to control the pH. Tween 40 (Merck, Germany) was used as emulsifier during microcapsule synthesis.

The morphology of micro-nanoPCMs was analyzed by SEM. The thermal properties of HA-F based microcapsules were measured a with 5°C/min heating and cooling rateusing approximately 5 mg of sample.
FTIR spectra for the samples were obtained at room temperature, utilizing the spectral wavelength range of 400–4000 cm^{-1}.

3. RESULTS AND DISCUSSION
The prepared HA-F based PCM microcapsules, as shown in Figure 1, exhibit a brown-black color attributed to the presence of HA.

Figure 1. Prepared HA-F based PCM microcapsules

The thermal stability of the produced composites was evaluated by conducting leakage tests. The results are presented in Figure 2. As can be seen clearly after thermal resistance test at 80 °C for 60 minutes prepared LA@HA-F microcapsules show good thermal resistance.

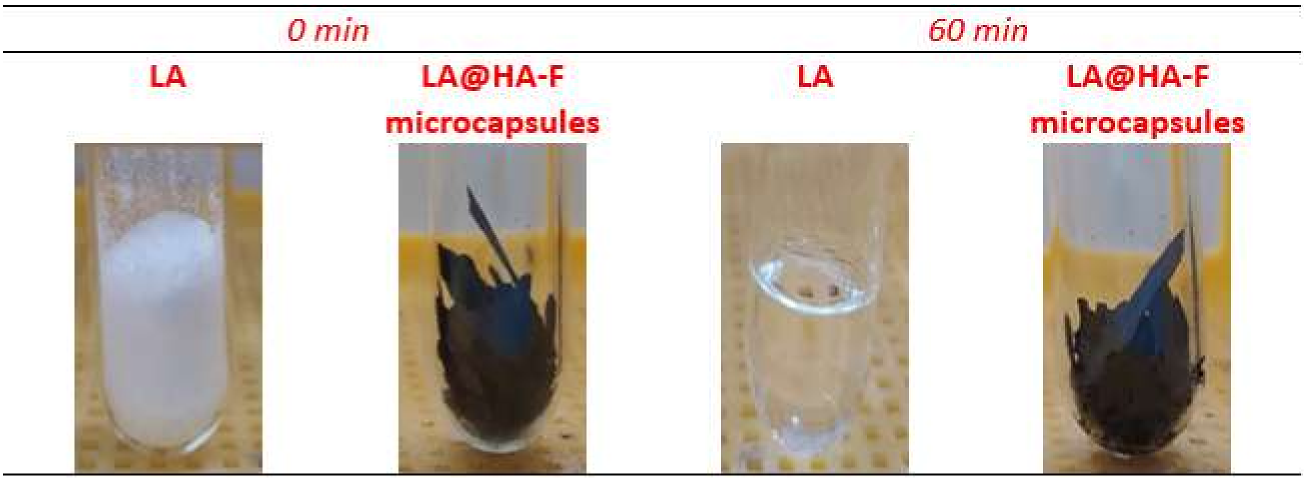


Figure 2. Lekage properties of HA-F based PCM microcapsules

The DSC analysis results of the produced composites demonstrate that(Figure 3) the samples exhibit a melting point ranging from 38.92 to 42.28°C and possess a latent heat value of 104.61 J/g, achieving a capsule efficiency of 57.72%.

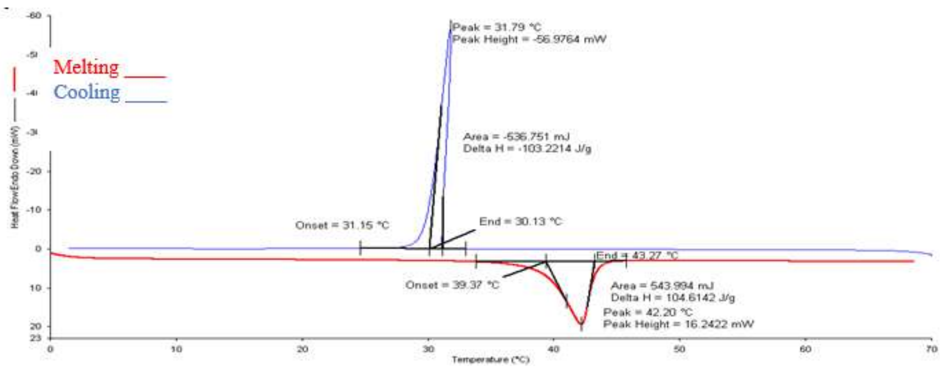


Figure 3. DSC Analyses of HA-F based PCM microcapsules

The particle size analysis of HA/LA composites (Figure 4) revealed a uniform distribution of particles with sizes ranging from 5 to 69 μm. The average particle size of the produced composites was approximately 10 μm.

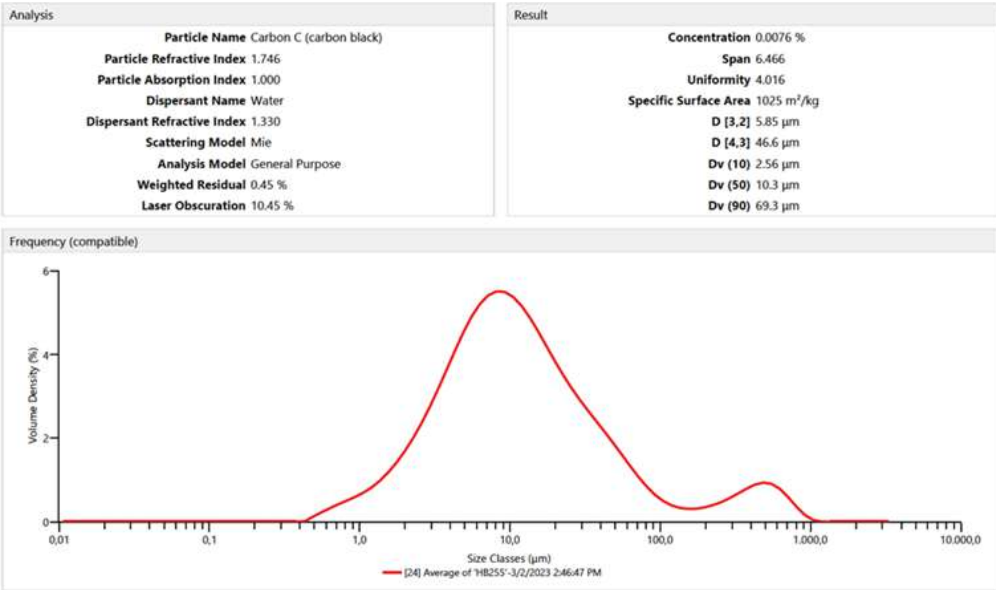


Figure 4. Particle size analyses of HA-F based PCM microcapsules

Chemical analysis was performed using FTIR analyses of LA HA-F based PCM microcapsules and HA, which are presented in Figure 5. The FTIR analyses clearly show that the capsules exhibit characteristic peaks corresponding to both LA and HA.

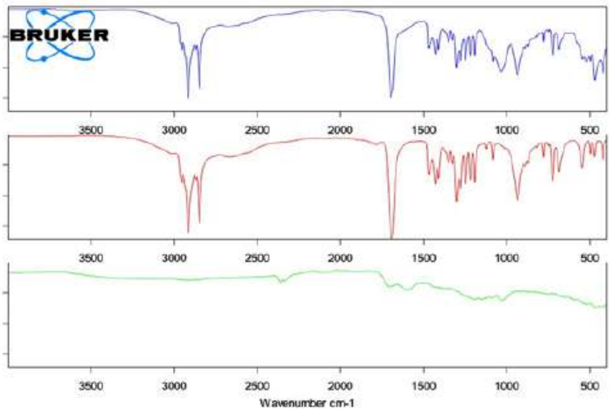
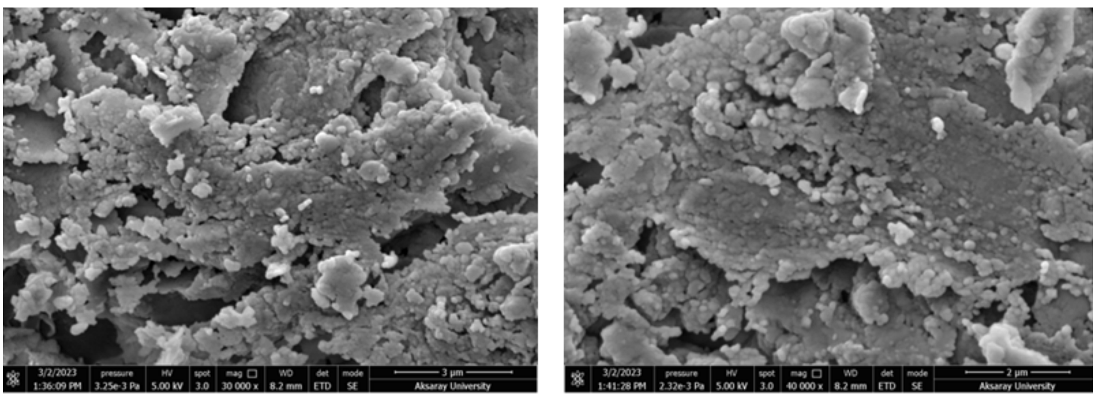


Figure 5. FTIR analysis of of HA-F based PCM microcapsules, LA, and HA (from top to bottom)

SEM analyses were conducted to determine the microstructural properties of the produced HA-F based PCM microcapsules, and the results are presented in Figure 6. As observed from the SEM analyses, it can be concluded that the products exhibit uniform morphologies.

Figure 6. SEM analyses of HA-F based PCM microcapsules



4. CONCLUSIONS

In this study, microcapsules of lauric acid (LA) were successfully prepared using a shell material based on humic acid (HA-F). The SEM and FTIR results provide confirmation of the successful encapsulation of the phase change material (PCM) with the new shell material. The leakage-free encapsulated lauric acid exhibits promising potential for energy storage applications.

Acknowledgements
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PREPERATION OF PHASE CHANGE MATERIAL MICROCAPSULES FOR THERMAL MANAGEMENT OF COMPUTERS

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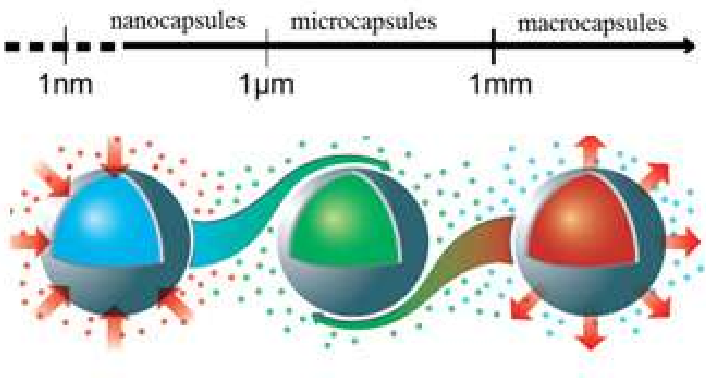
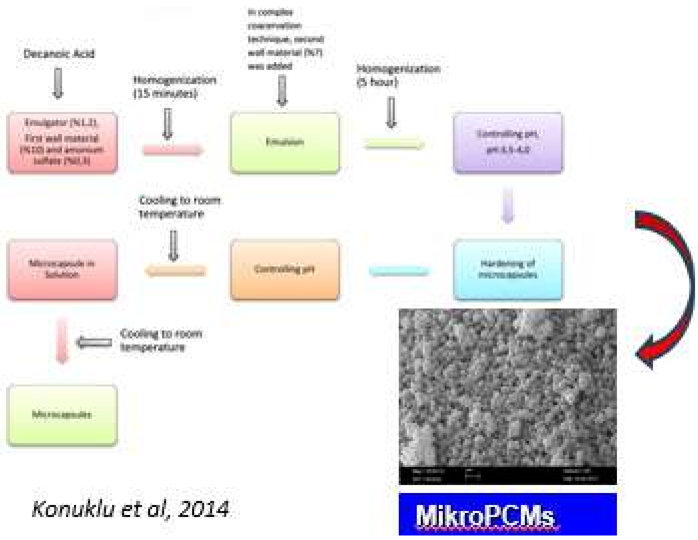
Abstract
The main purpose of this study is to achieve the production and characterization of phase change material microcapsules, which can respond quickly to thermal changes that can be used to cool computers. The thermal properties of the prepared microcapsules were analyzed by differential scanning calorimetry (DSC). Based on analyses it can be concluded that the prepared microencapsulated PCM can prevent the computers from overheating by acting as a thermal buffer that will melt when the device is warmed up. The utilization of the developed microcapsules in electronic devices enables a reduction in the cooling load of the device.
Keywords: phase change material, computer, microencapsulation, thermal management.

Introduction
The increasing use of electronic devices in business and social life has led to the development of smaller, heat-generating computers and mobile devices. To enhance efficiency and safety, effective cooling measures are essential. Research has focused on using phase change materials (PCMs) in industries where cooling is critical. PCMs act as thermal buffers, melting with device heating to maintain a constant temperature and provide passive cooling. As device temperature rises, PCMs store heat as sensible and latent heat, reducing the heating rate. Previous studies used LA microcapsules for cooling mobile phones(Konuklu 2019), while this study focuses on synthesizing PCM microcapsules to increase the cooling surface area for computers.



Methodology



Findings

In this study, PCM microcapsules were synthesized for cooling computers. DSC analysis results show that the prepared capsules can be used as latent heat storage materials in passive cooling of computers. The utilization of the developed microcapsules in computers enables a reduction in the cooling load of the device, leading to a safer and more efficient use.

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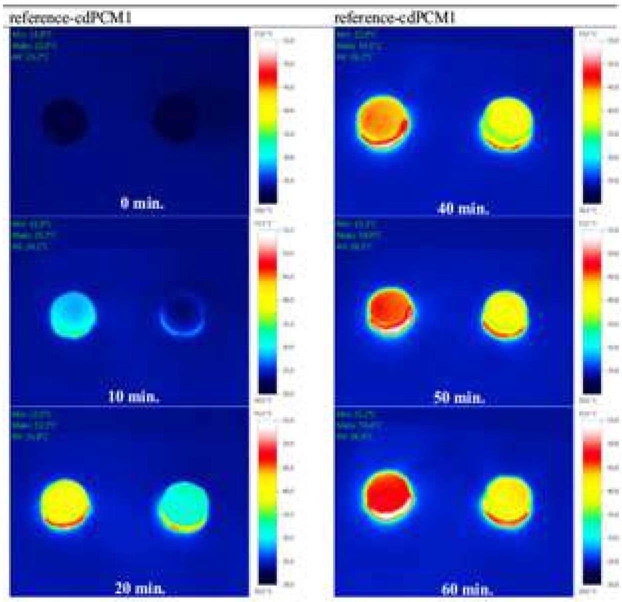

Fig. 14. Thermal performance test of reference mortar and cdPCM1 (microwave 1 min) containing mortar.

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DETERMINATION OF ELECTRICITY, HEATING-COOLING AND HYDROGEN PRODUCTION PERFORMANCE BY USING EXTERNALLY FIRED GAS TURBINE FLUE GAS IN TURBINE-BLEEDING REGENERATION SRC, ORC, LI-BR/H2O ABSORPTION CHILLER AND ELECTROLYSIS UNIT

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ABSTRACT
In this study, the thermo-economic and enviro-economic performance of the multi-generation system using externally fired gas turbine flue gas was investigated under optimum evaporator pinch point temperature difference (ΔTPP,e) conditions. Three different subsystems were investigated. The first is the Turbine-Bleeding Regeneration Steam Rankine Cycle (SRC-TBR), where high-temperature waste heat is used. Hydrogen production and cooling-heating performance were analyzed by integrating Proton Exchange Membrane (PEM) electrolysis unit and Li-Br/H2O Single Effect Absorption Chiller (SEAC) unit into this system. The second subsystem is Organic Rankine Cycle with internal heat exchanger (ORC-IHE) using medium temperature waste heat. In this system, electricity generation is examined. Finally, the basic ORC was used within the scope of electricity generation from low temperature (<150 oC) waste heat. The effect of the pinch point temperature change on the system performance was determined at each subsystem transition point. Levelized cost of electricity, cooling, and hydrogen (LCOE-$/kWh, LCOC-$/kWh and LCOH-$/kg) and payback periods (years) were determined under optimum ΔTPP,e conditions. CO2 reduction amounts (ton) have been determined within the scope of electricity and hydrogen production. Carbon Credit Gain (CCG-$) of the multi-generation system was determined by enviro-economic analysis.
Keywords: Turbine-Bleeding Regeneration, Hydrogen Production, Absorption Chiller, Thermo-enviro-economic, Pinch Point Temperature Difference

1. INTRODUCTION
In the IEA Electricity Market Report 2023, it is stated that the share of renewable energy in energy production will increase to 35% in 2025. When the emissions of the electricity sector are examined, it is stated that 13.2 Gt of CO2 has been reached, and the CO2 intensity will decrease to 417 gCO2/kWh in 2025 (IEA, 2023). Considering this report, in this study, electricity, cooling, heating and hydrogen productions with high-medium and low-temperature waste heat were examined within the scope of multi-generation production. Within the scope of electricity and hydrogen production, the amount of CO2 emission reduction (ton) and the Carbon Credit Gain (CCG-$) have been determined with thermo-enviro-economic analysis. Important studies in the multi-generation field in recent years are briefly explained below.

Nedaei et al. (2022) studied the solar driven Single Effect Absorption Chiller (SEAC), closed Brayton and Kalina cycle. They reached a COP value of 0.812 in the cooling unit. The payback period of the system was determined as 3.1 years. Alirahmi et al. (2022) studied the multi-production system including Organic Rankine Cycle (ORC), Proton Exchange Membrane (PEM) and SEAC. As a result of their optimization with Non-Sorting Genetic Algorithms-II (NSGA-II), they determined 37.85% exergy efficiency and a cost rate of 15.09 $/h. Nazari et al. (2021) studied solar assisted trigeneration system (containing gas turbine, ORC and Li-Br/H2O absorption refrigeration cycle). They used multi-objective multi-verse optimizer for maximum exergy efficiency and minimum cost rate. As a result of the optimization, they determined 22.2% exergy efficiency and a cost rate of 24.86 $/h.

Sun et al. (2023) studied the biofuel-based multi-production system (Brayton, steam, and organic Rankine, SEAC, desalination unit, solid oxide fuel cell, and thermoelectric generators). With the genetic algorithm, they determined the maximum exergy efficiency as 61.3% and the minimum cost as 0.27 $/s. They compared the results obtained at different interest rates (i = 5, 10, 15%). Nazari and Porkhial (2020) have done an exergo-economic analysis of a solar-biomass-based multi-production system (externally-fired gas turbine, steam, and organic Rankine, SEAC, desalination unit) . Two different optimization studies were carried out with maximum second law efficiency-net power and minimum cost rate. They found 10% lower cost rate with Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) compared to the base case.

In this study, the performance of the multi-generation system, which includes electricity, heating, cooling, and hydrogen production, was analyzed in terms of thermo-economic and enviro-economic criteria. It has been observed that different configurations of Steam Rankine Cycles (SRC) and Organic Rankine Cycles (ORC) have not been addressed in multi-generational studies. In addition, it was seen that the evaporator pinch point temperature difference between the subsystems was not examined separately.

In this study, configurations with turbine bleeding/regeneration in SRC (SRC-TBR) and ORC with internal heat exchanger (ORC-IHE) are discussed. The cooling and hydrogen production performance were analyzed by integrating Li-Br/H2O SEAC and PEM unit into the SRC-TBR configuration. The usability of waste heat at high-medium and low-temperature was investigated under different cycles. Thermo-economic and enviro-economic performance of the multi-generation system under optimum ΔTPP,e conditions were determined.

2. SYSTEM DESCRIPTION AND ANALYSIS

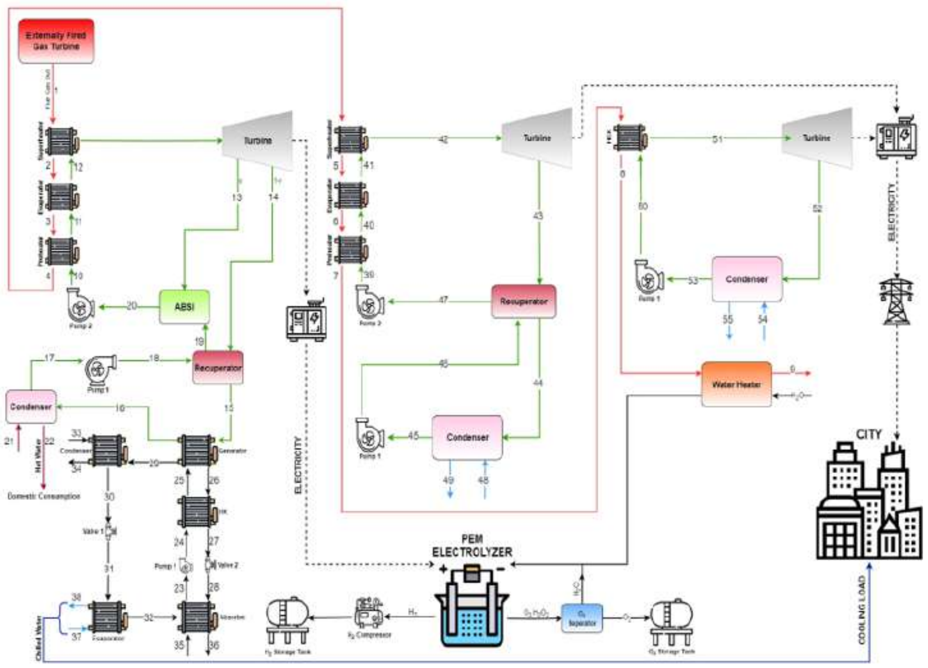

Fig.1. Schematic diagram of the proposed multi-generation system

In this study, a multi-generation system was investigated by using the waste heat from the externally fired gas turbine flue gases. This waste heat was used in different subsystems at high-medium and low temperature. These;

Subsystem-1: High temperature waste heat: SRC-TBR with SEAC and PEM Electrolysis Unit
Subsystem-2: Medium temperature waste heat: ORC-IHE
Subsystem-3: Low temperature waste heat: B-ORC

Firstly, electricity, cooling (with Li-Br H2O SEAC unit), heating (water heater unit via condenser for domestic consumption), and hydrogen productions (with PEM electrolysis) were investigated by using high temperature waste heat in SRC-TBR unit. Power for PEM electrolysis was provided from SRC turbine. The lean and rich mass fractions for Li-Br/H2O in the refrigeration unit were accepted as 57% and 61%, respectively. Electricity generation was investigated by using the medium temperature waste heat from the SRC-TBR unit in ORC-IHE. In this part, toluene fluid (Critical temperature: 318.75 oC) used at medium and high temperatures of ORC was used as organic fluid. Low-temperature waste heat from the ORC-IHE unit was also utilized in the B-ORC unit. Electricity generation with R245fa fluid (Critical temperature: 154 oC), which is frequently used in low temperature applications of ORC, has been investigated. Waste heat from the B-ORC unit was used in a PEM water heater unit to heat the water to 80 oC, which is the required water temperature for the PEM electrolysis process. Schematic of the proposed combined system are shown in Figure 1. Overall thermal and exergy efficiency expressions of the system are given in Equation 1-2.

$$\eta = \frac{\dot{W}_{net-SRC-TBR}+\dot{W}_{net-ORC-IHE}+\dot{W}_{net-B-ORC}+(\dot{m}_{H2}xLHV_{H2})+\dot{Q}_{cooling}+\dot{Q}_{heating}}{\dot{Q}_{in}} \quad (1)$$

$$\varepsilon = \frac{\dot{W}_{net-SRC-TBR}+\dot{W}_{net-ORC-IHE}+\dot{W}_{net-B-ORC}+(\dot{Ex}_{H2})+\dot{Ex}_{cooling}+\dot{Ex}_{heating}}{\dot{Ex}_{in}} \quad (2)$$

3. RESULTS AND DISCUSSION

In this study, the effect of pinch point temperature on system performance was determined between three different subsystems. By determining the optimum points for maximum hydrogen production and electricity, the system was examined in terms of economic, environmental, and enviro-economic criteria. LCOE, LCOC and LCOH and payback period of the system were determined. The environmental contribution of the multi-generation system was examined by determining the CO_2 reduction rate and CCG values. Pinch Point 1-2-3 refers to the temperature differences occurring in subsystem 1-2-3, respectively.

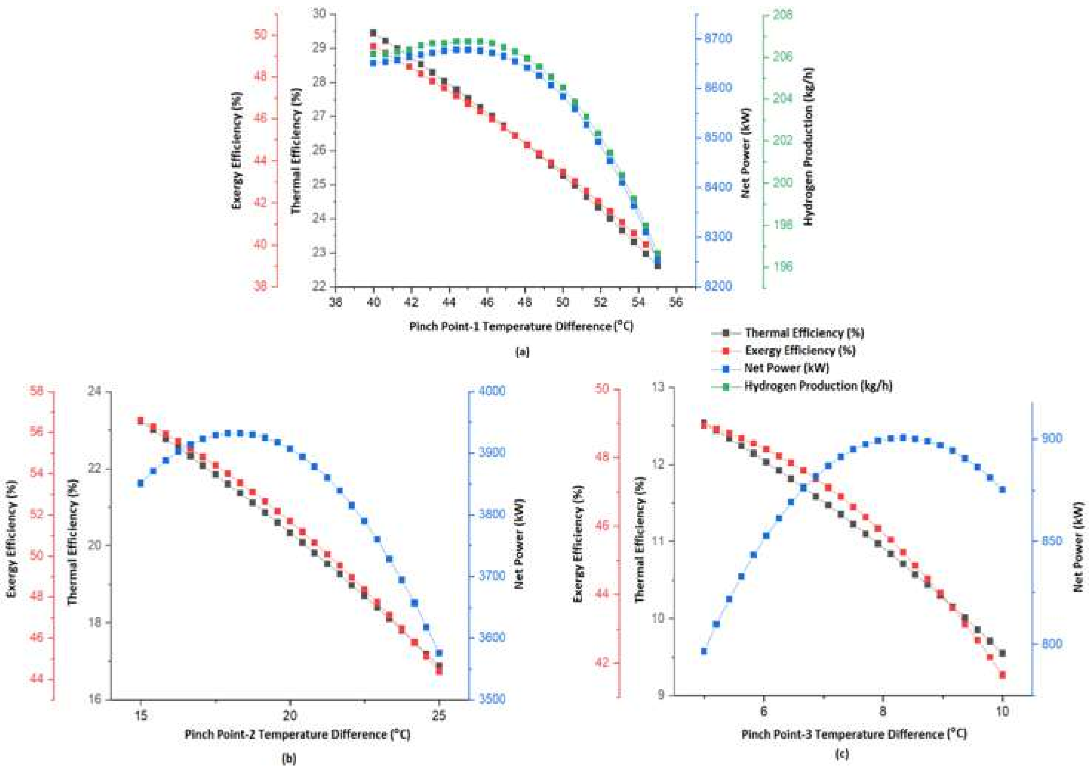

Fig.2. The effect of pinch point temperature change (a) Pinch point-1; (b) Pinch point-2; (c) Pinch point-3 on the thermodynamic performance and hydrogen production of the multi-generation system

In Figure 2a, the effect of increasing the pinch point-1 temperature on the SCR-TBR subsystem is examined. Although thermal efficiency and exergy efficiency decrease, it is seen that net power decreases after a certain value. When the decrease rate in the enthalpy drop in the turbine and the increase rate in the mass flow are examined together, it is seen that the rate of increase in the flow rate is high up to 44.38 oC, while the rate of enthalpy drop takes the lead after this value. The optimum $\Delta T_{PP,e-1}$ was determined as 44.38 oC. At this value, the net power is 8678 kW; thermal efficiency 27.78%; exergy efficiency was determined as 47.1%. By sending the obtained power to the PEM electrolysis unit, 206.7 kg of hydrogen per hour was produced.

In Figure 2b, the effect of increasing the pinch point-2 temperature on the ORC-IHE subsystem was investigated. It is seen that the net power increases up to 17.92 oC, and after this value, the enthalpy drop rate decreases the net power more effectively. The optimum $\Delta T_{PP,e-2}$ was determined as 17.92 oC. At this value, the net power is 3932 kW; thermal efficiency 21.6%; exergy efficiency was determined as 53.9%.

In Figure 2b, the effect of increasing the pinch point-2 temperature on the ORC-IHE subsystem was investigated. It is seen that the net power increases up to 17.92 oC, and after this value, the enthalpy drop rate decreases the net power more effectively. The optimum $\Delta T_{PP,e-2}$ was determined as 17.92 oC. At this value, the net power is 3932 kW; thermal efficiency 21.6%; exergy efficiency was determined as 53.9%.

In Figure 2b, the effect of increasing the pinch point-2 temperature on the ORC-IHE subsystem was investigated. It is seen that the net power increases up to 17.92 oC, and after this value, the enthalpy drop rate decreases the net power more effectively. The optimum $\Delta T_{PP,e-2}$ was determined as 17.92 oC. At this value, the net power is 3932 kW; thermal efficiency 21.6%; exergy efficiency was determined as 53.9%.

4. CONCLUSIONS

In this study, a multi-generation system consisting of electricity, hydrogen, heating, and cooling units was investigated by using the waste heat from the gas turbine. The effect of pinch point temperature differences on system performance was determined for each subsystem. A net power of 8678 kW was obtained from the SRC-TBR system at the optimum ΔTPP,e point. By using this power in the PEM unit, 1810 tons of hydrogen production was achieved annually. The SEAC unit is integrated into the SRC-TBR unit for cooling needs. 7295 kW cooling load was determined with SEAC. At the same time, 13225 kW heating load was determined in the SRC-TBR condenser. By incorporating the medium temperature waste heat from the SRC-TBR unit into the Toluene based ORC-IHE system, 4020 kW electrical output was obtained. By using the waste heat coming to 140-150 oC at the output of the ORC-IHE unit in the low-temperature B-ORC, another 682 kW of electricity was produced. Total electrical output is determined as 4702 kW. The payback period of the multi-generation system is determined as 3.448 years. Carbon credit gain was determined as 1.151 M$ by enviro-economic analysis.

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THERMO-ECONOMIC ANALYSIS OF GREEN HYDROGEN PRODUCTION USING DIESEL ENGINE AT DIFFERENT LOADS OF EXHAUST WASTE HEAT IN SRC AND ORC-IHE WITH ZEOTROPIC AND LOW GWP FLUIDS INTEGRATED WITH THERMOELECTRIC GENERATORS

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ABSTRACT
In this study, the thermo-enviro-economic performance of the Steam and Organic Rankine Cycles-Internal Heat Exchanger (SRC and ORC-IHE) combined system with thermoelectric generator (TEG) and Proton Exchange Membrane (PEM) was determined by using the waste heat of the marine diesel engine. The low temperature exhaust gas from the SRC was investigated in ORC-IHE under different organic fluids (pure, zeotropic, low global warming potential-GWP fluids). By using TEG instead of condenser, it is aimed to increase hydrogen production by obtaining more power output. Maximum hydrogen production was reached in the R1233zd(E) fluid. The economic performance of hydrogen production at different loads (100, 85, 75, 50%) of a diesel engine is compared. In this context, specific investment cost (SIC-$/kWh), levelized cost of electricity and hydrogen (LCOE-$/kWh and LCOH-$/kg) and payback periods (years) are compared. The CO2 reduction amounts were determined by environmental analysis and Carbon Credit Gain (CCG-$) was determined accordingly.
Keywords: Marine Diesel Engine, Different Load, Thermoelectric Generator, Thermo-enviro-economic, Hydrogen Production

1. INTRODUCTION
In the 2023-2031 Waste Heat Recovery (WHR) Market report, it is stated that the size of the waste heat recovery market is 63 billion dollars by 2022 and this value may increase to 121 billion dollars until 2031, depending on the strict regulations regarding carbon emissions (WHR Report, 2023). Within the scope of recycling waste heat and consequently reducing the carbon footprint, in this study, green hydrogen production by using high-temperature marine diesel engine exhaust gas in the Steam and Organic Rankine Cycles-Internal Heat Exchanger (SRC and ORC-IHE) combined system with thermoelectric generator (TEG) and Proton Exchange Membrane (PEM) was investigated

Demir and Çıtakoğlu (2022) investigated the ORC- absorption refrigeration cycle-PEM multi-generation system with marine diesel engine waste heat. They have reached a net power of 659 kW and a daily hydrogen production value of 306.8 kg. Gholamian et al. (2018) made a performance comparison by examining systems with and without TEG and PEM added to the ORC unit for power and hydrogen production. They found that the exergy efficiency of the ORC-TEG unit was 21.9% higher than the ORC using condenser.

Ding et al.(2022) examined the compressed air energy storage (CAES) system integrated with ORC and single effect absorption chiller (SEAC) within the scope of novel combined cooling, heating, and power system. Compared to the commercial CAES system, they determined 12.35% higher round-trip efficiency. Yılmaz and Öztürk (2022) analyzed the energy and exergy of a multi-system including power, heating, cooling, hot water and hydrogen production with compressed air production, Brayton, SRC, ORC and SEAC. They stated that the performance improved with the increase of the reference and combustion chamber temperatures. Mohtaram et al. (2022) studied wind turbines and parabolic-linear solar collectors based multi system for electricity, heating, cooling, and water desalination. They made energy, exergy, and exergo-economic analysis with Engineering Equation Solver (EES). They determined the effects of solar radiation, turbine inlet pressure, wind speed and ambient temperature on system performance.

In this study, it is aimed to produce hydrogen in the PEM electrolysis unit after the use of marine diesel engine waste heat in SRC and ORC-IHE with TEG. The usability of the exhaust gas in the diesel engine in two stages (high and low temperature) was investigated. It has been observed that studies examining hydrogen production from diesel exhaust gas are rare, and its effect on hydrogen production, especially at different loads, has not been examined. Therefore, in this study, the thermo-enviro-economic performance of hydrogen production under four different loads (100, 85, 75, 50%) was determined. For performance improvement, TEG is used instead of condenser in SRC and ORC-IHE unit. In addition, the performance of zeotropic and low-GWP fluids in the ORC-IHE unit was compared and the effect of organic fluid in hydrogen production was analyzed.

2. SYSTEM DESCRIPTION AND ANALYSIS

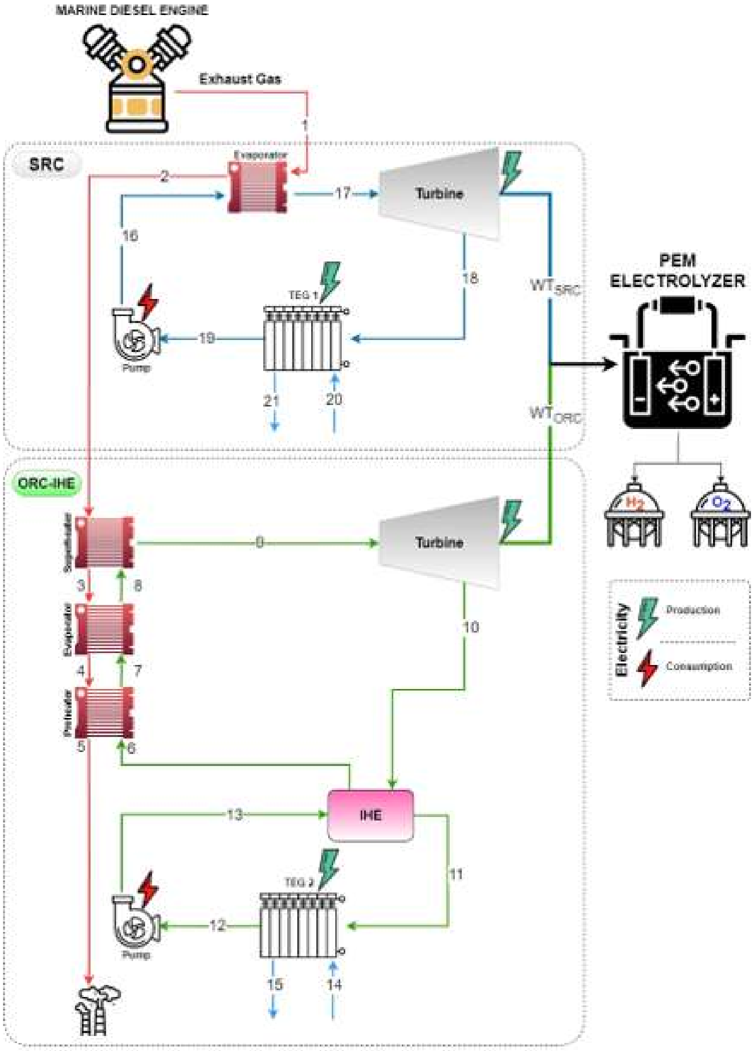

Fig.1. Schematic diagram of the proposed combined system

In this study, hydrogen production in SRC-ORC-PEM combined system was investigated by using marine diesel engine-rotation speed 1500 r/min, torque 6340 Nm-(for other technical parameters: Nawi et al., 2019) waste heat at different loads (100, 85, 75, 50%). Schematic of the proposed combined system are shown in Figure 1.
After generating electricity in the SRC unit, which is more suitable for high-temperature waste heat, the low-temperature heat below 160 oC was sent to the ORC-IHE unit. Here, the performance of 16 organic fluids with low critical temperature is compared. These fluids are;

•Zeotropic mixtures: R448A – R449A – R450A – R452A – R454C
•Pure: R134a – R152a
•Low GWP fluids: R1234yf – R1234ze(E) - R1234ze(Z) - R1243zf - R1233zd(E) - R1225ye(Z) - R1224yd(Z) - R1216 - R1336mzz(Z)
The electricity produced in the SRC and ORC-IHE units was directed to the PEM unit. Hydrogen production was carried out by PEM electrolysis.
The energy, exergy equilibrium relations and thermo-environment-economic fundamental relations of the combined system are given in Equation 1-5 (Nasser and Hassan, 2023).

$$\dot{Q} - \dot{W} = \sum_{out} \dot{m}_e h_e - \sum_{in} \dot{m}_i h_i \quad (1)$$

$$\left(1 - \frac{T_0}{T}\right) \dot{Q} + \sum_{in} \dot{m}_i ex_i = \sum_{out} \dot{m}_e ex_e + \dot{W} + T_0 \dot{S}_{gen} \quad (2)$$

$$Ze_{total}(\$) = \sum_{i=1}^{n} PEC_i \quad (3)$$

(where i = all components for three sub-system; PEC: Purchase Equipment Cost)

$$LCOH\left(\frac{\$}{kg}\right) = \frac{TIC + \sum_{n=1}^{N} \frac{TIC_{O\&M}}{(1+r)^n}}{\sum_{n=1}^{N} \frac{M_{annual,H2}}{(1+r)^n}} \quad (4)$$

(where r = discount rate; TIC: Total Investment Cost; $TIC_{O\&M}$: Operational and Maintenance Cost)

$$CCG = m_{CO_2 red.}\ x\ Z_{CO_2} \quad (5)$$

3. RESULTS AND DISCUSSION

In this study, firstly, the high temperature exhaust waste heat of the marine diesel engine was used in the SRC unit. Then, electricity generation was provided with ORC-IHE in order to benefit from low-temperature waste heat. Hydrogen production was analyzed in the PEM electrolysis unit. The power required for the PEM was supplied from the SRC-ORC combined system. The performance of low critical temperature organic fluids was compared in ORC-IHE. In Figure 2, the effect of the change in evaporation temperature between 60 oC and 100 oC on the net power of the combined system is given. The maximum power value was reached with 82.5 kW in the R1233zd(E) fluid.

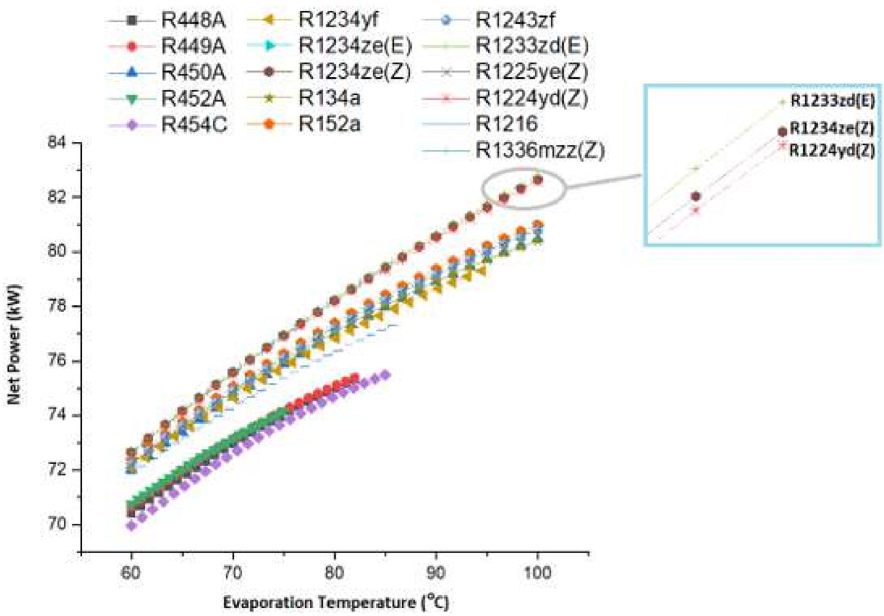

Fig.2. Effect of evaporation temperature change on net power for different organic fluids

In Figure 3a, a performance comparison was made at different loads of the marine diesel engine using R1233zd(E) in ORC-IHE. While 0.2708 mol/s hydrogen is produced at 100% load, this value decreases to 0.1208 at 50% load. Hydrogen production performance decreases by 55.39%. In Figure 3b, the thermo-economic and enviro-economic performance of the combined system with R1233zd(E) fluid was determined under different loads of the marine diesel engine. While the specific investment cost was 2701.3 $/kW at 100% load, it was determined as 3146 $/kW at 50% load.
With the decrease of the load from 100% to 50%; SIC ($/kW), LCOE ($/kWh) and LCOH ($/kg) increased by approximately 17%. Payback period (years) increased by 30% and carbon credit gain ($) decreased by 53% due to the decrease in hydrogen production.

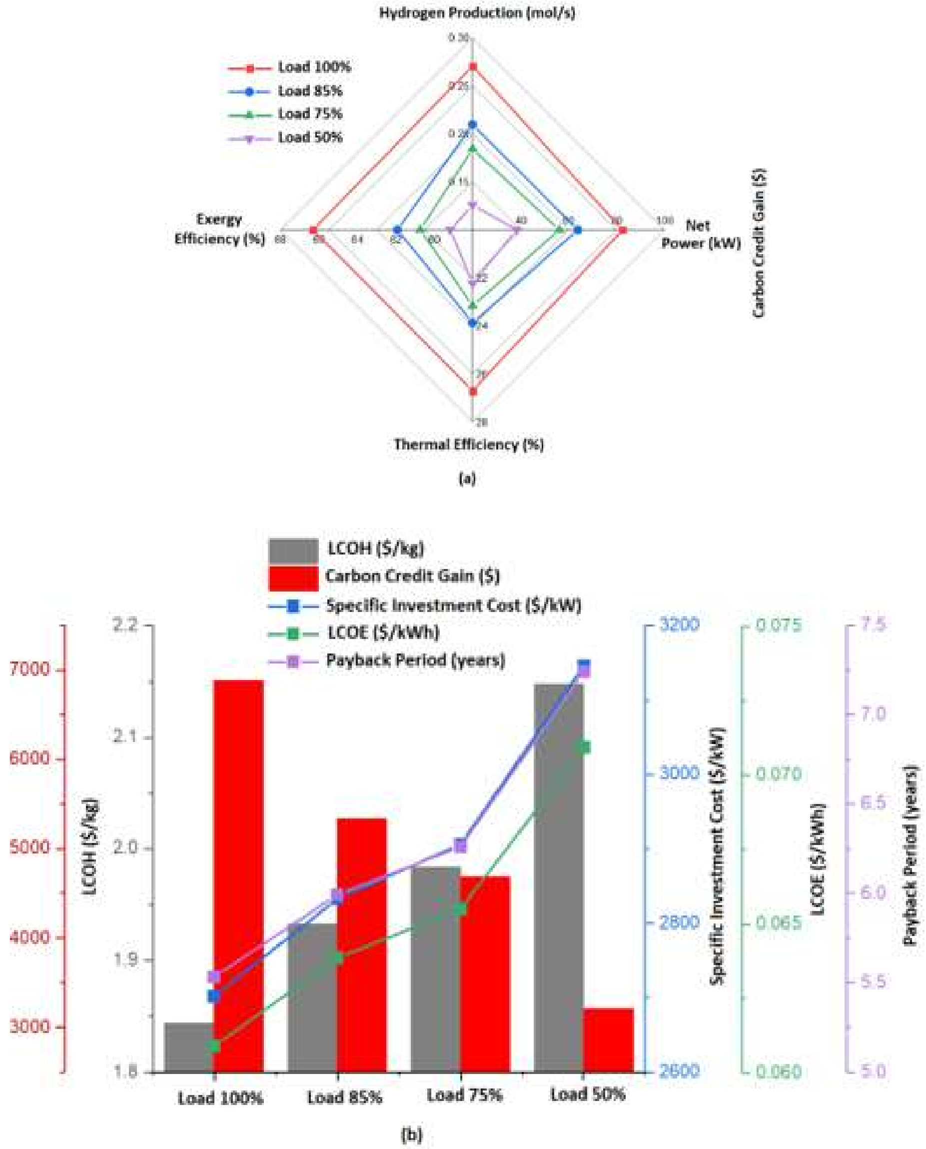

Fig.3. (a) Thermodynamic and hydrogen production performance of the combined system at different loads of the marine diesel engine (b) Enviro-economic performance of the combined system at different loads of the marine diesel engine

4. CONCLUSIONS

In this study, hydrogen production was investigated in the SRC-ORC-PEM combined system by using marine diesel exhaust waste heat in two stages (high and low waste heat) under four different loads (at 100%, 85%, 75%, 50%). System performance was compared using 16 organic fluids (pure, zeotropic and low GWP) in ORC-IHE. Maximum performance was obtained in R1233zd(E) at 100% load at 100 oC evaporation temperature. Net power, thermal and exergy efficiency was determined as 82.5 kW, 26.37%, 66% respectively. The payback period of the combined system is determined as 5.53 years. Annual hydrogen production was 17.21 tons and levelized cost of hydrogen was 1.84 $/kg. Its environmental-economic performance is remarkable with a carbon credit gain value of 6885 $.

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INVESTIGATION OF EXERGETIC AND ENVIRONMENTAL PERFORMANCE OF FREEZING FOOD CONSIDERING CRYOGENIC COOLING

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ABSTRACT
In this study, the energy and environmental performance of cryogenic cooling for frozen food applications was investigated, and its effectiveness was evaluated. In the study, especially the standard and cryogenic cooling performances of fruit and vegetable products were examined and the possible entropy potentials of these systems were evaluated. In the study, especially the environmental effects were evaluated through the Environmental Performance Index (EPI. In the analyzes made, an average of 43.68% reduction effect in terms of environmental impact is observed in a cryogenic cooling to be provided based on nitrogen. At the end of the study, the effects of the advantages of cryogenic cooling were also evaluated.
Keywords: Frozen food, Exergy, Entropy, Environmental performance, Sustainability

1. INTRODUCTION
Deep freezing technologies, the prevalence of which is rapidly increasing, especially in the food industry; These are the technologies used for fast or slow freezing for long-term preservation of the product or to preserve its structural properties, depending on the structure of the products. The speed of the freezing process directly affects both the food quality and the system capacity, as well as the energy consumption in the freezing processes. Especially when product preservation processes in cold storage are taken into account, cryogenic cooling applications come to the forefront in terms of energy performance compared to traditional technologies. In today's rapidly developing demand for frozen food, it is important to reduce the cost effects of energy input in production in terms of sustainable energy management and efficient use of energy. In addition, the fact that hydrocarbon refrigerants such as R404A, R134a, which are widely used today, are problematic fluids, especially due to their high global warming effects (GWP), has highlighted more environmentally friendly refrigerant preferences. When the cost effects are also considered, studies have been developed on effective solutions such as cryogenic cooling applications, considering the effects caused by classical cooling applications in cold chain applications.

Foods are preserved in cold or frozen storage according to their properties and storage times in cooling applications. While the products are kept cold between -5°C and +15°C, frozen storage is done between -12 and -25 depending on the characteristics of the product (Kantarman, 2011). It is important that the cryogenic gas does not react (inert) and prevents many oxidative reactions that may occur by replacing the air in the process (Yalçın et al, 2017). In the study, an evaluation was made between classical freezing processes and cryogenic freezing processes in terms of energy efficiency, and system performances were examined according to the reference products.

2. FROZEN FOOD SECTOR AND FROZEN APPLICATIONS
The frozen food sector, whose global influence has increased rapidly in recent years, is expected to reach approximately 383 Billion Dollars with a Compound Annual Growth Rate (CAGR) of approximately 5.5% until 2028, according to the estimates made in 2023. In particular, the increasing demand for frozen food and diversity in this context is rapidly increasing the market share(Research and Markets, 2021). In the food sector, where sectoral growth has gained value in recent years, the demand for frozen food shows a global increase. Especially for this sector, whose preferences for urban life are increasing, the growth rate has an effect of 4% on average. Especially the new conditions that emerged with COVID-19 have increased the demand of people in this context. The demand for frozen food has provided a diversified and versatile development with increasing competition. When the global frozen food market product categories in Figure 1 are examined; The ready meals category has the largest share in the total frozen food market with 24%, followed by the frozen fish/seafood category with 16.5%, frozen meat products, pizza, fruit and vegetables, bakery products, potato products, and other products. appears to continue to support growth. According to the report, the global frozen food market was worth $118 billion in 2012. (Kaale et al.,201).

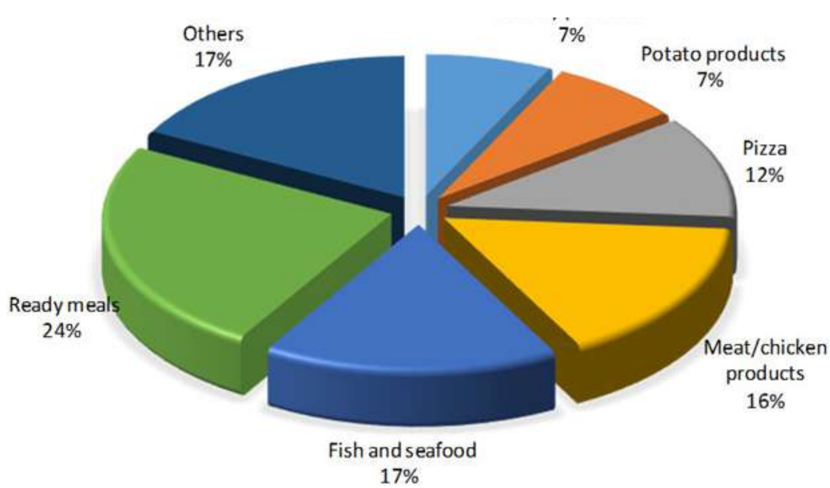

Fig.1 Global frozen food market product rates (Kaale et al.,2011)

Temperature is one of the most important parameters affecting the growth of microorganisms (Kaale et al., 2011). Microorganisms that cause spoilage in foods can maintain their biological activities down to -5 to -8 ˚C, yeasts to -10 to -12 ˚C, and molds to -12 to -18 ˚C. At temperatures lower than these temperatures, all chemical-biochemical and enzymatic reactions either stop completely or their efficiency decreases. By reducing the water activity in foods with a freezing process at low temperatures, both the reproduction of harmful formations can be prevented and the product can be prevented from losing water (Yalçın et al., 2017). In ice cream with cold air, which is mostly used in freezing processes, there is only natural air circulation, and therefore the freezing speed is slow. With this method, the freezing temperature usually varies between -23 °C and -29 °C. Freezing in airflow, freezing by indirect contact method, freezing by direct immersion and cryogenic freezing can quickly freeze foods. In air-flow freezing, the air at -30 °C to -45 °C is blown over the product at a speed of 10-15 m/s. In the case of ice cream with the indirect contact method, the temperature in the center of the packaged food; is cooled down to -18 °C between plates cooled to -45 °C. The direct immersion method is applied by immersing the packaged or unpackaged product in chilled liquid. In addition, there are many different cooling technologies and applications in frozen food applications, as can be seen in Figure 2.

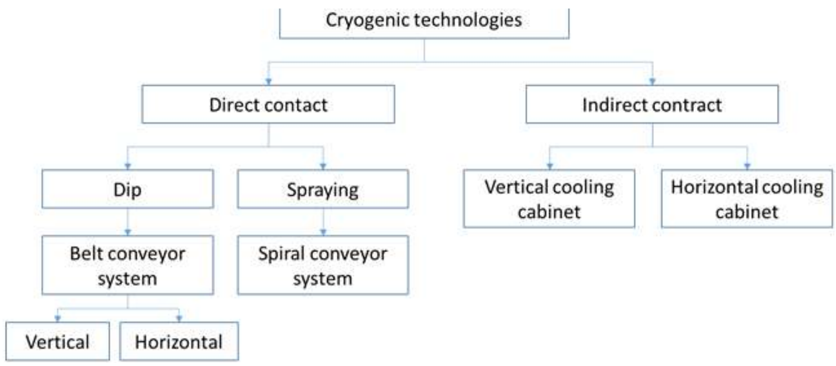

Fig.2 Cryogenic frozen applications (Khadatkar et al., 2010)

3. RESULTS AND DISCUSSION

In frozen food applications, classical system preference is made with classical CFC fluids, and double-stage systems are used instead of single cycle, and high-capacity CFC-capacity fluids are used with high energy. Such cooling preferences also have significant potential in terms of environmental impact. However, this is not the only problem with conventional cooling. Bacterial growth is also an important problem in conventional refrigeration. In traditional freezing processes, the cell membranes of the foods to be frozen break down, and as a result of this fragmentation, the cytoplasm in the cell membrane goes out of the cell, causing weight loss, decreased nutritional value, and deterioration of product quality. In cryogenic freezing, on the other hand, thanks to its fast freezing feature, water loss is minimized and weight loss is prevented. While the enzyme activity, oxidation, and vitamin values are preserved in foods, there is no deterioration in the appearance and taste of the food. On the other hand, the effects of the thermodynamic properties of the gases used in cryogenic cooling are important. As cryogenic gases; methane, oxygen, argon, hydrogen, helium, liquid nitrogen, and carbon dioxide.

In cryogenic freezing; The use of liquid nitrogen (LN2) has come to the fore in recent years because it does not have a toxic feature and does not react (inert) with any element of the food, on the contrary, it replaces air and prevents many oxidative reactions. In this study, the impact of energy and environmental sustainability for classical or cryogenic conditions in the direct freezing process is discussed. In the study, first of all, the freezing processes of the products whose reference values are given in Table xx were examined.

	Freezing point °C	Amount of Water % su	Specific heat (kJ/kg °C)		Latent heat of melting kJ /kg
			Above freezing point	Under freezing point	
1. Fruits					
Apple	-2	84	3,6	1,88	280
Banana	-2	75	3,35	1,76	255
Grapefruit	-2	89	3,81	1,93	295
Peach	-2	87	3,78	1,93	289
Pineapple	-2	85	3,68	1,88	285
Watermelon	-2	92	4,06	2,01	306
2. Vegetables					
Asparagus	-1	93	3,93	2,01	310
Green beans	-1	89	3,81	1,97	297
Courgette	-1	92	3,93	1,97	306
Carrot	-1	88	3,6	1,88	293
Sweetcorn	-1	76	3,35	1,8	251
Pea	-1	74	3,31	1,76	247
Tomatoes	-1	95	3,98	2,01	310

Freezing refers to a processing process in two frames. These process processes are pre-cooling and freezing stages. Accordingly, the energy demand for the pre-cooling phase has been examined and the distributions are given in Figure 3.

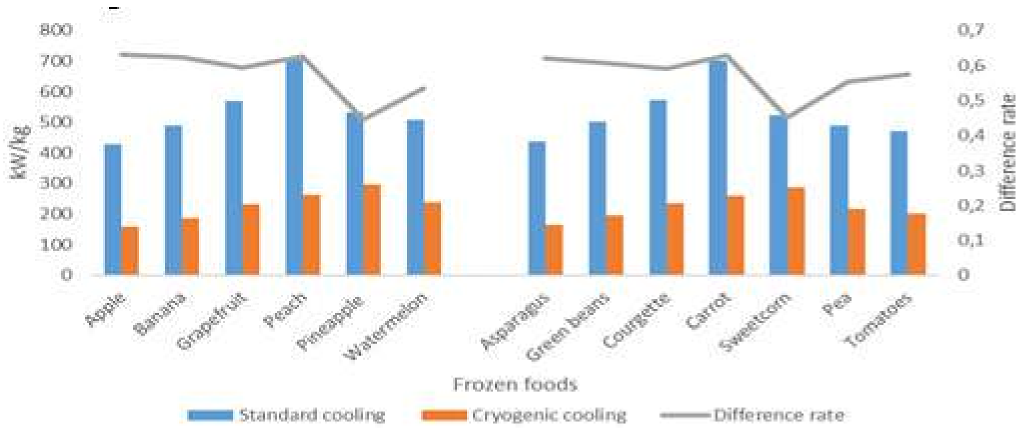

Fig.3 Exergy demand of products

R404A refrigerant was taken into consideration in the classical cooling preference and the COP value of the process for the demanded energy varies between 2.33 and 2.39. In this process, fluid-dependent entropy generation and distribution are also given in Figure 4.

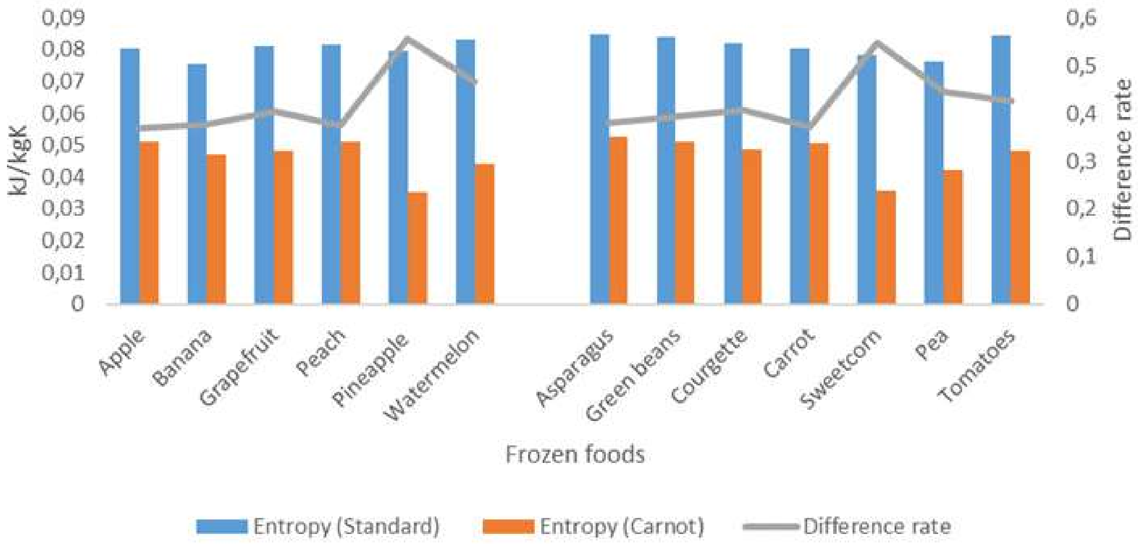

Fig. 4 Entropy generation of frozen foods

While the cryogenic preference in frozen foods provides an advantage of approximately 42% in entropy production, this effect indicates an average of 43.9% reduction in terms of environmental threat.

4. CONCLUSIONS

In this study, the effects of cryogenic cooling on energy and environmental sustainability, depending on the classical cooling potential, were investigated. Accordingly, an average of 57% efficiency stands out due to cryogenic cooling exergy demand, while an average of 43.68% advantage in terms of the environmental impact comes to the fore when entropy production is taken into account. The study especially needs energy management tools for such processes. Studies should be handled especially in terms of sustainability.

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INVESTIGATION OF O2 RATIOS ON STRUCTURAL AND OPTICAL PROPERTIES OF ITO FILMS FOR HIGH-EFFICIENCY SILICON HETEROJUNCTION SOLAR CELLS

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ABSTRACT
This study examined the properties of ITO films deposited on a 5x5 cm2 n-type silicon wafer using DC magnetron sputtering. The effects of different O2 ratios (0, 1, 1.5, 2, 2.5, 3, 5 sccm) at 200 °C were investigated. The ITO films deposited with 2.5 and 3 sccm O2 demonstrated the highest transmittance at 80%. Conversely, the film without O2 had the lowest transmittance at 61%. The ITO film deposited with 1.5 sccm O2 exhibited the lowest sheet resistance at 48.97 Ω/sq. XRD analysis confirmed the presence of crystal planes (211, 222, 400, 440, and 622). The ITO film with an O2 flow rate of 2.5 sccm was selected for the fabrication of a silicon heterojunction (SHJ) solar cell, based on its figure of merit (FOM) values. The resulting SHJ solar cell demonstrated an efficiency of 18.61%.
Keywords: Transparent conductive oxide (TCO), Indium Tin Oxide (ITO), DC magnetron sputtering, Sheet resistance, Silicon heterojunction solar cell (SHJ)

1. INTRODUCTION
Solar energy, with its remarkable potential as a renewable energy source, has garnered substantial attention in recent years (Khan et al., 2016). Its promise has been significantly bolstered by notable technological advancements and cost reductions. Notably, solar cells have emerged as a pivotal solution in combating global warming and mitigating the adverse effects of climate change (Ukoba et al., 2018). c-Si (crystalline silicon) based solar cells offer several advantages including high efficiency, long lifespan, low cost, and ease of manufacturing (Shrestha et al., 2015&Yadav et al., 2015). With c-Si, heterojunction technology is one of the most widely used technologies for solar energy conversion, efficiently transforming sunlight into electricity (Masuka et al., 2014). SHJ (Silicon Heterojunction) solar cells provide numerous benefits in solar energy conversion (Liu et al., 2020). With a combination of amorphous and crystalline silicon, they exhibit high efficiency, low temperature coefficient, reduced optical losses, and improved stability (Schulze et al., 2012). SHJ solar cells offer promising potential for cost-effective and sustainable photovoltaic applications. In recent years, remarkable conversion efficiencies of 25.6 % and 26.7 % have been achieved in SHJ solar cells (Taguchi et al., 2021& Green et al., 2021). The integration of transparent conductive oxides (TCOs) in Silicon Heterojunction (SHJ) solar cells brings notable advantages (Yates et al., 2012). TCOs enable efficient light transmission, enhance charge extraction, and improve overall performance. With increased conductivity, TCOs utilization boosts energy conversion efficiency, making SHJ solar cells a promising technology for sustainable photovoltaic applications (Calnan et al., 2010). The utilization of TCOs extends beyond SHJ solar cells and finds significance in various other devices such as light-emitting diodes (LEDs), dielectric transistors, flexible electronics, fuel cells, smartphones, monitors, and flat panel displays (Calnan et al.,2015& Varanytsia et al., 2016). Indium tin oxide (ITO), a compound consisting of indium (III) oxide (In2O3) and tin (IV) oxide (SnO2), is widely utilized in various applications, including solar cells, due to its favorable conductivity and permeability properties (Ambrosini et al., 2000). As a thin film, ITO is often chosen as a conductive layer because it exhibits lower surface resistance and higher permeability compared to alternative materials. Moreover, ITO functions as an n-type semiconductor material with a direct band gap ranging from 3.5 to 4.3 eV (Gaskell et al., 2012). This specific characteristic significantly influences the morphology, optical behavior, and electrical properties of ITO, enabling the deposition of high-performance materials (Alam et al., 2000). In this study, a series of ITO films were deposited on 5x5 cm2 SHJ solar cells using various Oxygen (O2) flows (0, 1, 1.5, 2, 2.5, 3, 5 sccm), and the performance of the cells was evaluated. The optoelectronic characteristics of the fabricated ITO films were analyzed within the wavelength range of 300-1200 nm. The main objective of this investigation was to improve the power conversion efficiency (PCE) of SHJ solar cells by reducing light reflection.

2. MATERIAL AND METHODS

2.1. Thin Film Deposition

ITO films were sputter-deposited onto soda-lime glass substrates with dimensions of 2.5 x 2.5 cm2 and a thickness of 1.1 mm using a DC magnetron integrated into a physical vapor deposition (PVD) system operating at a frequency of 13.56 MHz. A high-purity ITO sputtering target with 99.999% (5N) purity was utilized for the film deposition, resulting in films with an approximate thickness of 100 nm. Prior to introducing the glass substrates into the PVD chamber, a thorough cleaning process was conducted. Each substrate underwent a 5 minute ultrasonic bath treatment with acetone, followed by 5 minutes in ethanol, and concluded with a 10-minute immersion in distilled water. Subsequently, the substrates were dried using Nitrogen (N2) gas. The cleaned glass substrates were then loaded into the PVD system and held until a working pressure of 1x10-6 mbar was achieved. Throughout the deposition process, the pressure in the PVD system was maintained at 2x10-2 mbar by continuously supplying Argon (Ar) and O2 gases into the system. The film deposition was carried out at a temperature of 200 °C, with a power of 2050 W applied during the process.

2.2 Production of Silicon Heterojunction Solar Cells (SHJ)

In the second phase of this study, silicon heterojunction (SHJ) solar cells were manufactured using 5x5 cm2, 180 µm thick, (100) orientation random pyramid textured crystalline silicon (c-Si) substrates. The preparation of the substrates involved removing the oxide layer from the c-Si surface using a hydrofluoric acid (HF) solution, followed by rinsing with distilled water and drying with N2 gas. To enhance the performance of the SHJ solar cells, 10 nm thick hydrogenated amorphous silicon (a-Si:H (i)) layers were deposited on both surfaces of the c-Si substrate using plasma-enhanced chemical vapor deposition (PECVD) technique. The deposition process utilized silane (SiH4) and hydrogen (H2) gases. Following that, a 10 nm thick p-type a-Si layer (SiH4, H2, and Trimethyl boron (TMB) gas) was deposited on the front surface, while a 10 nm thick n-type a-Si layer (SiH4, H2, and Phosphine (PH3) gas) was deposited on the back surface. On the rear surface of the n-type a-Si:H layer, consecutive layers of 40 nm ITO and 220 nm silver (Ag) were deposited. The ITO and Ag layers were kept at a constant thickness for all SHJ solar cells. The front surface of the solar cells underwent deposition of a 100 nm thick ITO layer on the p-type a-Si:H layer, utilizing various O2 ratios (0, 1, 1.5, 2, 2.5, 3, and 5 sccm). Subsequently, the front surface of the solar cells was metalized using a screen-printing method with Ag paste.

3. RESULTS AND DISCUSSION

3.1 Structural and Morphological Features

In this study, the crystal structure of ITO films, produced with different oxygen ratios (0, 1, 1.5, 2, 2.5, 3, and 5 sccm), was analyzed using X-ray diffraction (XRD) method. The scan range for 2θ was set between 10° and 80°, and the findings are presented in Figure 1. The analysis revealed that all the deposited films exhibited polycrystalline characteristics, with diffraction peaks at (211), (222), (400), (440), and (622), indicating a cubic ITO structure (Lien, 2010). Increasing the oxygen ratio led to a reduction in the intensity of the (400), (440), and (622) peaks in the ITO films. Notably, at the 5 sccm O2 ratio, the (400) and (622) peaks completely disappeared. Furthermore, the intensity of the (222) peak initially decreased as the O2 ratio increased from 0 to 3 sccm, but then showed an increase at 5 sccm O2 (Figure 1).

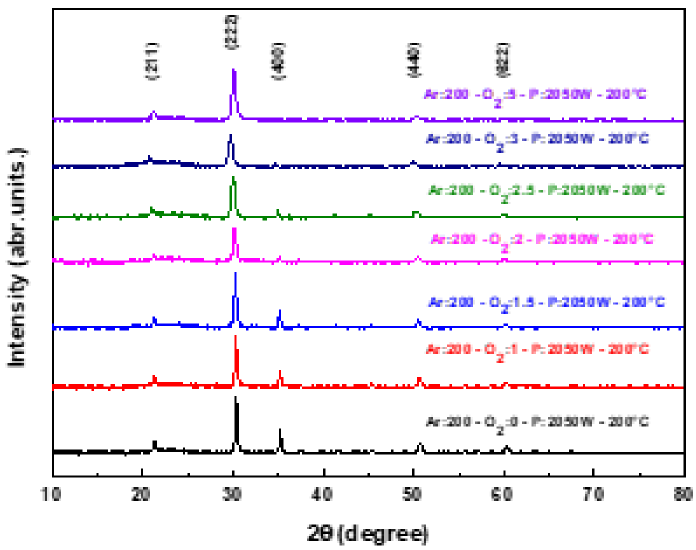

Figure 1: XRD patterns of ITO films deposited on glass substrate with O2 ratios of 0, 1, 1.5, 2, 2.5, 3, and 5 sccm.

3.2 Optical Properties of ITO Films

Figures 2 (a) and (b) present the optical transmittance and reflection spectra, respectively, of ITO films deposited on glass substrates using the PVD method with varying O2 ratios. Table 1 summarizes the optical properties of the films and the glass substrate. The transmittance spectra of the films, deposited with different O2 ratios, demonstrate excellent transparency in the visible range of the electromagnetic spectrum. In the wavelength range of 400-1200 nm, the ITO films deposited with various O2 ratios exhibited an average transmittance exceeding 61% and a reflection of over 11% (Table 1, Figure 2 (a-b)). Notably, an increase in the O2 ratio led to higher average transmittance values, except at the 5 sccm O2 ratio. The ITO films deposited with 2.5 and 3 sccm O2 ratios achieved the highest average transmittance of 80%, while the film deposited with 0 sccm O2 ratio exhibited the lowest transmittance of 61%. Moreover, increasing the O2 ratio resulted in enhanced transmittance in the near-infrared region and at higher wavelengths. Figure 2 (a) clearly illustrates that, among the ITO films with different O2 ratios, the film deposited with 2.5 and 3 sccm O2 ratios exhibited the highest transmittance in the infrared region.

Table 1. Transmittance and reflectance of ITO films deposited at O2 ratios of 0, 1, 1.5, 2, 2.5, 3, and 5 sccm.

O_2 (sccm)	Average Transmittance (%) (400-1200 nm)	Average Reflection (%) (400-1200 nm)	Transmittance (%) (550 nm)
0	61	11	62
1	74	11	77
1.5	78	12	80
2	78	12	80
2.5	80	14	81
3	80	14	81
5	78	16	79

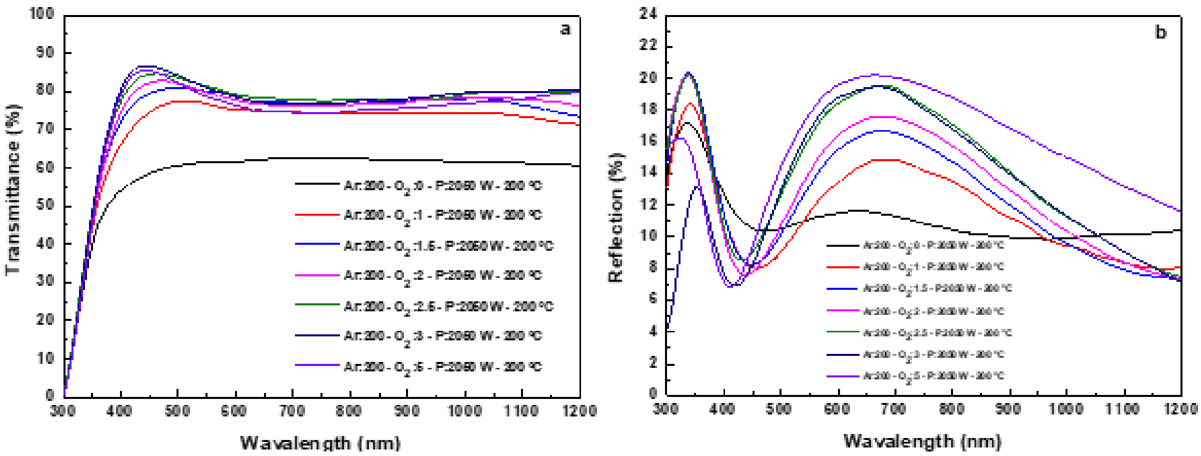

Figure 2: Transmittance (a) and reflection (b) spectra of ITO films deposited at O2 ratios of 0, 1, 1.5, 2, 2.5, 3, and 5 sccm.

3.3 Electrical Properties of ITO Films

Table 1 provides the transmittance values at a wavelength of 550 nm, which were used to calculate the figure of merit (FOM) of ITO films based on the oxygen (O2) ratio. The FOM (ϕTC) values were obtained using the equation ϕTC=T10/Rsh, which incorporates the transmittance and sheet resistance properties of the ITO films at 550 nm. Figure 3 illustrates the ϕTC and sheet resistance (Rsh) values of the ITO films deposited with different O2 ratios. It was observed that the ϕTC values increased from O2 ratios of 0 to 1.5 sccm, but significantly decreased at a ratio of 5 sccm. Additionally, the ϕTC values between 1.5 and 3 sccm ratios were found to be very close to each other. Among the ITO films, the one deposited with a 3 sccm O2 ratio exhibited the highest FOM value of (2.29x10-3 Ohm-1). Figure 3 presents the Rsh values of the ITO films deposited at various O2 ratios. It was noted that as the O2 ratio increased from 0 to 1.5 sccm, the Rsh value decreased, while beyond 1.5 sccm, the Rsh value consistently increased. The film deposited with a 5 sccm O2 ratio demonstrated the highest Rsh value of 127.08 Ohm/sq, whereas the film deposited with a 1.5 sccm O2 ratio exhibited the lowest Rsh value of 48.97 Ohm/sq.

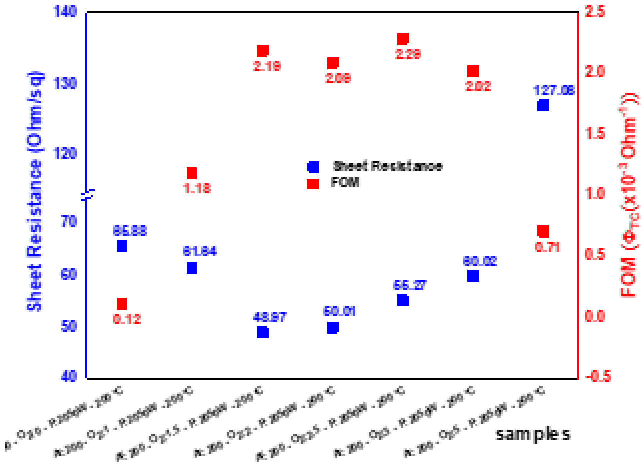

Figure 3. Results of the figure of merit (FOM) and sheet resistance (Rsh) for ITO films deposited with different O2 ratios (0, 1, 1.5, 2, 2.5, 3, and 5 sccm).

4. CONCLUSIONS

In this study, the structural, optical, and electrical properties of ITO films deposited on a 5x5 cm2 glass substrate using DC magnetron sputtering with various O2 ratios (0, 1, 1.5, 2, 2.5, 3, and 5 sccm) at 200 °C were investigated. The optical properties were evaluated by measuring the average transmittance in the visible region (400-1200 nm). The highest transmittance of 80 % was achieved in the ITO films deposited with 2.5 and 3 sccm O2, followed by films deposited with 1.5, 2, and 5 sccm O2, which exhibited transmittance values of 78 %. The ITO film deposited with 0 sccm O2 demonstrated the lowest transmittance of 61 %. Sheet resistance measurements revealed that the ITO film deposited with 1.5 sccm O2 had the lowest value of 48.97 Ω/sq. Moreover, this film exhibited a high figure of merit (FOM) value of 2.19x10-3 Ohm-1, indicating superior electrical performance compared to other films. X-ray diffraction (XRD) analysis confirmed the presence of crystal planes (211), (222), (400), (440), and (622) in all ITO films. Furthermore, the ITO film deposited with a 2.5 sccm O2 content demonstrated exceptional performance, resulting in 18.61 % high efficiency in the SHJ solar cell.

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USING ARTIFICIAL INTELLIGENCE ALGORITHMS FOR SOLAR ENERGY PREDICTION

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ABSTRACT

The whole world goes towards renewable sources in order to meet its energy demand because non-renewable energy sources are on the brink of exhaustion. Solar energy is likely to be a primary contributor to renewable energy in the near future. However, the integration of untrustable solar energy sources directly into the grid makes the present system complicated. So as to decrease the complexity, a micro grid system is a preferable solution. Solar energy forecasting models enhance the trustworthiness of the solar plant in micro grid operations. Vagueness in solar energy prediction is the difficulty in producing reliable energy. Evaluating, comprehending, training, and employing various forecasting models with existing meteorological data will provide the selection of a suitable forecast model for any certain location. New approximations and strategies show up from day to day in order to enhance the model accuracy, with a final goal of minimizing uncertainty in forecasting. Traditional methods involve many differential mathematical calculations. Big data usability at solar stations make use of several Artificial Intelligence (AI) techniques on the purpose of predicting and computing solar radiation energy. In this article, data sets related to solar energy production, which may include weather data, solar panel characteristics, historical energy production and other related factors, have been used. The aim is to develop a forecasting model that accurately detects solar energy production based on these variables. Machine learning algorithms, attribute engineering techniques and statistical analyses were used to create the most accurate model possible.

Keywords: Solar Energy, AI Techniques, Forecast, Machine Learning.

FROM SUNLIGHT TO CLEAN ENERGY: HARNESSING PLASMONIC Ni NANOPARTICLES AND MoS2 FOR SUSTAINABLE HYDROGEN GENERATION IN CdXZn1-XS PHOTOCATALYSTS

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ABSTRACT
Exploiting the interactions of chalcogenide-based nanomaterials is crucial for advancing photocatalysis. This study investigates the utilization of plasmonic nickel nanoparticles (Ni) and molybdenum disulfide (MoS2) in CdXZn1-XS photocatalysts for enhanced hydrogen production. By optimizing the nickel loading in Cd0.5Zn0.5S/MoS2 photocatalysts at varying concentrations (%1, 3, 5, 7, and 10), a significant improvement in hydrogen production is achieved. Notably, the Cd0.5Zn0.5S/MoS2 photocatalyst loaded with 1% Ni demonstrates the highest hydrogen production rate, reaching 2410 μmol(h. gcat)-1. This improvement can be attributed to the surface plasmon resonance (SPR) effect of Ni nanoparticles, which enhances the photocatalytic activity. The hetero-junction form of %xNi-Cd0.5Zn0.5S/MoS2, where Ni nanoparticles are present, exhibits improved photocatalytic activity by reducing surface recombination, spatially separating photo-generated charges, and providing active sites for reduction reaction. These findings highlight the significance of chalcogenide-based nanomaterial interactions and the positive impact of Ni nanoparticles on the enhancement of photocatalytic systems for efficient hydrogen production.
Keywords: Chalcogenides, Hydrogen Evolution, Nanocomposites Photocatalysis, Plasmonic Nickel.

1. INTRODUCTION
In recent years, the development of efficient and sustainable energy sources has become a pressing global challenge. Among the various renewable energy options, hydrogen has emerged as a promising candidate due to its high energy density and clean combustion properties (Dincer & Acar, 2017). Photocatalysis, which utilizes semiconductor-based materials to harness solar energy for chemical reactions, offers a viable pathway for hydrogen production. The integration of chalcogenide-based nanomaterials has garnered significant attention for enhancing the performance of photocatalytic systems (Nishiyama et al., 2021).
Chalcogenide-based nanomaterials, such as metal sulfides, have shown tremendous potential as photocatalysts due to their unique electronic and optical properties. Among them, cadmium zinc sulfide (CdZnS) solid solutions have gained prominence due to their tunable bandgap and favorable energy levels for hydrogen evolution. However, to further enhance the photocatalytic activity and overcome limitations such as charge recombination, novel strategies need to be explored (Navakoteswara Rao et al., 2021).
One promising approach is the incorporation of plasmonic nanoparticles into chalcogenide-based photocatalysts. Plasmonic nanoparticles, such as nickel (Ni), exhibit strong localized surface plasmon resonance (SPR) effects, which can enhance light absorption and improve charge carrier dynamics. The utilization of plasmonic nanoparticles in conjunction with chalcogenide-based materials holds great potential for achieving efficient hydrogen production through enhanced light absorption and charge separation.
In this study, the utilization of plasmonic Ni nanoparticles and molybdenum disulfide (MoS2) in CdXZn1-XS photocatalysts for enhanced hydrogen production were investigated. The aim is to exploit the interactions between chalcogenide-based nanomaterials and plasmonic nanoparticles to optimize the photocatalytic performance. By varying the loading concentration of Ni in Cd0.5Zn0.5S/MoS2 photocatalysts, the effect of Ni on hydrogen production were systematically explored (Pawar et al., 2019).
Improved photocatalytic activity in CdXZn1-XS photocatalysts is anticipated to be achieved through the incorporation of plasmonic Ni nanoparticles. The SPR effect of Ni nanoparticles is expected to enhance light absorption, promote efficient charge separation, and reduce charge recombination, ultimately boosting the overall hydrogen production efficiency. Furthermore, the unique properties of MoS2, such as its layered structure and excellent catalytic activity, make it an ideal co-catalyst in the CdXZn1-XS system, synergistically enhancing the photocatalytic performance.
In summary, this study explores the exploitation of chalcogenide-based nanomaterial interactions by harnessing plasmonic Ni nanoparticles and MoS2 in CdXZn1-XS photocatalysts. By investigating the effects of Ni loading on hydrogen production, we aim to enhance the efficiency of photocatalytic systems for sustainable hydrogen generation. The integration of plasmonic nanoparticles into chalcogenide-based photocatalysts holds great promise for advancing the field of renewable energy and facilitating the transition to a clean and sustainable future.

2. MATERIAL AND METHODS

High-purity chemicals were used, including cadmium acetate dihydrate, zinc acetate dihydrate, thiourea, thioacetamide, sodium hydroxide, nickel nitrate and ethylenediamine. The Cd0.5Zn0.5S/wt%MoS2 composite photocatalysts were synthesized as follows: 3.25 g of Cd0.5Zn0.5S was dispersed in 120 mL of DMF. Ammonium paramolybdate tetrahydrate and thiourea were added to the mixture. The resulting suspension was transferred into a 200 mL Teflon autoclave and heated at 180 °C for 24 hours. The Cd0.5Zn0.5S/MoS2 hybrids with different composite ratios were obtained by rinsing with deionized water and ethanol, followed by drying at 75 °C for 6 hours in a vacuum oven.
Characterization of the Cd0.5Zn0.5S/wt%MoS2 composite photocatalysts was performed using various techniques. X-ray diffraction patterns were obtained using a Rigaku D/Max-2200 diffractometer. The light absorption properties of the samples were measured using an Ocean optics model USB-4000 spectrophotometer.
To evaluate the photocatalytic activity for H2 production, the Cd0.5Zn0.5S/wt%MoS2 photocatalysts were subjected to visible light irradiation in the presence of an aqueous solution containing electron donors. The photocatalytic reactions were conducted in 250 mL quartz flasks. The amount of H2 produced was determined using gas chromatography. The quantum yield of hydrogen production under monochromatic light irradiation measured at 420 nm using a narrow band pass filter was determined.

3. RESULTS AND DISCUSSION

In Figure 1, it was found that Ni-Cd0.5Zn0.5S/MoS2 solid solutions consist of Wurtzite and Zinc-blend phases (Salah Hamza Hamid et al., 2023). The characteristic diffraction of MoS2 and Ni were not observed on Cd0.5Zn0.5S, likely due to high dispersion or low loading. The XRD patterns of Ni-Cd0.5Zn0.5S/MoS2 are similar to Cd0.5Zn0.5S/MoS2 and Cd0.5Zn0.5S, except for the increased intensity of the (002) peak due to Ni nanoparticles. High crystallinity facilitates efficient migration of charged carriers in the semiconductor.

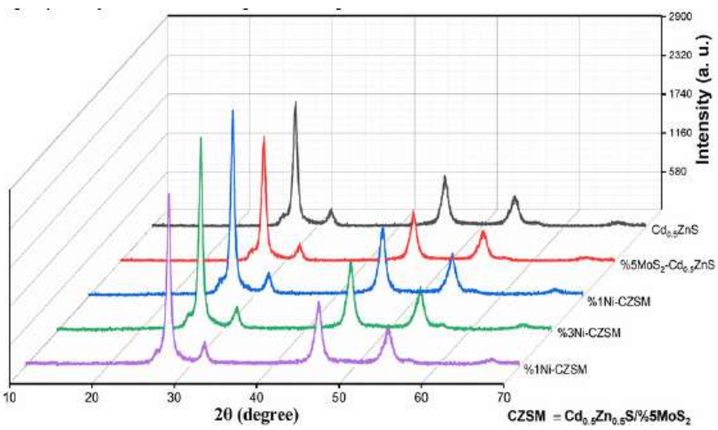

Fig.1. XRD patterns of Cd0.5Zn0.5S, Cd0.5Zn0.5S/5%MoS2, and x%Ni-Cd0.5Zn0.5S/%5MoS2 (x=1, 3, and 5).

Ni-Cd0.5Zn0.5S/MoS2 shows strong light absorption ranging from 420 to 580 nm. The visible light absorption is attributed to the localized surface plasmon resonance effect of Ni nanoparticles on Cd0.5Zn0.5S/MoS2. The addition of Ni enhances absorption, with 1% Ni-Cd0.5Zn0.5S/MoS2 exhibiting the highest absorbance. The bandgap energies indicate favorable conditions for efficient water splitting and solar utilization. The presence of Ni modifies the bandgap of Cd0.5Zn0.5S/MoS2. All synthesized catalysts demonstrate sufficient activity for hydrogen production.

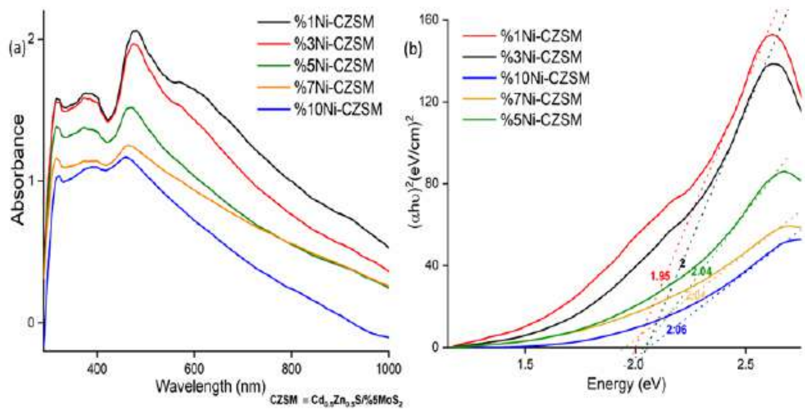

Fig. 2: UV-Vis absorption spectra of x%Ni-Cd0.5Zn0.5S/5%MoS2.

Different amounts of nickel (Ni) loading were investigated in Cd0.5Zn0.5S/MoS2 photocatalysts to optimize the loading quantity. The photocatalytic activity data clearly show a gradual decrease in hydrogen (H2) production with increasing Ni loading (Fig 3). Among the catalysts, the Cd0.5Zn0.5S/MoS2 sample loaded with 1% Ni exhibited the highest H2 production rate of 2410 μmol(h.gcat)-1. The hydrogen production with increased Ni loading (%3, %5, %7, and %10) was obtained as 2065, 2037, 1746, and 1455 μmol(h.gcat)-1, respectively. These results indicate that increasing the Ni loading content leads to a further increase in surface Ni coverage and a decrease in photocatalytic efficiency due to the protective effect of Ni co-catalyst.

The presence of %xNi-Cd0.5Zn0.5S/MoS2 hetero-junction form is assumed to be crucial for enhancing photocatalytic activity. Considering the Ni nanoparticles in their metallic state, it can be inferred that they significantly reduce surface recombination and spatially separate the nano-scale photo-generated charges on the Cd0.5Zn0.5S surface. Moreover, the nano-sized metallic Ni can provide active sites for proton reduction, contributing to improved activity and stability. The active sites play a role in enhancing both activity and stability.

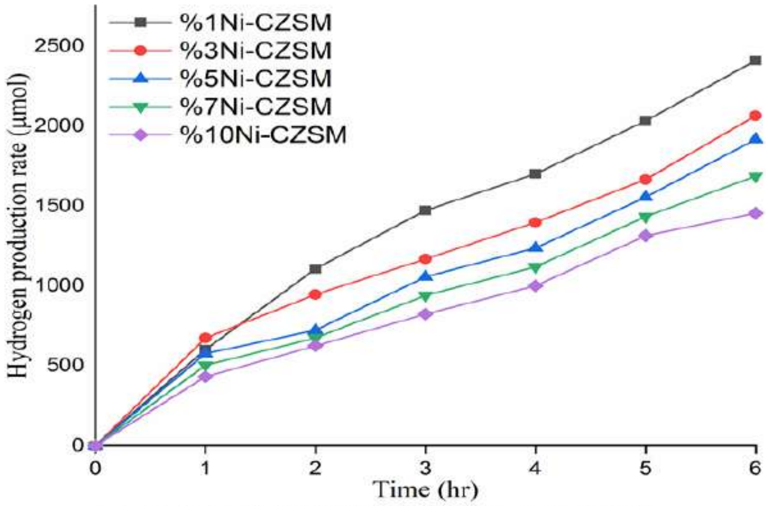

Fig. 3: The H_2 production rate of %xNi-$Cd_{0.5}Zn_{0.5}S$/5%MoS_2 photocatalysts.

Fig. 3: The H2 production rate of %xNi-Cd0.5Zn0.5S/5%MoS2 photocatalysts.

The optimization of Ni loading and the utilization of the %xNi-Cd0.5Zn0.5S/MoS2 hetero-junction form have shown promising results in improving photocatalytic activity. The findings shed light on the potential of chalcogenide-based nanomaterials, specifically the plasmonic effects of Ni nanoparticles, for efficient and sustainable hydrogen production. Future research can further explore the surface plasmon resonance phenomenon and optimize the parameters to maximize the photocatalytic performance of these materials.

Table 1. The Photocatalytic H_2 evolutions and the apparent quantum yields.

Ni content	Photocatalytic H_2 production μmol (h. g_{cat})$^{-1}$	AQY (%)
1.0	2410.81	8.44
3.0	2064.94	7.23
5.0	2037	7.13
7.0	1764	6.11
10	1455.11	5.09

4. CONCLUSIONS

In conclusion, this study investigated the optimization of nickel (Ni) and (MoS_2) loading in $Cd_{0.5}Zn_{0.5}S$ photocatalysts for enhanced hydrogen production. The results revealed a gradual decrease in hydrogen production with increasing Ni loading. Notably, the catalyst loaded with 1% Ni and 5% MoS_2 exhibited the highest hydrogen production rate. The incorporation of Ni in the $Cd_{0.5}Zn_{0.5}S/MoS_2$ hetero-junction form was found to be crucial for improving photocatalytic activity. The presence of metallic Ni in the photocatalysts was observed to significantly reduce surface recombination and spatially separate the photo-generated charges on the $Cd_{0.5}Zn_{0.5}S$ surface. Additionally, the nano-sized metallic Ni provided active sites for proton reduction, ultimately enhancing the activity and stability of the photocatalysts. These findings highlight the positive impact of surface plasmon resonance (SPR) of Ni nanoparticles on the photocatalytic performance.

By exploiting chalcogenide-based nanomaterial interactions, this study offers valuable insights for the design and development of efficient photocatalytic systems. The optimized $Cd_{0.5}Zn_{0.5}S/MoS_2$ photocatalysts with Ni loading demonstrate potential for clean and efficient hydrogen production, contributing to the advancement of sustainable energy applications. Further research can focus on exploring the SPR phenomenon and optimizing the parameters to maximize the photocatalytic efficiency of chalcogenide-based nanomaterials.

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INVESTIGATION OF THE EFFECT OF SOLAR RADIATION ON OPTIMUM INSULATION THICKNESS

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ABSTRACT
The present study investigates the effect of solar radiation on optimum insulation thickness for achieving energy savings in buildings. Using the degree-day method and polyurethane insulation material, the study examines two cities with different climatic conditions, Istanbul and Khartoum, to understand how the latitudes, altitudes, and surrounding environmental conditions affect energy requirements for cooling and heating purposes. The study reveals that the effect of solar radiation is critical in building design and optimum insulation thickness. Without considering the impact of solar radiation, annual optimum insulation thickness, energy savings per square meter, and payback time for Istanbul were found to be 0.054 m, 30.3 USD, and 15 years, respectively, whereas, for Khartoum, the corresponding values were 0.107 m, 143 USD, and 4 years, respectively. However, with the effect of solar radiation, the values for Istanbul and Khartoum varied depending on the wall direction. The study concludes that considering the effect of solar radiation is essential when determining the optimum insulation thickness to achieve energy savings, and the results of the study can be used as a guideline for building construction or renovating existing buildings in similar climates. Ultimately, the study may contribute to energy conservation and environmental protection.
Keywords: Energy Savings, Heating-Cooling Energy Requirements, Optimum Thermal Insulation Thickness, Solar Radiation, Building Design.

1. INTRODUCTION
The need for sustainable energy practices and energy-efficient buildings has become increasingly important in recent years. Researchers and engineers are actively exploring innovative strategies to reduce heating and cooling energy requirements. Among these strategies, optimizing the thermal insulation thickness of building envelopes has emerged as a promising approach. The thickness of thermal insulation plays a crucial role in minimizing heat transfer through the building envelope, leading to substantial energy savings (C. Zhang et al., 2021).
Solar radiation, as a readily available and renewable energy source, has the potential to influence the optimum thickness of thermal insulation. When solar energy reaches the Earth's surface, it interacts with buildings and their surroundings, significantly impacting their thermal performance. Understanding the intricate relationship between solar radiation and the optimum insulation thickness is of utmost importance for designing sustainable and energy-efficient buildings (Ucar & Balo, 2010).
Energy savings serve as a fundamental motivation for optimizing insulation thickness. Buildings globally contribute to a significant portion of energy consumption, with heating and cooling accounting for a substantial proportion of their energy demands. Effective insulation reduces heat transfer between the building's interior and exterior, thereby reducing the reliance on mechanical heating and cooling systems. By determining the optimum insulation thickness under varying solar radiation conditions, energy efficiency can be enhanced, leading to lower operational costs associated with heating and cooling (Emekcİ, 2022). This study will employ advanced modeling techniques, such as numerical simulations and energy performance analysis, to evaluate the effect of solar radiation on the optimum insulation thickness. Through simulations of various scenarios and the exploration of different combinations of solar radiation and insulation thickness, optimized solutions can be established for different geographical locations and building types (T. Zhang et al., 2020).
The findings of this research have significant implications for sustainable building design, energy efficiency, and environmental conservation. By identifying the optimum insulation thickness under varying solar radiation conditions, architects and engineers can make informed decisions during the design and retrofitting processes, ultimately leading to improved energy performance and reduced carbon emissions.

2. MATERIAL AND METHODS

2.1 Degree-Day (DD) method

The Degree-Day (DD) method is a measure used to plan the timing of crop cultivation, pest management, and building energy consumption. It involves calculating the total degree days starting from a chosen base date. Degree days are typically calculated as the integral of a function that accounts for temperature variations. The function is truncated based on upper and lower thresholds or suitable limits. Various methods can be used to estimate or measure degree days, including continuous temperature measurements, sinusoidal approximation, or modified formulas. The Degree-Day method provides valuable insights into energy consumption, allowing for energy monitoring, targeting, and prediction of heating and cooling costs in buildings.

$$DD(HDD) = \sum_{i=1}^{n} (T_b - T_{o,i}) \quad , \quad \text{if } (T_0 < T_b) \tag{1}$$

$$DD(CDD) = \sum_{i=1}^{n} (T_b - T_{o,i}) \quad , \quad \text{if } (T_b < T_o) \tag{2}$$

Without the influence of solar radiation:

$$T_{o,i} = \frac{T_{o,max} + T_{o,min}}{2} \tag{3}$$

With the influence of solar radiation:

$$T_{o,i} = T_{sun-air} = T_0 + \frac{\alpha_s q_s}{h_o} - \frac{\varepsilon \sigma (T_0^4 - T_{surround}^4)}{h_o} \tag{4}$$

where Tb is the indoor temperature (baseline temperature), To is the daily average outdoor temperature, and n is the total number of days with heating or cooling. The daily average temperature is determined by averaging the maximum and minimum temperatures measured per day.

2.2 Economic Analysis and Optimum Insulation Thickness:

One of the economic evaluation techniques is Life Cycle Cost (LCC) analysis, which determines the total cost of owning and operating a facility over time. It is evident that as insulation thickness increases, insulation costs rise while heating, cooling loads, and energy expenses decrease. Adding more insulation increases the total cost of the material used in proportion to its thickness. The cost of additional insulation thickness should be balanced against reduced heating or cooling costs. The optimum insulation thickness is the thickness at which the total cost is minimized. Selecting a thickness value beyond the optimum increases the total cost. The total cost (Ct) to consider in optimization includes the cost of insulation material (Ct,ins), additional insulation cost (Cad), and the present value of heating energy consumption cost over the building's lifespan (Ch,pv). Therefore, the total heating cost per unit area of the wall is expressed as follows.

$$C_t = C_{t,ins} + C_{h,pv} = C_{ins}\ x + C_h\ PWF \tag{5}$$

$$C_{t,a} = C_{ins}\, x + C_{ad} + \left[\frac{86400\ PWF}{\left(R_{w,t} + \frac{x_{ins}}{k_{ins}}\right)}\right]\left[\frac{C_f\, HDD}{LHV\,\zeta} + \frac{C_e\, CDD}{COP}\right] \tag{6}$$

$$x_{opt,a} = \left[\frac{86400\ PWF\ K\,(C_f HDD/\zeta LHV + C_e CDD/COP)}{C_{ins}}\right]^{\frac{1}{2}} - R_{w,t}K \tag{7}$$

$$ECS = C_{t,a@x=0} - C_{t,a@x=x_{opt,a}} \tag{8}$$

$$\text{payback period} = \frac{C_{ins}\, x_{opt,a} + C_{ad}}{ECS/LT} \tag{9}$$

Parametre	Value
Natural gas Lower Heating Value (LHV)	34526000 J/m^3
Natural gas price (C_f) (İGDAŞ, 2022)	0.4 USD/ m^3
Electricity price (C_e)	0.13 USD/kWh
Heating system efficiency (ζ)	0.93
Cooling coefficient of performance (COP)	2.5
Insulation material (polyurethane) Thermal conductivity(K)	0.034 W/m K
Insulation material (polyurethane) price (C_{ins})	150 USD/m^3
Installation cost of insulation (C_{ad})	15 USD/m^2
Interest rate (i)	0.14
Inflation rate (g)	0.13
Lifetime (LT)	20 yıl
Present worth factor (PWF)	18.3
$R_{t,w}$	0,6125

3. RESULTS AND DISCUSSION

In this study, the impact of solar radiation on the outer walls of Istanbul and Khartoum, the most populous cities in Turkey and Sudan, located in regions with two different climatic conditions, was taken into account. The heating and cooling loads, optimum insulation thicknesses, energy savings, and payback periods were calculated. The results obtained for the main and intermediate orientations are summarized in follows tables and Figures below:

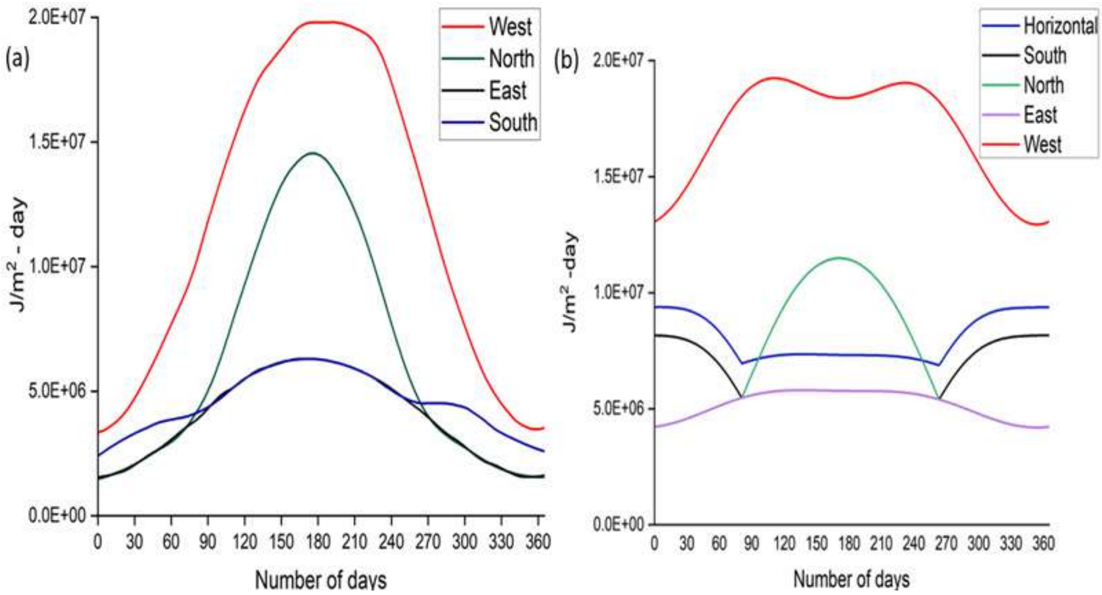

Fig. 3: (a) and (b) Variation of the daily total solar radiation (qs) falling on the vertical surface in the main directions in Istanbul and Khartoum.

Table 2. Optimum insulation thickness and economic analysis in Istanbul

Main	Horizontal	South	West	North	East
$x_{a,opt}$ (m)	0,054	0,052	0,054	0,054	0,053
$C_{t,a}$ (USD/m^2)	51,83	50,32	51,58	51,58	50,78
ESC(USD/m^2)	32,06	28,42	31,45	31,45	29,48
P.P (year)	14,2	18,4	14,5	14,5	15,4
İntermediate	**-**	**S – W (45°)**	**N– W (45°)**	**N – E (45°)**	**S – E (45°)**
$x_{a,opt}$ (m)	-	0,051	0,056	0,053	0,053
$C_{t,a}$ (USD/m^2)	-	49,94	52,49	50,77	50,77
ESC(USD/m^2)	-	27,59	33,67	29,47	29,47
P.P(year)	-	16,35	13,62	15,40	15,40

Table 3. Optimum insulation thickness and economic analysis in Khartoum

Main	Horizontal	South	West	North	East
$x_{a,opt}$ (m)	0,125	0,114	0,124	0,114	0,112
$C_{t,a}$ (USD/m^2)	90,56	84,47	89,63	84,74	83,78
ESC(USD/m^2)	195,94	161,01	190,43	162,48	157,28
P.P(year)	5,37	6,15	5,47	6,11	6,26
intermediate	**-**	**S – W (45°)**	**N– W (45°)**	**N – E (45°)**	**S – E (45°)**
$x_{a,opt}$ (m)	-	0,120	0,121	0,112	0,112
$C_{t,a}$ (USD/m^2)	-	87,79	88,26	83,78	83,78
ESC(USD/m^2)	-	179,65	181,47	157,28	157,28
P.P (year)	-	5,70	5,66	6,26	6,26

Based on the results, Khartoum requires more energy for cooling due to its proximity to the equator, longer summer season, and high temperatures compared to Istanbul's heating needs. Economic factors affect optimal insulation for exterior walls, with Istanbul needing about half the insulation thickness of Khartoum. Considering solar radiation, there is a significant reduction in cooling and heating costs, up to 75% in Khartoum and 6% in Istanbul. Khartoum has a shorter payback period for the optimal insulation system.

4. CONCLUSIONS

Based on the results of this study, it is recommended to implement an optimal insulation system in both cold and hot regions, considering the impact of solar radiation. The selection of the best design that maximizes the benefits of solar energy is crucial. This will not only reduce cooling and heating costs but also contribute positively to environmental preservation by reducing emissions from energy production. Further research and development of different insulation materials are needed, particularly for advanced-designed buildings. The importance of insulation for buildings should be widely disseminated among the population, and efforts should be made to reduce costs.

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ASSESSING THE IMPACT OF CLIMATE CHANGE ON SOIL MOISTURE AND SOIL EROSION IN NORTHWEST MOROCCO BASED ON NUCLEAR TECHNIQUES (CAESIUM-137 RE-SAMPLING AND EXCESS LEAD-210 SEDIMENT DATING) AND REMOTE SENSING

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ABSTRACT
Climate change threatens soil and water resources in Africa. In Northwest Morocco, which is located at the extreme Northwest of Africa and typical of African Mediterranean areas, soil erosion is intense and the situation could have been triggered by the climate change impact. The annual long periods of drought decreases soil moisture and increases soil aridity in consequence which in turn makes soil more vulnerable to soil erosion.
The Caesium-137 technique was used in this study in combination with the re-sampling approach to evaluate changes in soil redistribution between two different periods 1954-2000/2001/2002 and 1954-2017/2018. Lead-210 in excess was used to assess changes in sedimentation rates within El Hachef dam. Moreover, data on soil moisture were obtained by Sentinel 1 for the period 2018-2022. The obtained data on soil moisture shows that soil moisture decreased from 0.184 to 0.169 cm3/cm3 in El Hachef watershed and from 0.203 to 0.192 cm3/cm3 in the Nakhla watershed and from 0.255 to 0.233 cm3/cm3 in the Raouz watershed. This shows that the tendency of soil aridity is toward increase in the three watersheds. Moreover, based on the Caesium-137 technique, the results show that the mean soil erosion rates decreased from 38.5 to 31.5 t.ha-1.yr-1 in the study sites of El Hachef watershed due to some beneficial changes in land use consisting of more frequent fallows and the regional crop rotation however, the decreasing tendency in the mean annual soil loss does not dominate in the whole El Hachef watershed since the sedimentation has increased by around 30% between the periods 1950-2002 and 1950-2015 due to probably climate change impact and intensive agriculture in other sites in the region. The mean soil erosion rates decreased from 36 to 29 t.ha-1.yr-1 in the study site of the Nakhla watershed due to the beneficial impact of agricultural practices and the implemented soil erosion control strategy and from 11.9 to 10.9 t.ha-1.yr-1 in the study sites of the Raouz watershed. Within this last watershed, soil erosion rates had slightly increased from 4.5 to 5.7 t.ha-1.yr-1 in one field where agricultural practices were not changed. This variation represents an increase of the soil erosion rate of about 26% between the two periods and could be due to climate change impact on soil erosion in this area. Furthermore, the results show that the Raouz watershed which recorded the highest values of soil moisture is the most stable (recorded the lowest erosion rates) in comparison with the other watersheds which recorded lower values of soil moisture and higher rates of soil erosion.
The results of this study proved the effectiveness of the used approach in assessing changes in soil erosion rates and soil moisture in the study area. They also showed that sustainable agricultural practices can mitigate the complex effects of climate change on soil loss.
Keywords: soil erosion, soil moisture, climate change, Caesium-137, remote sensing.

1. INTRODUCTION
Soil erosion has been the main threat of the natural resources, mainly soil and water, in Northwest Morocco. Indeed, the complex effects of soil erosion and climate change impacts negatively the sustainability of soil resources and water reservoirs in Northwest Morocco. This region is typical of extreme Northwest African Mediterranean areas submitted to several natural and anthropic pressures. Land use and climate change impacts are among the factors that trigger the situation in the area (Moustakim, 2021). Recent studies on vulnerability to climate change in Mediterranean areas in general and particularly in Morocco have shown a trend of increasing aridity leading to a decrease in soil moisture which in turn accelerates soil erosion (Mokssit, 2012). So, the annual long periods of drought contribute in increasing soil aridity in the area. The Northwest Morocco is also known by the clayey texture of soil permitting less infiltration and more runoff which enhances soil erosion by water (Ibrahimi, 2005). In this regard, the soil water content (SWC) is a key state variable in determining the partitioning of infiltration and surface runoff permitting making optimal water management decisions (Franz et al., 2016). It impacts a variety of applications, including agricultural management, climate and weather applications, flood and drought forecasting and groundwater recharge. Moreover, SWC is a key parameter in helping understand and predicting the timing and severity of natural disasters such as drought and landslides and controlling irrigation systems (Franz et al., 2016). However, it is still a difficult parameter to continuously monitor and measure at a catchment scale because of its heterogeneous characteristics.

Endeavors to find efficient methods of assessing the climate change impact on soil moisture and soil loss are continuing. In recent years, the cosmic ray probe (CRP), which is an in-situ technique, has been implemented in several countries across the globe and may fill the intermediate scale gap in soil moisture measurements. At large scales, remote sensing methods provide near-surface estimates of soil moisture but there is significant influence of surface conditions (Wagner et al., 2007) and a significant gap still exists between point observations with remote sensing. However, no single point measurement can be entirely representative of larger areas, because of the heterogeneity that exists in soil properties, topography, land cover and meteorological conditions.

This study is currently based on remote sensing data to assess the spatiotemporal change in soil moisture which may have occurred these last years. Moreover, it is based on the combination between the Caesium-137 technique and the re-sampling approach to assess changes in soil redistribution between two different time-intervals and Lead-210 in excess was used to assess changes in soil sedimentation rates in an important water reservoir in the region.

2. MATERIAL AND METHODS

The study sites were previously sampled between 2000 and 2003 (Ibrahimi, 2005) and re-sampled in 2017 and 2018. Consistently with the previous samplings, soil samples were collected along parallel or single transects within the fields following the slope gradient and the runoff directions in each field. From twenty to twenty two soil samples were collected from the agricultural fields of each watershed. Moreover, some samples were collected from the reference site, which is a stable site, in each watershed according to systematic grids. In general, the collected samples were two types either bulk cores or sectioned cores from 4 to 5cm increment. One to two sectioned cores were collected from the agricultural fields to tell about the tillage depth whereas in the reference sites, the sectioned cores are expected to confirm the stability of these sites since the period of the first sampling campaigns. In addition, a sediment core, 30 cm deep, was collected to establish the sedimentation history in the "9th of April Dam" using a corer 8.5 cm in inner diameter. Soil and sediment samples were oven dried at 60°C, disaggregated, manually and automatically ground, then sieved at 2 mm and homogenized. Sub-samples from each bulk and sectioned core were put in specific cylindrical pots and analyzed by gamma spectrometry using High Purity Germanium detectors (HPGe) of 50% and 30% efficiency for counting times reaching 100 000s. The analysis of 210Pbex in the sediment core requires sealing samples for at least 21 days to prevent the escape of 222Rn and to establish secular equilibrium between 210Pbtot, 226Ra, and 214Bi.

The 137Cs inventory (areal activity (Bq m-2)) in each sample was calculated. The relative uncertainties ranged between 6% and 50% for few samples with very low activities. The comparison of the inventories with the reference site inventory permit to determine points of soil loss and gain in the field. Then, the Mass Balance Model 2 (MBM2) (Walling et al., 2002) which takes into account both the temporal variation of the 137Cs fallout input and the fate of the freshly deposited 137Cs fallout prior to incorporation into the plough layer by tillage was used to convert the previous and the recent 137Cs inventories (t ha−1 yr−1) of both periods into erosion rates (t ha-1 yr-1). It can be used as follows:

$$d(A)/dt=(1-\Gamma)I(t)-(\lambda+PR/d)A(t) \qquad (1)$$

A(t) is the 137Cs inventories (Bq m−2); t is the time since the onset of 137Cs fallout (yr) considered in 1954; R is the soil erosion rate (kg m−2 yr−1) which can be converted to t ha−1 yr−1; d is the cumulative mass depth representing the average plough depth (kg m−2); λ is the decay constant for 137Cs (yr−1); I(t) is the annual 137Cs deposition flux at time t (Bq m−2 yr−1); Γ is the proportion of the recently deposited 137Cs removed by erosion before being incorporated into the plough layer; P is the particle size factor.

The obtained previous and recent erosion rates associated with each period were compared to evaluate changes that had occurred in soil redistribution.

The Constant Rate Supply (CRS) model (Appleby and Oldfield, 1978) was used to calculate the sedimentation rates (kg m−2 year−1 or t ha−1 yr−1) based on 210Pbex sediment dating techniques. The model is based on the following formula:

$$R = \frac{\lambda I(z)}{A(z)} \qquad (2)$$

R: sedimentation rate (kg m -2 yr -1) associated with layer z; I(z): total 210Pbex inventory (Bq m−2) of the sediment core below depth z; λ: radioactive decay constant of 0.03114 yr-1; A(z): 210Pbex activity (Bq m−2) at depth z.The data on soil moisture in the three watersheds was obtained by Sentinel 1 satellite which permits to derive soil moisture data only from 2018 to 2022. Rainfall data are also necessary to support and explain changes in soil moisture but we previously obtained rainfall data only up to 2017 from the Hydraulic Basin Agency of Loukkos.

3. RESULTS AND DISCUSSION

The results show that the mean soil erosion rates decreased in the Nakhla site from 36 to 29 t ha−1 yr−1 (Table 1) during the period between the two sampling campaigns (2002−2017) due to the beneficial impact of agricultural practices and the soil erosion control strategy that was implemented within the framework of the "PREM" project (Moustakim et al., 2019). This latter was established by the Moroccan government to mitigate the in-site and off-site effects of soil erosion for a sustainable management of soil and especially water resources in the Nakhla watershed. Indeed, the storage capacity of the Nakhla dam, which contributed to the water supply of Tetouan city since 1962, has progressively decreased due to the accelerated erosion in the watershed, described by numerous studies. In 1997, the direct interventions targeted in the upstream part of the Nakhla watershed were based on the plantation of olive trees in contour lines and then, the mechanical and biological stabilization of gullies. Our study site benefited from more frequent fallow with natural vegetation and olive plantations (Moustakim et al., 2019). In the study sites of El Hachef watershed, the results show that the mean soil erosion rates had decreased from 38.5 to 31.5 t.ha-1.yr-1 due to some beneficial changes in land use consisting of more frequent fallows and the regional crop rotation. However, the decreasing tendency in the mean annual soil loss does not dominate in the whole El Hachef watershed since the sedimentation has increased from 0.20 g.cm-2 yr-1 in 1950 to 0.80 g.cm-2 yr-1 in 2015 in the water reservoir. An increase of the mean sedimentation rate of around 30% was observed between the periods 1950-2002 and 1950-2015. This increase was attributed to the combined impacts of climate change and intensive agriculture in some fields in the region (Moustakim et al., 2022). Indeed, soil erosion is intense in the region but land use and climate change impacts are among the main factors that trigger the situation there (Moustakim, 2021). In the study sites of the Raouz watershed, the mean soil erosion rates decreased from 11.9 to 10.9 t.ha-1.yr-1 (Table 1). Soil erosion rates had slightly increased from 4.5 to 5.7 t.ha-1.yr-1 in one field where agricultural practices were not changed (Moustakim et al., 2022). This slight variation represents an increase of the soil erosion rate of about 26% between the two periods and could be due to climate change impact on soil erosion in this area.

Table 1. Mean erosion rates in the study sites of the three watersheds.

Watershed		*Mean erosion rates* ($t.ha^{-1}.yr^{-1}$)			
		Previous (1954-2000/2001/2002)		*Recent (1954-2017/2018)*	
Nakhla		36.1		29.0	
El Hachef	Site 1	26.3	38.5	20.2	31.5
	Site 2	50.8		42.7	
Raouz	Site 1	19.4	11.9	16.1	10.9
	Site 2	4.5		5.7	

The data derived from Sentinel 1 from 2018 to 2022 show that soil moisture generally decreased which could be due to the rises in temperature increasing water loss through evapotranspiration and causing in consequence moisture stress in soil (figure 1). Indeed, it decreased from 0.184 (2018) to 0.169 cm3/cm3 (2022) in El Hachef watershed and from 0.203 to 0.192 cm3/cm3 in the Nakhla watershed and from 0.255 to 0.233 cm3/cm3 in the Raouz watershed. This means that soil aridity is increasing in the study area. This fact means that soil will be more vulnerable to erosion in the study area. Indeed, correlations between the mean erosion rates for the periods 1954-2017/2018 and soil moisture data show that the highest mean erosion rates of about 31.4 t.ha-1.yr-1 (1954-2017) and the lowest mean annual soil moisture of 0.17 cm3/cm3 were recorded in El Hachef watershed whereas the Raouz watershed recorded the lowest mean soil erosion rates of 10.9 t.ha-1.yr-1 (1954-2018) and accordingly the highest soil moisture of 0.24 cm3/cm3. This confirms that soil moisture has an impact on soil stability. The decreases in soil moisture and increases soil aridity in consequence making soil more vulnerable to erosion threatens more the sustainability of water reservoirs in the region.

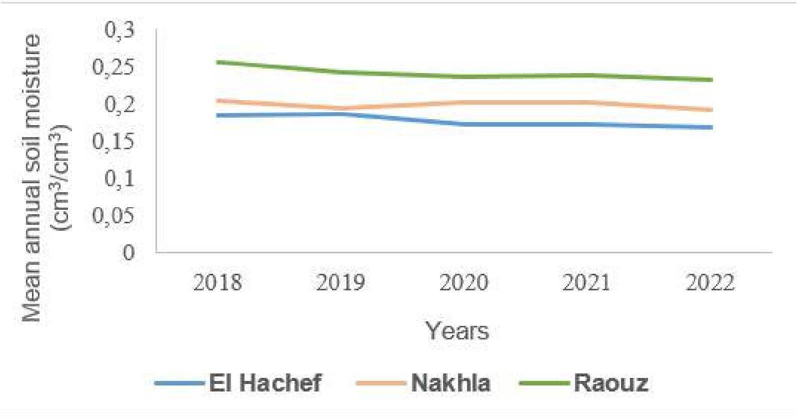

Fig.1.Soil moisture in the study sites from 2018 to 2022.

4. CONCLUSIONS

This study is the first in Morocco assessing the impact of climate change of soil erosion and sedimentation and soil moisture based on nuclear techniques and remote sensing. The results showed that the tendency is toward aridity and sustainable agricultural practices permitted to mitigate the negative impact of erosion and climate change on soil loss in the study sites. As it was reported in the PREM project, the programs of soil and water management should first raise the awareness of farmers about the importance of soil conservation strategies and nowadays about the impact of climate change on the natural resources. They must also be defined within the socio-economic context of the population and their practices, then integrate their participation to select the suitable soil conservation strategies.

Cosmic Ray Probe could be calibrated and installed in the area to obtain accurate in situ data. It is already installed and calibrated in the Merchouch area in Morocco and permitted to obtain the average soil moisture content over hundreds of square metres there. Perspectives are toward installing this tool in all Morocco to obtain accurate data on soil moisture using nuclear techniques. The current challenges facing the natural resources mainly water requires a continuing innovation in diagnosing tools to obtain reliable datasets as well as on climate change impact for sustainable management of soil and water.

Acknowledgement

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DETERMINANTS OF THE COUNTRIES' PERFORMANCES REGARDING CLIMATE CHANGE

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ABSTRACT
The aim of this study is to highlight the determinants of the countries' performances regarding climate change by using both correlation and multiple regression analyses. For this purpose, the scores given in the Climate Change Performance Index (CCPI) were used as dependent variable while income, population size, country size, total natural resources rents, governance and urbanization were used as independent variables for the year 2021 in the regression analysis. According to the results obtained, it has been found that total natural resources rents have negative impact on the performances of the countries regarding climate change.

Keywords: Climate Change Performance Index, regression analysis, correlation analysis

1. INTRODUCTION
Climate change has become one of the most important environment problems for the countries over the past decades. The existence of the negative effects of climate change makes the issue a priority among the urgent issues to be solved. Within this context, among Sustainable Development Goals (SDGs) declared by United Nations (UN) in 2015, SDG13 highlights climate change, its negative impacts and focuses on what corrective actions should be taken to prevent environmental degradation (UN, 2022).

According to the Sustainable Development Goals Report 2022, climate change continues to sound the alarm for humanity. Energy-related carbon dioxide emission increased 6% in 2021, disasters will increase 40% from 2015 to 2030 and global temperature continues to rise. If it continues in this way, sea level will rise 30-60 cm by 2100. These predictions exhibit dangerous effects of the climate change.

There have been numerous studies examining factors affecting climate change status of the countries in the literature. In this study, income, population size, country size, total natural resources rents, governance and urbanization factors were used as the independent variables based on the previous studies conducted in the literature (Kerk & Manuel, 2012; Dua & Xiab 2018; Alhassan & Kwakwa, 2023; Ulucak et al., 2020; Kwakwa et al., 2022; Safdar et al., 2022; Chien et al., 2023).

The aim of this study is to highlight the determinants of the countries' performances regarding climate change. The rest of this study is organized as follows: Second part presents the information about the data set, variables, and the method. In the following part, results obtained from the analysis are given and last section is dedicated to conclusions.

2. MATERIAL AND METHODS
To reveal determinants of climate change performance of the countries, correlation analysis and multiple regression analysis which are used to determine whether there is a relationship between variables were conducted.

Correlation analysis produces correlation coefficient (r) while regression analysis states the relationship between variables through mathematical equation. Correlation coefficient lies between -1 and 1 and as this coefficient approaches the 1 or -1, it means that relationship between variables gets much stronger. The formula for mathematical equation of multiple regression analysis is provided as below.

$$y = \beta 0 + \beta 1x1 + \beta 2x2 + \beta 3x3 + \ldots + \beta kxk + \varepsilon \quad (1)$$

where y is the dependent variable, x1, x2, x3, ..., xk are the k independent variables, and ε is the random error term. β is the regression coefficient that indicates the relationship between variables.

Scores of the countries in Climate Change Performance Index (CCPI) 2022 were used as dependent variable in regression analysis. CCPI is used for monitoring the countries with respect to their climate protection performances and one of the main targets of the CCPI is to enhance climate protection efforts and is to ensure progress of the countries in this issue. CCPI has four sub-categories which are Green House Gas (GHG) Emissions, Renewable Energy, Energy Use, and Climate Policy and total score is calculated for each country based on these categories and countries are ranked by their scores. Moreover, the countries are divided into 5 groups which are called very high, high, medium, low, very low with respect to level of the scores. For the year 2021, there is no country in very high level.

In this index, despite there are 61 countries, after dropping European Union (EU) and Chinese Taipei (Taiwan) due to lack of data, 59 countries were analyzed. The variables used in the analysis, their abbreviations and sources of the data sets are presented in Table 1.

Table 1: Variables Used in Analyses

Dependent Variable	**Abbreviation**	**Source**
CCPI Score	CCPI	CCPI Report 2022
Independent Variables		
GDP per capita, PPP (current international $)	GDPPC	World Bank (WB) World Development Indicators (WDI)
Total natural resources rents (% of GDP)	TNRR	WB-WDI
Land area (sq. km)	Land	WB-WDI
Population, total	Pop	WB-WDI
Urban population (% of total)	Urb	WB-WDI
Governance (0-100 Score)	Gov	WB-Worldwide Governance Indicators

3. RESULTS AND DISCUSSION

In this part of the study, first, data set was examined with respect to missing data and outlier using both boxplot and statistical tests. As land area, population and total natural resources rents variables are highly skewed, natural logarithm of these variables were taken and four countries were dropped from the sample due to outliers. As a result, final data set includes 55 countries. Descriptive statistics regarding variables are given in Table 2.

Table 2. Descriptive Statistics for Variables Used

	Mean	**Median**	**Std. Dev.**	**Range**	**Minimum**	**Maximum**	**N**
CCPI	51,77	54,03	13,60	57,44	19,23	76,67	55
GDPPC	36887,90	36109,75	18742,19	73313,00	7241,98	80554,98	55
Urb	72,93	76,03	14,31	62,73	35,39	98,12	55
LnPop	17,17	17,43	1,56	7,03	14,03	21,07	55
LnLand	12,90	12,76	1,77	7,48	9,13	16,61	55
Gov	62,89	68,34	25,41	86,20	10,65	96,85	55
LnTNRR	-0,41	-0,46	1,87	7,71	-4,61	3,11	55

After presenting descriptive statistics, results of the bivariate Pearson correlation analysis are provided in Table 3. According to the correlation analysis results, CCPI is negatively correlated with LnLand and LnTNRR variables. In addition, it has been seen that there are relationships among independent variables. GDPPC and Gov are correlated with all independent variables. In addition, the relationship between GDPPC and Gov is found to be very high (r=0,835). This situation indicates the existence of multicollinearity problem in the regression model.

Table 3. Bivariate Pearson Correlations Between Variables

	CCPI	GDPPC	Urb	LnPop	LnLand	LnTNRR	Gov
CCPI	1	,064	-,034	-,092	-,302**	-,330**	,262***
p-value		,644	,808	,505	,025	,014	,054
GDPPC		1	,504*	-,437*	-,346*	-,476*	**,835***
p-value			,000	,001	,010	,000	,000
Urb			1	-,175	,037	-,120	,369**
p-value				,202	,788	,382	,006*
LnPop				1	,748*	,296**	-,504*
p-value					,000	,028	,000
LnLand					1	,652*	-,486*
p-value						,000	,000
LnTNRR						1	-,567*
p-value							,000
Gov							1

*, **, *** are significant levels at 1%, 5%, and 10%, respectively.

Regression analysis has some assumptions to be satisfied. Error term in the model should be normally distributed and has constant variance and there should be no autocorrelation between error terms. Also, the independent variables should not be linearly related (multicollinearity).

To prevent multicollinearity problem, stepwise regression method was used. When the assumptions are checked it has been seen that all assumptions are satisfied. Accordingly, only total natural resources rents variable is found statistically significant whereas the other variables are not. In other words, there is a negative relationship between CCPI and TNRR variables. This finding supports the results of the correlation analysis.

Table 4. Regression Analysis Results

ANOVA				
R	0,330			
R square	0,109			
F	6,473			
Sig.	0,014			
Durbin-Watson	1,872			
Regression Equation				
Dependent Variable: CCPI				
	Unstandardized Coefficients		t	Sig.
	B	Std. Error		
(Constant)	50,801*	1,788	28,406	,000
LnTNRR	-2,396**	,942	-2,544	,014

*, ** are significant levels at 1% and 5% respectively.

4. CONCLUSIONS

This study examines the determinants of the countries' performances regarding climate change using both correlation and multiple regression analyses. While scores of the countries in Climate Change Performance Index (CCPI) were used as dependent variable, independent variables were compiled from literature. According to the results obtained from analyses, TNRR variable is found to be statistically significant, and it has negative impact on CCPI score of the countries. This finding is consistent with the results of previous studies (Posocco & McNeill, 2023; Adams & Klobodu, 2017). When the countries in the last category (very low) of the CCPI are examined, it has been seen that the value of TNRR variable is higher than the other countries. According to the studies in the literature, TNRR is a controversial topic and it can be considered both a curse and a blessing for the countries (Ploeg, 2011). Democracy and bureaucratic quality, the existence of rule of law, corruption, and underdeveloped financial systems are playing important roles in determining effect of this factor. As a result, total natural resources rents cause environmental degradation and countries should take preventing actions to fulfil the targets of SDGs by 2030.

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DEVELOPMENT AND ANALYSIS OF A MULTI-ROTOR WIND TURBINE AND SOLAR ENERGY-BASED INTEGRATED SYSTEM FOR RURAL ELECTRIFICATION

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ABSTRACT
Over 200 million people residing in rural areas in India lack access to electricity from grid connections. An appropriate & cost-effective solution can be an integrated system which lowers the reliance on grid supply and improve dependability. For rural electrification and energy demand, a solar–wind integrated system is proposed with a thermal energy storage unit and a solar desalination unit for sustained economic growth for rural development. The system is aimed to utilize locally available resources to fulfil energy demand. Energy and exergy analyses are used for the performance assessment of the system. The overall exergy and energy efficiencies of the system are estimated. The proposed system design is incorporated for Indian climatic conditions at location Lordiyan (Phalodi, Rajasthan) village with a population count of around eight thousand individuals. Environmental sustainability, rural development and carbon emission issues are deemed while developing the system.
Keywords: Solar desalination, Multi-rotor wind turbine, Concentrated solar power, Exergy, Energy storage

1. INTRODUCTION
Energy plays an intrinsic utility in our day to day pursuits, its plays an imperative role where it drives the modern socio-economic development. Use of clean, alternative & sustainable energy becomes inevitable as fossil fuels are finite in nature and burning leads to issues of carbon emissions, climate change & greenhouse effect. UN's sustainable development goal (SDG) 7th aims at affordable and clean energy for all as it directly brings the economic and social growth which is of prime importance to the very foundation of G20. Also, a more alarming reason is the worsening climatic conditions due to rising global carbon emissions as addressed in SDG 13 (IEA, 2022). It is undeniable that fossil fuels have played a significant role in advancing human civilization over the past two centuries and will continue to do so in the foreseeable future. However, there is growing concern about their limitations and their impact on the global climate. As a result, the international community recognizes the need to transition towards sustainable development. Most countries currently rely on three main energy sources: fossil fuels, nuclear power, and renewable energy. Nevertheless, fossil fuels such as coal, oil, and natural gas are non-renewable and have limited reserves (IEA, 2019). India is ranked as the third-largest country in the world in terms of both energy production and consumption. The country produces roughly 1,380 TWh of energy annually and consumes approximately 1,190 GWh of energy through various sources. There are still over 80,000 villages in India that do not have access to electricity, mainly because it is challenging to provide electricity to these areas due to geographical and economic limitations (IEA, 2021). The expenses for setting up and maintaining distribution lines in remote regions are significantly high. Moreover, there is a considerable risk of increased transmission line losses, and the reliability of power supply is also poor in these areas. Extending utility grid lines to remote and un-electrified areas involves a high initial investment, long lead time, low usage rates, inadequate voltage regulation, and frequent power outages. Therefore, to ensure a convenient, cost-effective, and reliable power supply, it is crucial to consider alternative electricity generation and distribution methods in rural areas. As a result, distributed energy generation is gaining popularity and promotion as it overcomes the shortcomings of the traditional approach. Renewable sources such as solar, wind, and biomass can generate electricity locally in various ways. In areas with abundant sunlight and wind, a hybrid approach combining solar and wind energy can be employed to reduce the reliance on conventional sources of power to meet demand. A combined system has the potential to overcome the seasonal fluctuations of wind and sunlight by generating a more consistent and stable output from renewable energy sources. This article outlines the development and execution of a small-scale wind-solar integrated system that can provide uninterrupted power to a rural load.

2. SYSTEM DESCRIPTION
The proposed system mainly consists of a concentrated solar power-driven Rankine cycle with a thermal storage unit, a multi rotor wind turbine system power source and a solar water desalination unit (as shown in Fig. 2.1). In the concentrated solar power, the vital aspects for the performance of system are mainly the direct normal irradiation and aperture area. A new system configuration is introduced in wind power i.e. multi-rotor because of its ease in installation, transportation, maintenance and overall reduced cost compared to conventional single rotor wind turbines (Sandhu, N. S. et al., 2018). Where, solar still desalination unit can produce potable water by tapping solar radiation as a cost-free source of energy. The solar desalination system exhibits a significant economic benefit in contrast to other distillation methods (Duffy, J. A., & Beckman, W. A., 1984).

The main outputs of the integrated system are electricity, distilled water and space heating.

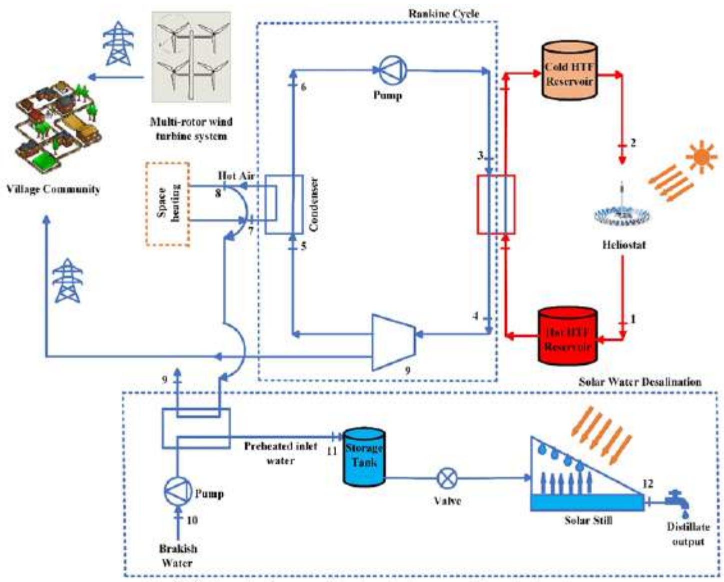

Fig 2.1 Schematic diagram of wind and solar energy integrated cycle

3. THERMODYNAMIC ANALYSIS

The assumptions made for the analysis of the integrated system are as follows:
•Heat exchanger and pipeline losses are neglected.
•The environmental dead-state conditions are T0 =298 K and P0=101.325 kPa.
•Turbines, pumps and storage tanks are considered to be adiabatic in nature.
•All processes at steady state.
•The change in kinetic and potential are neglected.
•The isentropic efficiency of all turbines and pumps are taken as 82%.
•Wind energy to electricity conversion
•Working fluid used in the TES system, Steam Rankine cycle are HiTec XL & water.

3.1 Balance Equations

MBE: mass balance equation
EBE: energy balance equation
EnBE: entropy balance equation
ExBE: exergy balance equation

For Rankine Cycle:
For condenser:

MBE: $\dot{m}_5 = \dot{m}_6$ (1)

EBE: $\dot{Q}_{co} = \dot{m}_5 (h_5 - h_6)$ (2)

EnBE: $\dot{m}_5 s_5 + \dot{s}_{gen,co} = \dot{m}_6 s_6 + \dot{Q}_c / T$ (3)

ExBE: $\dot{m}_5 ex_5 = \dot{m}_6 ex_6 + \dot{Q}_{co} (1 - T_o / T_5) + \dot{Ex}_{d,co}$ (4)

For pump:

MBE: $\dot{m}_6 = \dot{m}_3$ (5)

EBE: $\dot{W}_P = \dot{m}_6(h_3 - h_6)$ *(6)*

EnBE: $\dot{S}_{gen,p} = \dot{m}_6(s_3 - s_6)$ *(7)*

ExBE: $\dot{Ex}_{d,p} = \dot{m}_6(ex_6 - ex_3)$ *(8)*

For turbine:

MBE: $\dot{m}_4 = \dot{m}_5$ *(9)*

EBE: $\dot{m}_4 h_4 = \dot{m}_4 h_4 + \dot{W}_T$ *(10)*

EnBE: $\dot{m}_4 s_4 + \dot{S}_{gen} = \dot{m}_5 s_5$ *(11)*

ExBE: $\dot{Ex}_4 = \dot{W}_T + \dot{Ex}_5 + \dot{Ex}_D$ *(12)*

For heat exchanger:

MBE: $\dot{m}_4 = \dot{m}_3$ *(13)*

EBE: $\dot{Q}_{HE} = \dot{m}_4(h_4 - h_3)$ *(14)*

EnBE: $\dot{s}_{gen,HE} = \dot{m}_4(s_4 - s_3)$ *(15)*

ExBE: $\dot{Ex}_{d,HE} = \dot{m}_4\left((h_4 - h_3) - T_o(s_4 - s_3)\right) + \dot{Q}_{HE}(1 - T_o / T_3)$ *(16)*

4. RESULTS AND DISCUSSION

In performing the energy and exergy analyses of the solar biomass integrated multigeneration system, values of mass flow rate (kg/s), temperature (K), pressure (kPa), specific enthalpy (kJ/kg) and specific exergy (kJ/kg) are determined for each state of the system. The reference-environment conditions are taken to be the ambient conditions, for which the temperature and pressure are 298 K and 100 kPa, respectively. Thermodynamic values are calculated using Engineering Equation Solver (EES) software.

Table 2.1 Electricity load estimation of a house

Appliance	Quantity	Rating (W)	Working Hour (hrs)	Requirement (KWh)
Tubelight	4	40	5	0.8
CFL	4	10	5	0.2
Fan	4	75	15	4.5
Refrigerator	1	200	24	4.8
Television	1	70	4	0.28
Water Pump	1	700	0.5	0.35
Washing Machine	1	850	0.5	0.425
Blender	1	500	0.2	0.1
			Total = 11.46 units	

Table 2.1 shows the overall load of a single family. 11.46 units (kWh) are consumed per day by one family. Hence, requirement for 1300 families = 11.46 x 1300 = 14,898 units/day. We would produce extra power so that any fluctuation in demand, intermittency of renewables and loss due to efficiency of system components is sustained. Power to be produced = 15,000 units/day. On the other hand, based on literature survey it was reviewed that despite having a lower energy storage capacity compared to salt-based systems, the solid media system has the lowest global environmental impact per kWh stored across all scenarios. This is because of its simple construction, making it the most environmentally friendly thermal energy storage system (Oró, E., Gil, A. et al., 2012). Therefore, there is an intensive need in R & D of solid media thermal energy storage system for solar thermal applications. Though sand based thermal storage system is economic but it is not much explored by researchers to emphasize its usefulness (Schlipf, D., et al., 2015). More research work is needed to carried out to explore its utility in high temperature solar thermal storage applications.

5. CONCLUSIONS

•Integration of solar and wind energy has promising solution for multigeneration energy production capability in both rural and as well as urban regions. The proposed system design based on wind and solar thermal power and its performance analysis encourages further innovation and development of wind & solar thermal power in Rajasthan.
•New methods are yet to incorporate to utilise biomass energy (cow dung particularly) generation in the existing system while considering the environment impact and sustainability in cognizance.

NOMENCLATURE

$\dot{Ex}$	*exergy rate, kW*
ex	*specific exergy, kJ/kg*
h	*specific enthalpy, kJ/kg*
HE	*heat exchanger*
$\dot{m}$	*mass flow rate, kg/s*
$\dot{Q}_c$	*heat rate, kW*
s	*specific entropy, kJ/kg-K*
T	*temperature, K*
$\dot{W}_P$	*work rate, kW*

Subscripts

co	*condenser*
p	*pump*
d	*destruction*
gen	*generation*

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ASSESSMENT OF ENVIRONMENTAL IMPACT OF IRREVERSIBILITY IN A COOLING SECTION OF DRY-TYPE CEMENT PRODUCTION PLANT

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ABSTRACT
While the effect of production costs in the cement sector, which is known as the energy-intensive sector, reaches 55%, its energy-based environmental impact has an intense structure. In this context, together with many national and international limitations, in this sector where emission control is prominent, production-based energy inefficiency is also quite high. In this study, the cooling process of the dry-type cement production process was examined and its environmental effects were examined with an exergetic approach. In the study, the exergetic efficiency that can be used for the clinker cooling work process was found to be 17%, while the exergetic potential of the waste hot gases was found to be 51.8%. At the end of the study, irreversibility and its effects due to entropy production in the cooling process were evaluated.
Keywords: Frozen food, Exergy, Entropy, Environmental performance, Sustainability

1. INTRODUCTION
In global energy consumption, the cement sector, which consumes about 5% of the industry-sourced potential, constitutes approximately 50% of the product energy costs. In the sector with intense energy flow for each process, mostly dry-type cement is produced (Worrell, E. and Galisky, 2008; Söğüt et al; 2009) The process of preparing the intermediate clinker, which is mostly produced in the rotary kiln, which is the main consumption source in the process, is the focus in this context. Reducing the ambient temperature, which reaches approximately 1300 °C, to 100 °C at the process exit and maintaining its quality can be seen as an important engineering process. However, this process represents a section where intense energy transfers take place and which is the focal point of energy management (Raziuddin et al., 2013). The evaluation criterion of energy and environmental sustainability in cement production is solved with the exergetic approach, which is a qualitative criterion of thermodynamics. Especially in this approach, entropy production is the result of the relationship of exergy destruction with the environment. In this context, the impact of environmental sustainability develops as a quantitative measure of the ethnopia produced. Entropy is the approach that has concrete outputs in terms of thermodynamics in these process analyzes, which mostly have emission evaluations today.

The cement sector is a sector under pressure in terms of energy and environmental sustainability due to the impact of global climate change. It has approximately 8% of the total emissions in terms of global impact (Lehne and Preston, 2018; Watts, 2019) and is an important source of pollution depending on its main components. visible. However, energy-related pollution for production processes is also valuable in terms of the formation of this potential. While this situation highlights opportunities based on energy efficiency for production processes, it also creates opportunities for reducing process-based emissions. Today, many studies such as energy and exergy analyses based on the entire cement production, including cement mills, rotary kilns, and mills, have been discussed. However, emissions impact and assessments have different approaches. Only the causes, which are the main product inputs of cement production, occur and the emission potential due to chemical reactions in the formation of clinker is approximately 50%. This value is defined as approximately 540 kg of CO2 per ton in kinker production. However, while the fuel-related emission for the whole process is approximately 40%, the effect of other vehicles is approximately 10% (The Pembina Institute and Environmental Defense, 2014).The main component of cement production is clinker production, and the cooler section in this structure is an important component for shaping the clinker. It is important to manage the efficiency of this process, the high heat taken from the clinker, and the waste heat for the calcination generated during the process. Especially the waste heat generated in the cooler section, the correct management of heat flows, and the correct efficient use of the energy-demanded calcination in the rotary kiln process will be the right step for the development of energy and environmental sustainability. In this study, the environmental impact of the cooler section in the reference cement production was evaluated together with the beneficial exergy efficiency, and the entropy production potential was examined. In the study, especially the usability potential of the obtained waste potential and the dimensions of the environmental pollution it causes were evaluated, and their environmental effects were discussed together with the production of entropy.

2. CEMENT PRODUCTION AND COOLING PROCESS

World cement production has been rapidly increasing its sectoral impact on a global scale with a compound growth effect of 4.4% since 1995. According to the data of 2022, the market capacity, which has reached approximately 4.1 billion tons, has an increasing trend of approximately 3 times compared to 1995. While rapidly increasing its share of trade on a global scale, it accounts for approximately 13% of the global potential in GDP. Global expectations especially support the change in the sector, which has an important potential in the fight against climate change. In this context, 2050, and 2100 targets have been developed. Indeed, the way to prevent the 2 C scenario from occurring in 2100 is foreseen to be reduced by at least 50% in fossil-based energy consumption. However, for the scenarios cement sector, the way to reach the 2050 targets is to reduce the sectoral emission potentials by 24% (IEA, 2018).

Dry-type cement production is a production with a systematic flow from raw meal mill to cement production. Especially after the first intermediate product is obtained as raw meal, the clinker produced in the rotary kiln process is one of the main outputs in cement production. Clinker production, which is the basic structural feature of cement, consists of three parts: cyclones, rotary kiln process, and cooling process. In dry-type cement production, the clinker system is conveyed to the cooling unit with a flow in a grid structure. In these processes, which have different technological applications such as grate, planetary, shaft, and rotary coolers, the clinker is cooled down and the heat released is used in production processes with energy recovery.

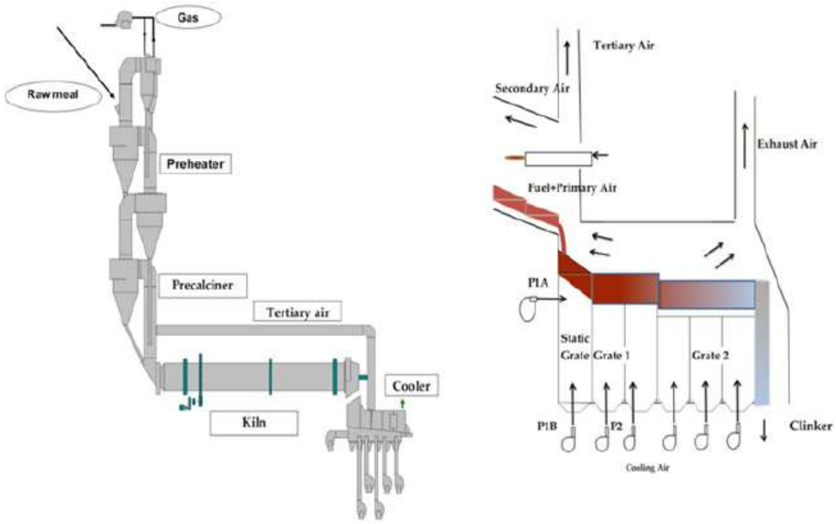

Fig. 1 Rotary kiln process and cooling unit (Tsamatsoulis, 2021)

Cooling processes constitute an important part of the quality of the clinker. Indeed, the clinker cooling conditions have a great influence on the mineralogical structure of the clinker. When the cooling performance effect of clinker is examined, it is seen that the amount of C3S is 59.8% in slow cooling, 65.2% in medium-speed cooling, and 70% in fast cooling. The higher the amount of C3S in a clinker, the higher the strength of the cement to be obtained from that clinker. For this reason, the flow process in the clinker cooling process should be cooled in a suitable flow process depending on the production conditions of the requested cement. Thus, the amount of C3S in its body is preserved without decomposition (Sogut, 2005). The cooling section has high fan flows and intense heat energy movement. Controlled management of the heat exchange occurring in this unit contributes to the development of both energy and environmental sustainability for cement factories.

3. RESULTS AND DISCUSSION

The process of bringing the clinker to workable temperature in the cooling process is a type of heat exchanger where intense heat movement is experienced. For this purpose, the cooling process of clinker, which has a temperature of 39237 kg and 1723 K per hour, to 101 °C was investigated. Material flows and temperature distributions in the study are given in Table 1.

Table 1 Mas flow rate of cooling process

Input				Output		
No	Material	T_1 (K)	Mass flow kg/h	Material	T_1 Ürün Sıc.(K)	Mass flow kg/h
1	Clinker	1723	39237,94	Clinker	374	39237,94
2	Fan(1)	298	50773,16	Gas	895	53392,42
3	Fan(2)	298	38621,03	Heat gas to tras mill	874	31579,47
4	Fan(3)	298	33252,97	Cyclone chimney	453	76725,33
5	Fan(4)	298	33073,26	Total		200935,16
6	Leaking air	297	5976,80			
Total			200.935,16			

Exergy performance of the flow; evaluated with four separate efficiency assessments. The direct output of the process is the clinker. However, while some of the gas obtained is transmitted to the trass mill, some of it is transmitted to the rotary kiln as heat gas. In this context, the exergy flow provided with these two gas flows is performed as improvement exergy. In this case, the sum of the losses caused by the exergy consumption and discharged from the cooler cyclone chimney is also considered exergy destruction. In this context, the exergetic performance of the flow is examined and the distributions are given in Table 2.

Tablo 2 Exergy flow rate of cooling process

Input				Output		
No	Material	T_1 (K)	Exergy flow kWh	Material	T_1 Ürün Sıc.(K)	Exergy flow kWh
1	Clinker	1723	65593,94	Clinker	374	353,58
2	Fan(1)	298	3,10	Gas	895	20642,47
3	Fan(2)	298	2,36	Heat gas to tras mill	874	11064,79
4	Fan(3)	298	2,03	Cyclone chimney	453	32060,84
5	Fan(4)	298	2,02	Total		64121,67
6	Leaking air	297	-6,93			
Total			65596,51			

The standard efficiency of the cooler referenced in the study, depending on thermal flows, was found to be 84.53%. In the analysis, the entropy produced in the system was found to be 52 kWh/K per unit hour when considered over the total input-dependent output. The total exergy efficiency of the flow was calculated separately depending on the parameters mentioned above. Accordingly, their distribution is given in Figure 2.

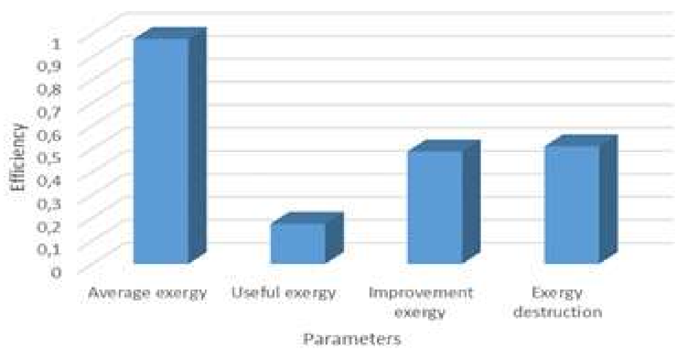

Fig.2 Efficiency rates

The functions of production processes should be taken into account in efficiency analysis. Exergy efficiency to be used in this context can be seen as improvement exergy efficiency rate. The environmental effects of the process were also evaluated separately through the efficiency distributions based on these data, and the improvement rates were examined for the two environmental impact criteria developed. Accordingly, their distribution is given in Figure 3.

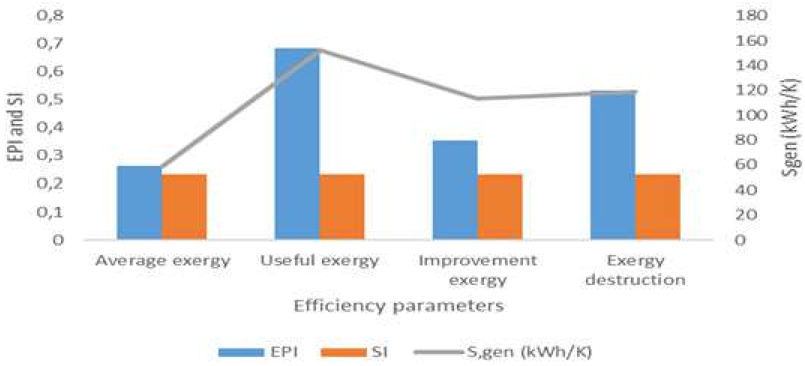

Fig.3 Environmental effect indicator

The analyzes indicate a 26% improvement compared to the exergy flow for the cooling process due to exergy destruction, while this rate is 34.16% for environmental sustainability.

4. CONCLUSIONS

This study is based on the investigation of the impact parameters that will improve energy and environmental sustainability in production lines, based on the cooling process in a cement factory. The points to be considered in terms of exergy for the complex structure of the production processes have been evaluated. According to the efficiency approaches developed in the study, this value was found to be 34.16% in terms of environmental impact versus a 26% improvement in Exergy efficiency according to the improvement rate. The work can be improved in many ways with entropy optimization.

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SURFACE PLASMON RESONANCE-MEDIATED OPTICAL TUNABILITY AND PHOTOCATALYTIC ACTIVITY IN Ag-DECORATED Cd0.5Zn0.5S PHOTOCATALYSTS

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ABSTRACT
The incorporation of noble metal nanoparticles onto semiconductor photocatalysts to harness the surface plasmon resonance (SPR) effect has attracted significant attention. In this study, we investigate the SPR-mediated optical tunability and photocatalytic activity in Ag-decorated CdXZn1-XS photocatalysts. At a 1% mass ratio, Ag nanoparticle loading achieves an impressive hydrogen (H2) production rate of 2457 μmol(h.gcat)-1, surpassing pure Cd0.5Zn0.5S samples by threefold, owing to the SPR effect. However, excessive loading (3% and 5% mass ratios) lead to decreased H2 production due to charge accumulation and electron recombination. The superior photocatalytic performance of %x Ag-Cd0.5Zn0.5S samples is attributed to SPR-induced optical absorption enhancement. The optimized structure allows for maximum component interaction, resulting in improved photocatalytic performance. UV-vis absorption spectra confirm enhanced absorption in the visible light region, highlighting the influence of SPR-induced surface plasmon resonance. This study contributes valuable insights into SPR-mediated optical tunability in CdxZn1-xS photocatalysts, aiding the design of advanced photocatalytic materials.
Keywords: Ag-decorated CdXZn1-XS, Hydrogen production, Surface plasmon resonance (SPR), Visible light region.

1. INTRODUCTION
In recent years, the field of photocatalysis has witnessed a surge in interest due to its remarkable potential in tackling pressing environmental issues, including water and air purification, solar energy conversion, and carbon dioxide reduction. Semiconductor-based photocatalytic materials have garnered considerable attention, owing to their unique electronic properties and tunability, which make them suitable for efficient light-driven processes. In this perspective, CdXZn1-XS photocatalysts have emerged as highly promising candidates owing to their, adjustable bandgaps, improved charge carrier dynamics, and chemical stability (Elgohary et al., 2021).
The development of advanced photocatalytic materials necessitates a thorough understanding of their underlying mechanisms and the application of tailored design principles. In this regard, the incorporation of noble metal nanoparticles onto semiconductor surfaces has proven to be a successful strategy for enhancing photocatalytic activity. By introducing noble metals such as silver (Ag), it becomes possible to facilitate the generation and separation of charge carriers, extend light absorption across a broader range of wavelengths, and promote surface reactions. Ag, in particular, exhibits exceptional plasmonic properties that can be effectively harnessed through a phenomenon known as surface plasmon resonance (Navidpour et al., 2023).
The historical roots of plasmonic can be traced back to the late 19th century when Lord Rayleigh first discovered surface plasmons on metallic surfaces. Since then, significant progress has been made in understanding and harnessing plasmonic phenomena, leading to groundbreaking advancements in optics, electronics, and materials science. Plasmonic-enhanced photocatalysis has emerged as a particularly promising research direction, offering exciting prospects for tailoring material properties and unlocking novel functionalities (Savoia et al., 2013).
This study aims to delve into the fascinating influence of Ag decoration on the optical tunability and photocatalytic activity of CdXZn1-XS photocatalysts. By leveraging Ag as a plasmonic sensitizer, we can harness its capacity to interact with incident light and excite localized surface plasmons, thereby significantly enhancing light absorption and utilization within the semiconductor system. Additionally, the interaction between Ag and the CdXZn1-XS solid solutions can give rise to the formation of metal-semiconductor heterojunctions, which facilitate efficient charge transfer and separation processes, ultimately leading to a substantial improvement in photocatalytic performance (Kumar et al., 2016).
Through a comprehensive investigation into the fundamental principles governing SPR-mediated optical tunability and photocatalytic activity in Ag-decorated CdXZn1-XS photocatalysts, this study aims to contribute to the advancement of photocatalytic materials. The knowledge gained from this research will pave the way for innovative strategies to harness surface plasmon resonance, enabling enhanced light-matter interactions and improved performance across various photocatalytic applications. By bridging the gap between plasmonic and photocatalysis, this work opens up new avenues for the design and development of highly efficient and sustainable photocatalytic systems.

2. MATERIAL AND METHODS

In the synthesis of /wt%Ag-Cd0.5Zn0.5S composite photocatalysts, different weight percentages of Ag (0.5, 0.75, 1, 3, and 5) were utilized. To obtain 1%Ag-Cd0.5Zn0.5S, 1 g of Cd0.5Zn0.5S was dissolved in 50 ml ethanol along with 15.97 mg of Ag(NO3)2.6H2O, followed by 15 minutes of thorough mixing to achieve a homogeneous solution. The resulting suspension was then transferred to a 200 ml Teflon autoclave and heated at 180 °C for 12 hours in an oven. After the solvothermal process, the precipitate was washed twice with deionized water and once with ethanol. Finally, the catalyst was dried at 75 °C for 6 hours under vacuum conditions.

Characterization of the photocatalysts involved several techniques. Scanning electron microscope (SEM) accompanied by energy-dispersive X-ray spectrometry (EDAX) were performed on a Thermo Scientific Quattro environmental scanning electron microscope (ESEM). Gaseous Analytical Detector (GAD-CBS) detector were used to obtain SEM micrographs. The light absorption properties of the samples were measured using an Ocean optics model USB-4000 spectrophotometer.

For the evaluation of photocatalytic activity in H2 production, the photocatalysts were subjected to visible light irradiation in the presence of an aqueous solution containing electron donors. Photocatalytic reactions took place in 250 ml quartz flasks, and the amount of H2 generated was determined using gas chromatography. Additionally, the quantum yield of hydrogen production was measured at 420 nm using a narrow band pass filter under monochromatic light irradiation.

3. RESULTS AND DISCUSSION

To examine the microstructure of the prepared %xAg-Cd0.5Zn0.5S photocatalyst, the %1Ag-Cd0.5Zn0.5S sample was characterized using SEM imaging (Fig.1).

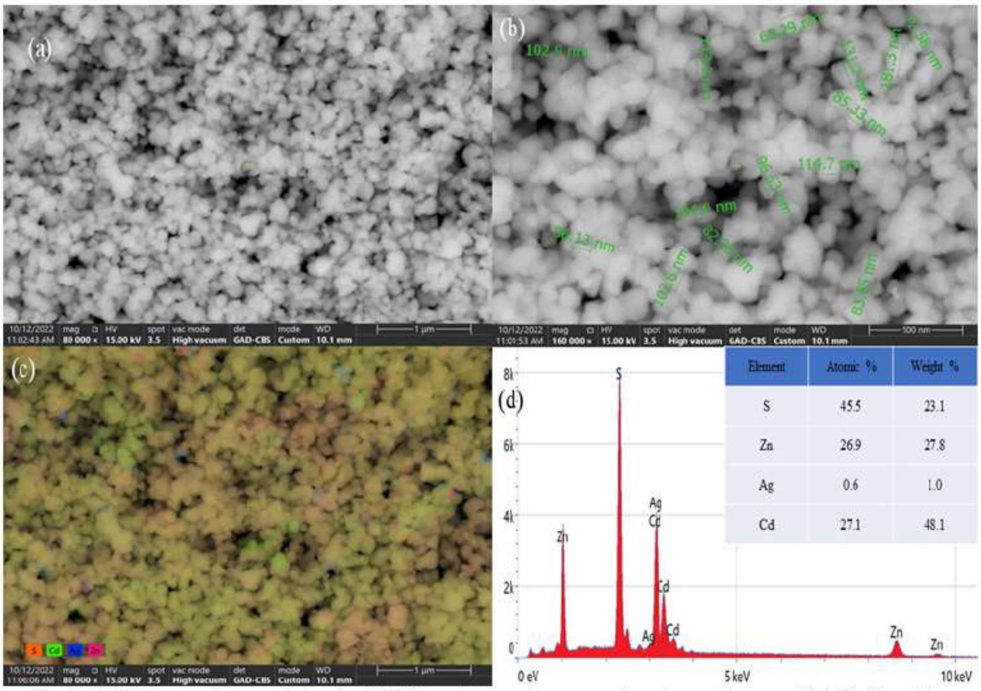

Fig.1. (a) SEM image, (b) crystal size, (c, d) EDX spectrum and corresponding elemental maps of Cd, Zn, S, and Ag.

Fig.1. (a, b) display the SEM images of %1Ag-Cd0.5Zn0.5S. However, the presence of Ag nanoparticles was not observed in %1Ag-Cd0.5Zn0.5S. This can be attributed to the low amount of added AgNO3 and the smooth surface of %1Ag-Cd0.5Zn0.5S, making it difficult for Ag particles to adhere to the surface and some being located between nano-layers. Elemental mapping results indicate the presence of Cd, Zn, S, and Ag elements. A uniform distribution of Cd, Zn, S, and Ag atoms along the nanoparticles was determined (Fig.1. (c)). EDX results (Fig.1. (d)) reveal an approximately equimolar content of Cd and Zn, which is in good agreement with the estimated values for the atomic compositions of the solid solution.

Light absorption strongly influences photocatalytic activity. Pure Cd0.5Zn0.5S exhibits absorption edges around 480 nm (Salah Hamza Hamid et al., 2023). However, all %xAg-Cd0.5Zn0.5S samples show significant absorption in the visible light region, greatly enhanced by loading Ag nanoparticles onto Cd0.5Zn0.5S (Fig.2. (a)).

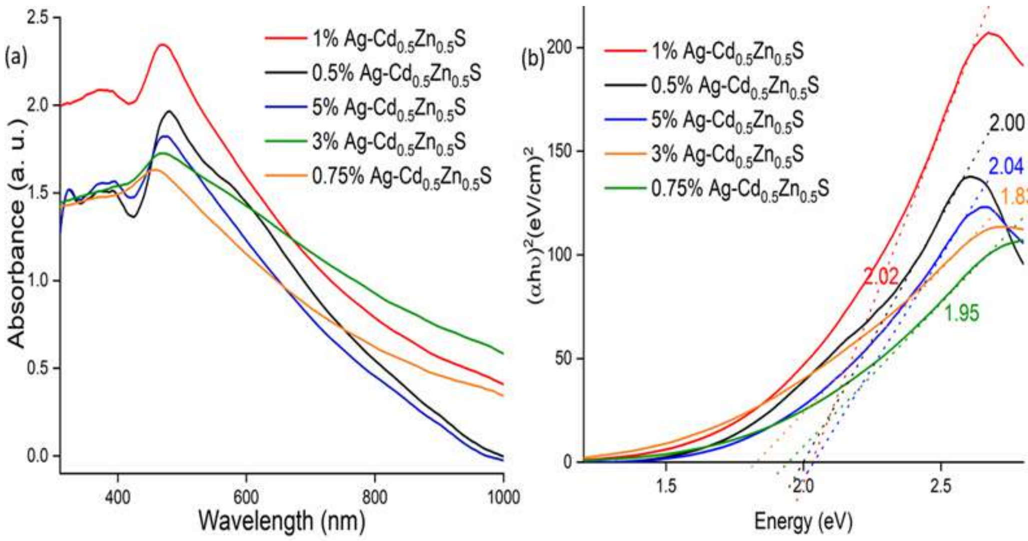

Fig. 2: UV-Vis absorption spectra of x%Ni-Cd0.5Zn0.5S/5%MoS2.

This enhancement can be attributed to the SPR effect of Ag nanoparticles. Ag nanoparticles typically exhibit SPR wavelengths in the range of 400-500 nm. The presence of Ag nanoparticles contributes to the photocatalytic activity of Cd0.5Zn0.5S by improving its absorption in the visible light region. The bandgap energy of the Ag-Cd0.5Zn0.5S composite is relatively higher than that of Cd0.5Zn0.5S and Ag inclusion leads to a redshift in the UV-VIS absorption spectrum and a narrowing of the optical bandgap energy of Cd0.5Zn0.5S (Fig.2. (b)). The binary composite photocatalyst, with its broad light absorption width and high absorption intensity in the visible region, holds promise for improving solar energy utilization efficiency and achieving enhanced photocatalytic performance under visible light conditions.

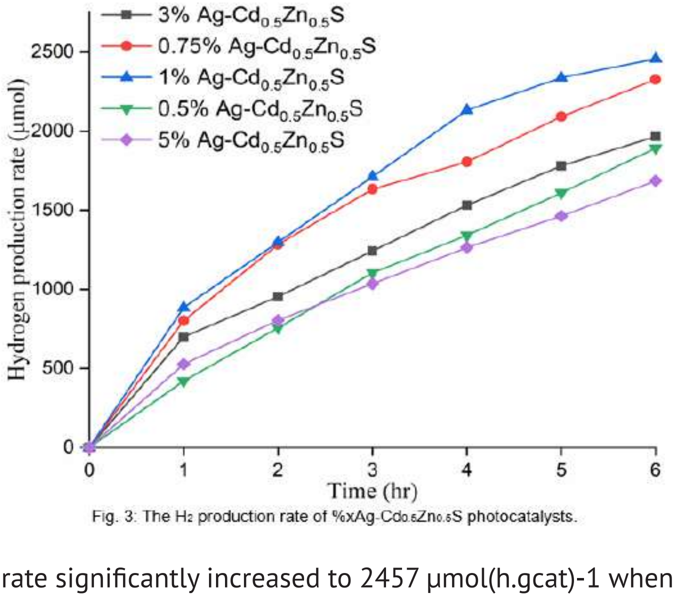

Fig. 3: The H2 production rate of %xAg-Cd0.5Zn0.5S photocatalysts.

As expected, the H2 production rate significantly increased to 2457 μmol(h.gcat)-1 when Ag nanoparticles were loaded at a 1% mass fraction (Fig. 3.). This improvement is three times higher than Cd0.5Zn0.5S and can be attributed to the surface plasmon resonance (SPR) effect. However, loading Ag nanoparticles at a 3% mass fraction resulted in a decrease in the H2 production rate to 1993 mmol μmol(h.gcat)-1 (Table 1.). Excessive loading of Ag nanoparticles negatively impacted the photocatalytic performance due to their role as recombination centres for photo-generated electrons. The enhanced photocatalytic activity of %x Ag-Cd0.5Zn0.5S can be attributed to the close interaction between Ag and Cd0.5Zn0.5S, allowing for improved performance. Further research can explore surface plasmon resonance phenomena and optimize parameters to maximize the photocatalytic performance of these materials.
Table 1. The Photocatalytic H2 evolutions and the apparent quantum yields.

Ag content	Photocatalytic H_2 production μmol $(h.\ g_{cat})^{-1}$	AQY (%)
0.50	1781.19	6.24
0.75	2326.33	8.15
1.00	2457.79	8.61
3.00	1993.34	6.98
5.00	1686.18	5.90

4. CONCLUSIONS

This study demonstrates the successful incorporation of Ag nanoparticles onto CdXZn1-XS semiconductor photocatalysts to harness the surface plasmon resonance effect, resulting in enhanced optical tunability and photocatalytic activity. The optimized loading of Ag nanoparticles at a 1% mass ratio achieves an impressive hydrogen production rate of 2457 μmol(h.gcat)-1, surpassing pure Cd0.5Zn0.5S samples by threefold. This significant improvement can be attributed to the SPR effect, which enhances the absorption of visible light and facilitates efficient charge separation. However, excessive loading of Ag nanoparticles at higher mass ratios (3% and 5%) leads to a decrease in H2 production due to charge accumulation and electron recombination. The close interaction between Ag and Cd0.5Zn0.5S in %x Ag-Cd0.5Zn0.5S samples plays a crucial role in the superior photocatalytic performance, allowing for improved component interaction and enhanced efficiency. The findings highlight the importance surface plasmon resonance effect in optimizing the photocatalytic performance of CdXZn1-XS photocatalysts. Further research can explore the fine-tuning of parameters and surface plasmon resonance phenomena to maximize the photocatalytic potential of these advanced materials.

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Confidence-Based Regression with Energy-Based Models in Deep Learning

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ABSTRACT
Regression methods vary from deep learning classifications. Confidence-based regression, a computer vision technique, assigns a confidence score to each input-target pair (x, y). This method yields outstanding results with the task-specific design and probabilistic interpretation.
This article presents a probabilistic regression method. A deep neural network estimates the unnormalized density from the input-target pair using a conditional target density p(y|x) model with energy as the basis (x, y). Monte Carlo sampling lowers the negative log probability of this p(y|x) model. Our technique outperforms linear regression and other probability- and confidence-based algorithms in four computer image regression challenges.
When Faster-RCNN is used for object recognition in the COCO dataset, the suggested model improves average accuracy (AP) by 2.3% and provides a new, cutting-edge visual tracking system technique for bounding box prediction. Our technique covers more concerns than trust-based solutions, including age and head position. Hence, the suggested probabilistic regression method for computer vision is realistic and efficient.
Keywords: Deep learning classifications, Regression approaches, Probabilistic interpretation, Conditional target density, Energy-based model

1. INTRODUCTION
Controlled regression in machine learning involves constructing a model to predict a target value (y) from input (x) using training data. Computer vision and other industries use this problem. Computer vision regression challenges include item recognition, head and body position estimation, age estimation, visual tracking, and medical image analysis. Finance, economics, and the social sciences employ regression analysis to predict future occurrences from previous data. It helps identify data trends and patterns for informed decision-making [1]. Marketing research uses regression analysis to investigate consumer behavior and predict sales. Deep neural networks (DNNs) are often employed for regression since they can directly train data visualizations. Regression uses several approaches to express losses and output, unlike categorization. Linear regression teaches a DNN to predict y from x. Loss functions like L2 or L1 loss penalize the difference between estimated and ground truth target values while training model parameters. In indirect regression, the DNN predicts intermediate values utilized to calculate the target value. This strategy clarifies input-output relationships [2]. Energy consumption in Turkey, which is developing steadily and rapidly, rises daily due to rising industrial activities, technology, and population [3].
Fossil fuels solve the growing requirement. Fossil fuels' carbon emissions cause enormous environmental damage. The International Energy Agency expects energy-related CO_2 emissions to rise by 20% by 2035 [4]. Fossil fuels emit the most carbon. 2015 witnessed the UNFCCC's Paris Accord—the 2016 agreement aimed to boost renewable energy investment and reduce Turkey's fossil fuel use. Offering significant financial incentives accelerated the process. Solar power facilities have also significantly benefited from tax incentives. When sunshine lasts 7 hours and 50 minutes, solar power plants amortize faster [5]. Current studies show that 64% of installed capacity is renewable. Its capacity is 7.2% solar—daily growth [6].

2. MATERIAL AND METHODS
Using a deep neural network (DNN) function f: X Y R, we offer a probabilistic regression technique based on an energy-based model that directly makes a scalar prediction for each input-target combination. Here, X and Y denote the input and target spaces, whereas RP is the mapping parameters for an input-target pair (x, y) in X Y to a scalar value f(x, y) in R. The suggested model p(y|x;), the conditional target density is developed the negative log-likelihood is reduced, guided by confidence-based regression techniques.
Monte Carlo methods have been widely used in various fields, such as physics, finance, and machine learning [7]. Monte Carlo is a computational method that involves generating a large number of random samples or simulations of a complex system or function and using statistical analysis to estimate the behavior of the system [8]. In the context of machine learning, Monte Carlo methods are often used to estimate the expected value of a function or to compute the likelihood of a model given data [9]. In this passage, Monte Carlo importance sampling is used to estimate the partition function Z(x,) by minimizing the negative log-likelihood [10,13]. By using Monte Carlo importance sampling, the model can estimate the partition function efficiently and accurately.

Table 1. Performance Comparison of Object Detection Approaches Using Different Probability Models

Name	Straight	Gaussian	Gaussian	Laplace	Confidence	Confidence
Approach	F-RCNN	Mixt	cVAE	IoU-Net	IoU-Net	Ours
AP (%)	39.2	39.7	36.4	37.8	38.1	38.5
AP50(%)	61.5	60.1	59.1	59.2	59.3	58.8
AP75(%)	61.8	60.8	59.8	42.5	40.9	41.4
FPS	12	12	12	12	12	12

Table 1 provides a summary of the performance of several object identification methods on the COCO dataset. The "Approach" column specifies the various techniques, whilst the other columns show the findings for assessment criteria.

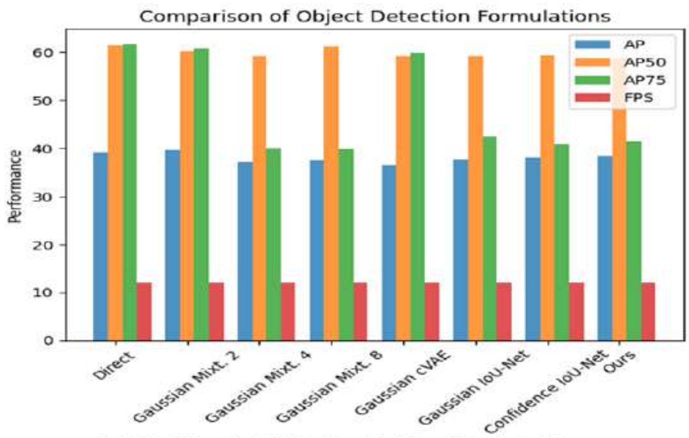

Fig.1. Using Different Probability Models and Confidence Estimation Techniques.

Compared to existing object identification techniques, such as Faster-RCNN and IoU-Net, the suggested method displays higher performance [14,15]. The suggested technique illustrates the efficacy of employing deep neural networks to predict outputs and maximize performance by outperforming other approaches while retaining rapid inference speeds [16,17]. This method is applicable to different computer vision applications, such as picture segmentation and instance segmentation, making it a flexible technique for improving the accuracy of deep learning models [18].

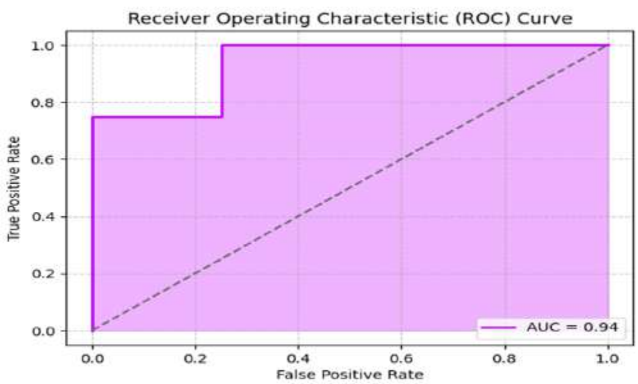

Fig. 2. ROC Curve of Using Different Probability Models and Confidence Estimation Techniques

Future study might investigate the application of this technology to sectors other than computer vision, verifying its wide applicability.

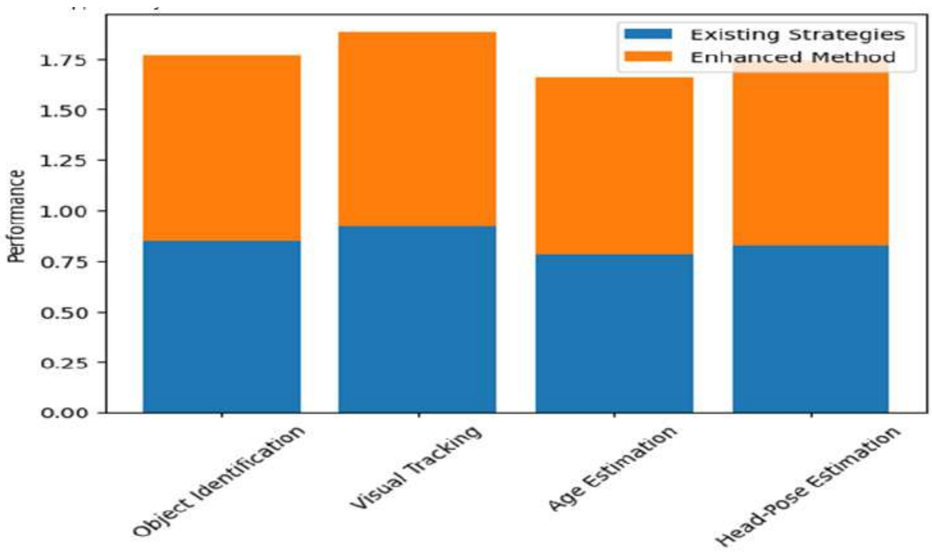

Fig. 3. Comparison of the Models
This bar graph illustrates the performance of the improved strategy in comparison to previous solutions for four specific computer vision regression problems.

2. RESULTS AND DISCUSSION

Modeling the conditional target density p(y|x) using a deep neural network (DNN) is proposed as an unique regression approach in this research. The DNN, indicated by f(x,y), predicts the unnormalized density given an input-target pair (x, y) as input. The model is trained to estimate the partition function Z(x,) by minimizing the negative log-likelihood via Monte Carlo importance sampling. During test time, gradient-based refinement is used to optimize the DNN output f(x,y) with respect to y in order to anticipate the targets. It is proven that the suggested strategy has great accuracy and wide application across four distinct computer vision tasks. Future work will investigate better architectural designs, alternative regression applications, and the possibilities for aleatoric uncertainty estimates using the suggested technique. In conclusion, the suggested regression technique using a DNN to describe the conditional target density yields remarkable results in a variety of computer vision applications. The authors' use of Monte Carlo significance sampling to estimate the partition function and gradient-based refinement for target prediction enables efficient and precise computing. Future research will concentrate on improving the DNN's architecture and broadening the use of the approach to additional regression applications. In addition, the authors recommend investigating aleatoric uncertainty estimates, which might increase the application of the suggested technique. The findings reported in this research demonstrate the advancement potential of computer vision systems using this regression approach.

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A GEOTHERMAL-BASED THERMOCHEMICAL CYCLE INTEGRATED WITH CARBON CAPTURING IN A CEMENT FACTORY FOR METHANE PRODUCTION

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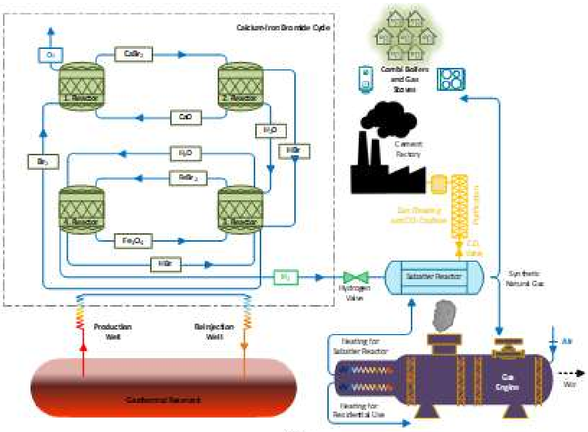
ABSTRACT
In this study, a newly developed geothermal energy-based calcium-iron bromide cycle for hydrogen generation and potential use in the Sabatier reactor for ultimately methane production is analyzed. Hydrogen, produced by the thermochemical cycle, and CO2, emitted by the cement factory are supplied to the Sabatier reactor. Methane obtained in the reactor is used in the gas cooker, combi boiler, and gas engine for the electricity and heating requirements of a community. The system is entirely analyzed in terms of thermodynamics. Parametric studies are conducted for different ambient temperatures and mass flow rates of the gases. The waste heat is minimized by integrating subsystems. Electricity and heating power with a rate of 39.72 MW and 10.4 MW are provided to the community. The energy and exergy efficiencies of the thermochemical cycle are calculated as 9.8% and 11.12%, respectively. A 5.5 kg/s of CO2 is captured and utilized in the integrated system.
Keywords: Geothermal Energy, Exergy, Hydrogen, Methane, Thermochemical cycle

1. INTRODUCTION
For a sustainable ecosystem, new methods and fuels are essential. Innovative integrated systems are used to meet the rising demand for energy as a result of population growth and changing lifestyles. Waste minimization is critical for energy conservation. For a sustainable environment, integrated systems are more important than ever. Renewable energy sources should be integrated with fossil fuel-based systems for wise usage. In this way, hydrogen is a viable option for the efficient storage of energy (Sorgulu and Dincer, 2023). Thermochemical cycles can produce hydrogen by employing heat. Due to the high temperatures, geothermal reservoirs are promising sources for thermochemical cycles. By using the Sabatier reactor, synthetic methane (natural gas) can be produced from hydrogen and carbon dioxide. A significant amount of CO2, released to the environment as flue gas, can be captured and reacted with hydrogen. In this way, methane, which is widely used for industrial and residential purposes, is produced. In this study, the electricity and heating requirements of the community are provided with a novel system. CO2 is captured to reach less environmental impact. The specific objectives are to develop an environmentally friendly system and to analyze it in a view of energy and exergy. Waste heat is minimized by integrating subsystems. CO2 from the cement factory and waste heat of the gas engine are utilized to produce synthetic methane in a Sabatier reactor.



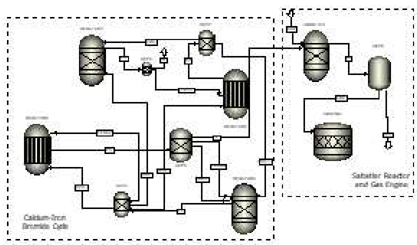


Fig. 1. (a) Schematic illustration and (b) Aspen Plus flowsheet of the integrated system

2. SYSTEM DESCRIPTION AND ANALYSIS

The schematic illustration and Aspen Plus flowsheet of the integrated system are given in Figs. 1(a) and 1(b). As shown in Fig. 1 a geothermal reservoir, calcium-iron bromide cycle, Sabatier reactor, gas engine, combi boilers, and gas cookers are integrated with each other to provide electricity and heating. In order to produce hydrogen, high temperatures of the geothermal reservoir are utilized in the thermochemical cycle. Hydrogen produced by the calcium-iron bromide cycle is utilized in the Sabatier reactor to produce methane. Methane produced in the reactor is supplied to a gas engine to produce electricity. The waste heat of the gas engine is used in the Sabatier reactor. Also, methane is supplied to the combi boiler and gas stove for residential use.

The Aspen Plus software is used for the calcium-iron bromide cycle, gas engine, and Sabatier reactor (Aspen Plus User Guide, 2023). Engineering Equation Solver (EES) is employed for the calculations and parametric studies of the entire system (EES, 2023).

3. RESULTS AND DISCUSSION

The changes in exergy rates of the thermochemical cycle, hydrogen production reaction, geothermal source, Sabatier reactor, and gas engine as to hydrogen mass flow rates and ambient temperature are given in Figs. 2(a) and 2(b). Here, for a 1 kg/s hydrogen production, energy and exergy rates of heat required for the thermochemical cycles are calculated as 1226 MW and 613.1 MW. For an environment temperature of 27 °C, energy and exergy rates of the heat required for the Sabatier reactor are obtained as 15.11 MW and 7.2 MW.

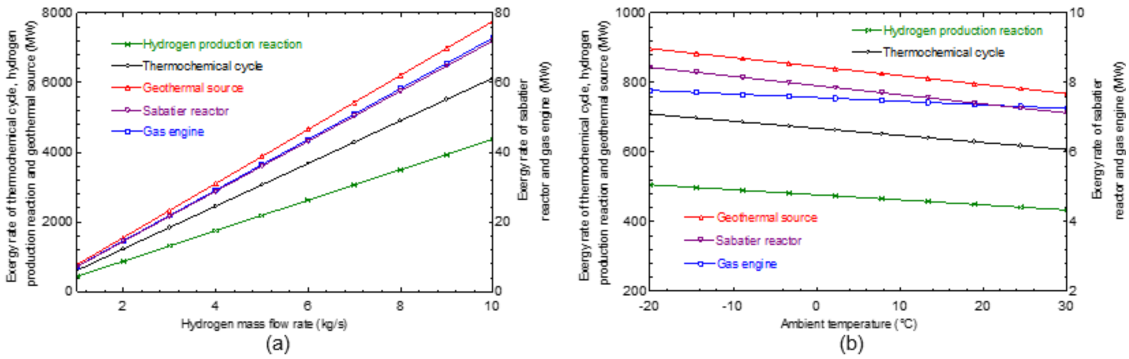


Fig. 2. Variations in exergy rates of subsystems as to (a) hydrogen mass flow rates (b) ambient temperature

The changes in hydrogen and methane mass flow rates as to different cement mass flow rates is given in Fig. 3. Here, a yearly potential production of 192.7 thousand ton of cement is considered. For the selected cement production, 5.5 kg/s of CO2 is captured and supplied to the Sabatier reactor.

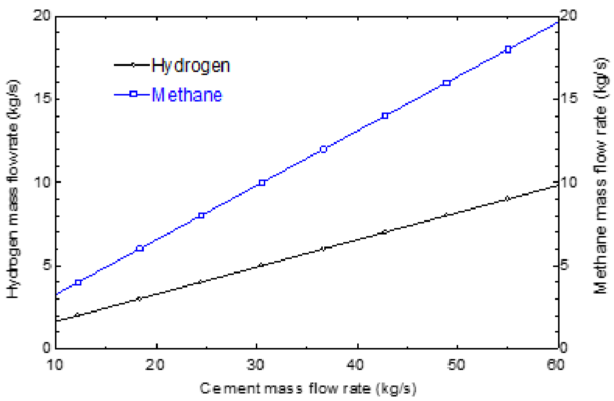


Fig. 3. Variations in hydrogen and methane mass flow rates as to different cement mass flow rates

4. CONCLUSIONS

The electricity and heating needs of the community are met with this novel integrated system in an environmentally friendly manner. CO2, emitted by the cement factory, is captured for less environmental impact. The energetic and exergetic efficiencies of the calcium-iron bromide cycle are calculated as 9.8 and 11.12%, respectively. A 5.5 kg/s of CO2 is captured and used in the Sabatier reactor. 39.72 MW of electrical power and a 10.4 MW of heat rate are utilized for residential use.

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A STUDY ON GREEN HYDROGEN PRODUCTION POTENTIAL IN CANADA

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Abstract
The current study investigates green hydrogen production potential from various renewable energy resources, including biowastes, available for the country of Canada. The hydrogen production potential is described in detail for the country as a whole as well as each of the cities in Canada. It is obtained that the total green hydrogen production is 286.95 Mt using solar, wind, geothermal, hydroelectric, biomass (including wastes), tidal, and wave energies. The results show a promising potential for Canada to be among the world's green hydrogen-producing countries.
Keywords: Green hydrogen, Canada, Renewables, Electrolyser, Environment

1. Introduction
To make the global commitment greater than ever before for achieving climate change mitigation, an implementation of relevant rules and regulations is desperately needed. The energy sector requires a drastic change in this regard and struggles financially to achieve a quick transition from fossil fuels into hydrogen economy for a decarbonized future. An implementation of carbon-free fuels in many energy market segments with hydrogen, which can be utilized as an energy carrier, fuel and feedstock, is a crucial to the needs. A transition to renewable energies for producing carbon-based fuels in a green manner is an essential for hydrogen synthesis from water through electrolysis using renewable energy sources. Despite being abundantly present in many things, such as water, biomass, and fossil fuels, hydrogen is not the only element in the universe. How to create it in a way that is more effective, efficient, and kind to the environment is a crucial question for us? Hydrogen is regarded as an alternative energy option since it works well with electricity and renewable energy sources. When addressing hydrogen generation technologies, renewable and non-renewable resources are divided into two main categories. There are a variety of options available, including methane steam reforming, oil/naphtha reforming, coal gasification, biomass, biological sources, and water splitting techniques (Seyitoglu et al. 2017). Utilizing renewable resources from the aforementioned possibilities in order to manufacture "green hydrogen" is the main goal of developing new infrastructures for the generation of hydrogen. As a result, the concept of a "hydrogen farm" was created, in which available resources are employed to generate green hydrogen as a durable source of energy for various economic sectors and their operations (Dincer et al. 2021). The main purpose of the current research paper is to potentially study Canada's hydrogen production potential based on renewable energy resources in different regions of the country with the usage of an alkaline electrolyser (ALEL) and proton exchange membrane electrolyser (PEMEL). A thorough examination of each province helps identify the areas with greater potential for the production of hydrogen. Additionally, it is anticipated that the data would be used to construct the nation's energy supply network for both national and international with a focus on hydrogen technologies.

2. System Description and Analysis Details
The most commercially viable method for producing high-purity hydrogen from water splitting is electrolysis. Water electrolysis is based on the motion of the electrons, supported by an external circuit (Godula-Jopek 2015). Commercially available electrolyser types include alkaline, solid oxide electrolysers (SOE), and polymer membrane electrolysers (PEM). The electrolyte mostly consists of sodium hydroxide (NaOH) or potassium hydroxide (KOH). The characteristics of alkaline and PEM electrolysers used in the calculations for the current investigation are shown in Table 1.

Table 1. Typical specifications of Alkaline electrolyser (ALEL)

Specification	Alkaline Electrolyser (ALEL) (NEL Hydrogen)	Proton Exchange Membrane (PEMEL) (NEL Hydrogen)
Model Name	Nel-A1000	Nel-MC500
Net Production Rate (Nm^3/h)	600	492
Production Capacity Range (%)	15-100	10-100
Power Consumption at Stack (kWh/Nm^3)	4.4	4.5
Delivery Gauge Pressure (bar)	1-200	30
H_2 Purity (%)	99.9	99.999
Ambient Temperature (°C)	5-35	20-40
Efficiency (%)	66.10	64.63

In this study, south-facing PV panels with latitude-15° tilt are considered in the calculations. The average photovoltaic potential (kWh/kWp) was found by randomly selecting over 100 spots for each province itself. For wind energy, wind speed, wind power, and wind frequencies are taken into consideration. Additionally, already installed each wind turbine and its capacities, heights, and wing lengths are taken from the official government database and added to the potential as well. Based on the reported data from official sources, hydropower, wave, and tidal energies are considered as one sub-section. Both installed and currently under construction hydroelectric power plants are included in the research. For wave and tidal applications, both sea surface and undersea conditions are taken into account. Geothermal energy potential is investigated for each province but three provinces namely Alberta, British Colombia, and Yukon selected for their high geothermal potential. For biomass energy, urban waste, livestock waste, forestry residue, forestry waste, crop residue, and purpose-grown energy crops are included. All data are taken directly from the Canadian government's official sources (CER, 2023).

3. Results and Discussion

In this study, every province of Canada investigated for green hydrogen production potential from renewable energy sources. Solar, wind, geothermal, hydroelectric, biomass, tidal, and wave energies were considered in the calculations. For determining the availability for each region, particularly mountainous areas, some specific geographic factors are taken into account. Table 2 shows each province's green hydrogen production potential from chosen renewable energy resources.

Table 2. Total hydrogen production potential from renewable energy resources for every province in Canada.

Province	Hydrogen production from solar energy (Mt)	Hydrogen production from wind energy (Mt)	Hydrogen production from hydroelectric, wave, and tidal energies (Mt)	Hydrogen production from geothermal energy (Mt)	Hydrogen production from biomass energy (Mt)
Alberta	3.26	2.11	0.04	26.09	0.52
British Colombia	5.38	3.48	1.14	1.88	0.45
Manitoba	0.90	0.58	0.67	0	0.24
New Brunswick	1.32	0.85	0.06	0	0.20*
Newfoundland and Labrador	0.77	0.50	0.89	0	0*
Nova Scotia	0.07	0.04	0.02	0	0*
Ontario	33.01	21.37	0.73	0	0.36
Prince Edward Island	0.09	0.06	0	0	0*
Quebec	103.53	67.03	4.04	0.01	0.43
Saskatchewan	1.12	0.72	0.07	0	0.45
Northwest Territories	0.13	0.09	0	0	0
Nunavut	0.07	0.04	0	0	0
Yukon	0.53	0.34	0.01	1.26	0
Total	150.17	97.23	7.67	29.24	2.65

*These four provinces are considered Atlantic Territories and their total biomass potential is given in the New Brunswick row.

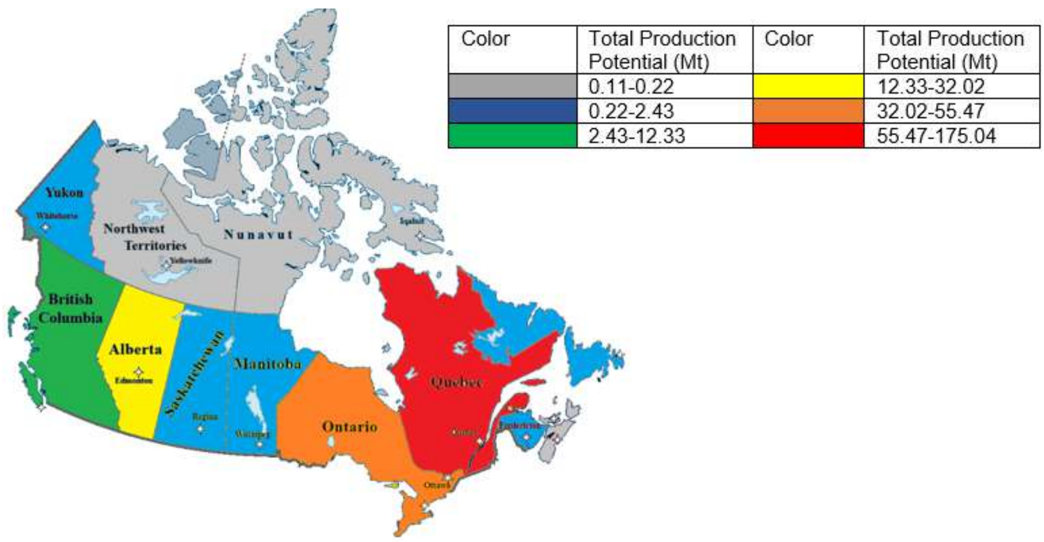

Figure 1. Canada's hydrogen production potential based on renewable energy resources.

Figure 1 shows the hydrogen energy map for Canada in terms of hydrogen production potential using renewable energy resources and wastes which is colored in terms of capacities and potentials. The capacity increases from grey color to red which is the highest potential.

4. Conclusions

The renewable energy data are primarily taken from the Canada government's official site to study the green hydrogen production potential of Canada using alkaline and PEM electrolysers where the hydrogen production potential is estimated to be 286.95 Mt. For the 13 provinces, total green hydrogen production potentials are obtained as follows: 175.04 Mt, 55.47 Mt, 32.02 Mt, 12.33 Mt, 2.43 Mt, 2.39 Mt, 2.36 Mt, 2.16 Mt, 2.14 Mt, 0.22 Mt, 0.15 Mt, 0.13 Mt, and 0.11 Mt for Quebec, Ontario, Alberta, British Colombia, New Brunswick, Manitoba, Saskatchewan, Newfoundland and Labrador, Yukon, Northwest Territories, Prince Edward Island, Nova Scotia, and Nunavut, respectively. The findings of this study suggest that the potential for renewable energy is a possible replacement for manufacturing hydrogen in a number of Canadian regions.

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PERFORMANCE EVALUATION OF GEOTHERMAL ASSISTED VAC SYSTEM WITH LIBR-H2O FOR RESIDENTIAL COOLING

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ABSTRACT
Buildings have the biggest share of the total energy consumption of nearly every country in the World. It is very well known that, heating and cooling systems consume large amount of energy in the buildings. Therefore, nowadays renewable energy sources are tried to integrated to HVAC-R system to reduce energy consumption. Geothermal energy is one of the most advantageous renewable energy sources, since it can be used for various purposes such as power production, heating and cooling of spaces, food drying and snow melting etc.In this study, a geothermal assisted cooling system with a vapor absorption refrigeration system is studied in order to meet 10 kW cooling demand of a 150 m2 detached house in Izmir, Turkey. The vapor absorption refrigeration system is considered having lithium bromide-water solution pair. The thermodynamic performances of the refrigeration systems are compared by conducting detailed energy and exergy analyses. For base case operating conditions, generator temperature is 95°C, condenser and absorber temperatures are 30°C and evaporator temperature is 2°C. The exergetic efficiency of the lithium bromide-water vapor absorption refrigeration system is determined as 30%.
Keywords: Geothermal cooling, building, VAC, performance assessment, exergy analysis

1. INTRODUCTION
Energy and climate change are the global problems. Energy demand increases continuously with increasing population and developing technology. 40% of the total global emissions and 36% global energy consumption originates in the buildings and building construction sector (IEA, 2019). According to International Energy Agency (IEA), CO2 emissions must be reduced by 77% in the building sector by the year 2050 to ensure that global warming is below 2°C. Nowadays, around 60% of global energy consumption in buildings comes from space heating, cooling and domestic hot water heating systems (IEA, 2013). In another IEA's report, states that the number of residential air conditioners will increase to 210 million units from 47 million by 2050 in the Middle East, thus especially for extremely hot days space cooling systems can result around 70% peak residential electricity demand (IEA, 2018). That is, space cooling has great importance, and focusing on it is essential to reduce energy consumption and global emissions. Particularly, considering environmental impacts, we need to turn to renewable energy sources for space cooling. Geothermal energy can be a good alternative for space cooling. Heat pump is the widely used equipment for space heating and cooling. Another very promising equipment for space cooling is vapor absorption cycle (VAC) system, which is a thermal-driven cycle and does not require a compressor unlike other cooling systems. Therefore, VAC systems require thermal energy as a heat source and geothermal energy can be a good solution for these systems. VAC system uses various working fluid pairs, consist of refrigerant–absorbent. Ammonia–water (NH3–H2O) and lithium bromide- water (LiBr- H2O) are commonly used solutions (Karamangil et al., 2010).VAC systems have some advantages of reducing the electrical consumption of cooling systems and avoiding damage to the ozone layer because they do not use refrigerants such as Chlorofluorocarbons (CFCs) (Pongtornkulpanich et al. 2008). Therefore, studies on VAC systems have been intensified in the last decades and there are many studies about VAC system in the literature. Ebrahimi et al. (2015) developed a steady-state model for the VAC system for data centers and compared the LiBr-H2O and NH3-H2O working pairs. They concluded that the VAC system with LiBr-H2O had better performance but sensitivity analysis is required to select the appropriate working pair depending on the operating conditions. Yoon et al. theoretically studied a VAC system with LiBr-H2O working fluid pair and found that the maximum cooling capacity is 100 W and the COP value is 0.87. Mehrabian and Shahbeik, (2005) developed a computer program to analyze a single-stage VAC system with H2O–LiBr thermodynamically. Similarly, a user friendly visual software was developed by Karamangil et al., (2010) to select the appropriate working pair for the VAC system depending on the operating conditions. A VAC system with an NH3-H2O working pair was studied by Chiriac and Chiriac, (2010) and the COP value was found to be 0.73. How the performance of a H2O-LiBr VAC system is affected by the changes in parameters such as generator, evaporator, condenser temperatures is examined theoretically in a study conducted by Kaynakli and Kilic (2007). In the study of Modi et al., (2017) the COP and the second law efficiency of a single effect VAC system using LiBr-H2O working pair were determined as 0.74 and 25% for the generator temperature of 87°C, respectively.Vapor absorption refrigeration system with geothermal energy source is used for space cooling in the World, but it is not common in Turkey. But Turkey has huge geothermal potential especially for direct-use applications. Therefore, in this study a geothermal based VAC system is studied to meet cooling energy requirement of a 150 m2 family house located in Izmir, Turkey. As a contribution to the literature, the performance of the single-stage VAC system with LiBr-H2O working pairs are studied by conducting detailed energy and exergy analyses, and the results are presented in a single article.

2. MATERIALS AND METHODS

The considered single-stage geothermal energy based VAC system with LiBr-H2O working pair is shown in Fig. 1 in a schematic form. The main components of the VAC system are generator, condenser, solution heat exchanger (SHEX), absorber, evaporator, pumps, expansion valves and main heat exchanger. In the system water uses as refrigerant and LiBr uses as absorbent.

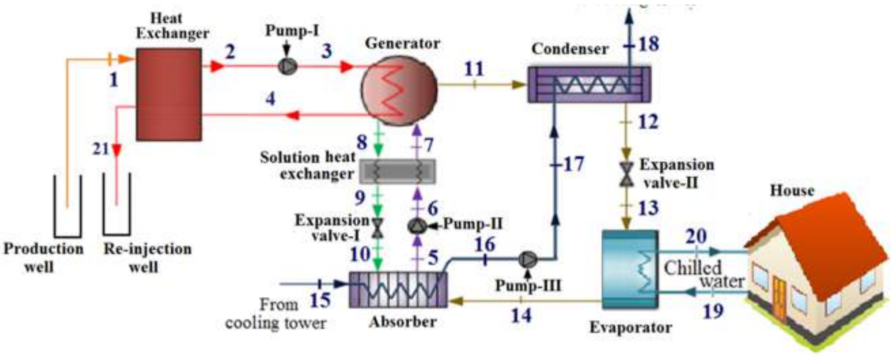

Fig. 1. The schematic illustration of the single-stage geothermal energy based vapor absorption cooling system (adapted from Ozcan et al., 2019.

3. THERMODYNAMIC ANALYSES

Energy and exergy analyses have been conducted to the considered VAC systems. Exergetic product-fuel efficiency is defined as the ratio of the exergetic product rate ($\dot{P}$) to exergetic fuel rate ($\dot{F}$):

$$\varepsilon_{\dot{P}/\dot{F}} = \dot{P}/\dot{F} \tag{1}$$

Exergy destruction rate of the components is calculated by Eq. (2) based on exergetic product-fuel efficiency.

$$\dot{Ex}_{dest} = \dot{F} - \dot{P} \tag{2}$$

Exergetic efficiency of the whole system is determined by Eq. (3) and Eq. (4):

$$\varepsilon_{\dot{P}/\dot{F}} = \frac{\sum \dot{P}}{\sum \dot{F}} \tag{3}$$

$$\varepsilon_{sys} = \frac{\dot{Q}_{evap}}{\dot{m}_1(\psi_1 - \psi_{21}) + \sum \dot{W}_{pump,elec}} \tag{4}$$

4. RESULTS AND DISCUSSION

The motivation of the study is to investigate the performance of the VAC system driven by geothermal energy to meet the cooling demand of a single- family detached house in İzmir, Turkey. The peak cooling load of the house for 24°C design indoor temperature is calculated as around 10 kW. Therefore, the evaporator heat capacity is taken as 10 kW in the VAC system. The thermodynamic properties of working pairs are determined using Engineering Equation Solver (EES) software package program and they are presented in Table 1.

Table 1. Thermodynamic data for the VAC system with LiBr-H2O working pair.

State	Fluid	T (°C)	P (kPa)	$\dot{m}$ (kg/s)	X (-)	h (kJ/kg)	s (kJ/kg.K)	ψ (kJ/kg)	$\dot{E}$ (kW)	$\dot{E}x$ (kW)
1	water	100	800	0.077		419.7	1.307	34.67	32.20	2.66
2	water	95	600	0.077		398.5	1.250	30.35	30.60	2.33
3	water	95	700	0.077		398.6	1.250	30.46	30.61	2.34
4	water	60	650	0.077		251.7	0.831	8.52	19.33	0.65
5	LiBr-H_2O	30	0.706	0.015	0.40	61.2	0.297	0.13	0.94	0.00
6	LiBr-H_2O	30	4.247	0.015	0.40	61.2	0.297	0.13	0.94	0.00
7	LiBr-H_2O	56.7	4.247	0.015	0.40	127.5	0.507	4.15	1.97	0.06
8	LiBr-H_2O	85	4.247	0.011	0.55	187.7	0.524	59.27	2.10	0.66
9	LiBr-H_2O	41	4.247	0.011	0.55	96.4	0.252	48.92	1.08	0.55
10	LiBr-H_2O	41	0.706	0.011	0.55	96.4	0.252	48.92	1.08	0.55
11	water	80	4.247	0.004	0	2650.0	8.741	48.63	11.14	0.20
12	water	30	4.247	0.004	0	125.7	0.437	0.08	0.53	0.00
13	water	2	0.706	0.004	0	125.7	0.457	-5.98	0.53	-0.03
14	water	2	0.706	0.004	0	2504.0	9.102	-204.80	10.53	-0.86
15	water	25	110	1.277		104.9	0.367	0.01	134.00	0.01
16	water	27	100	1.277		113.3	0.395	0.03	144.70	0.03
17	water	27	110	1.277		113.3	0.395	0.04	144.70	0.05
18	water	29	100	1.277		121.6	0.423	0.11	155.30	0.14
19	water	12	100	0.477		50.5	0.181	1.22	24.08	0.58
20	water	7	110	0.477		29.5	0.106	2.38	14.08	1.14
21	water	65	800	0.077		272.8	0.893	11.01	20.92	0.84

The exergy analysis has been conducted to each component of the VAC system. The exergetic fuel and product rates and exergy destruction rate of the components are given in Table 2. According to the relative irreversibilities, the generator has the highest exergy destruction in both VAC systems. The evaporator and absorber follow the generator.

Table 2: Exergy destrution rates of the each component in the VAC system at operating conditions of the base case.

Device	$\dot{F}$ (kW)	$\dot{P}$ (kW)	$\dot{E}x_{dest}$ (kW)
Generator	1.588	0.805	0.783
Solution heat exchanger	0.116	0.062	0.054
Evaporator	0.771	0.554	0.218
Pump2	0.000	0.000	0.000
Pump3	0.013	0.013	0.001
Absorber	0.176	0.023	0.153
Condenser	0.204	0.093	0.111
Pump 1	0.008	0.008	0.000
Expansion valve 1	0.548	0.548	0.000
Expansion valve 2	0.000	-0.025	0.025
Heat exchanger	1.815	1.677	0.139
Overall system	**5.241**	**3.757**	**1.484**

In the considered system the heat exchanger has the highest exergetic efficiency, the absorber has the minimum efficiency value in VAC option. The exergetic efficiency of the VAC system is calculated as 30%.

5. CONCLUSIONS

In this study geothermal energy based vapor absorption cooling system with LiBr-H2O working pair has been studied to provide the required cooling load of a single-family detached house in Izmir, Turkey.
The main outcomes of the study are summarized as follows:

•For the base case operating conditions, the geothermal resource temperature, condenser temperature, evaporator temperature and absorber temperature are taken as 100°C, 30°C, 2°C and 30°C, respectively.
•Total exergy destruction rate of the VAC system at base case operating conditions is calculated as 1.484 kW.
•The component, which has the highest exergy destruction rate in the system, is the generator for both VAC options. It is responsible more than 50% of the total exergy destruction of the whole system. Therefore, it has highest improvement potential rate and should be firstly focused on it to increase the overall system efficiency.
•COP of the VAC system is 0.89.
•The second law efficiencies depending on the COP values of the VAC systems is determined as 41.4%.
•The exergetic efficiency of the VAC system is 30%.

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Istanbul, Turkey

ENVIRONMENTAL IMPACT INVESTIGATION OF USING HYDROGEN SULFIDE AND WASTE-BASED HYDROGEN IN BLENDING WITH BLACK SEA NATURAL GAS

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ABSTRACT
In this study, an environmental impact assessment of the use of natural gas extracted from the Black Sea with the hydrogen produced from municipal solid wastes and hydrogen sulfide obtained from the Black Sea is performed. Several volumetric hydrogen ratios in the blend are employed to obtain the saved natural gas reserves and, therefore, life cycle impacts. With the addition of hydrogen to natural gas, annual natural gas use decreases from 59.85 to 55.66 billion m3. With this decrease, global warming and acidification potential values decrease from 275 to 255 kg CO2 equivalents per year and from 0.32 to 0.29 kg SO2 equivalents per year, according to the results of life cycle analysis.
Keywords: Hydrogen sulfide, municipal solid wastes, hydrogen production, natural gas, emissions.

1. INTRODUCTION
Natural gas consumption in Turkey is generally increased over the years as seen in Fig. 1. In addition, carbon emissions from the use of natural gas increase, which leads researchers to cleaner fuels such as hydrogen. Transition to 100% hydrogen economy is possible with the use of hydrogen and natural gas mixture. Ozturk et al. (2023) experimentally studied the effect of hydrogen addition in natural gas on the efficiency of burning and emissions emitted. While carbon monoxide and carbon dioxide emissions decrease as the hydrogen content of the mixture increases, nitrogen oxides emissions exhibit a changing tendency. Sun et al. (2022) investigated the effect of hydrogen ratio (from 0 to 100%) on the burning and emission parameters (CO and NO) of laminar-premixed methane flame under the working conditions of gas turbine. According to the results, the adiabatic flame temperature and also laminar burning velocity increased as the hydrogen content increased.

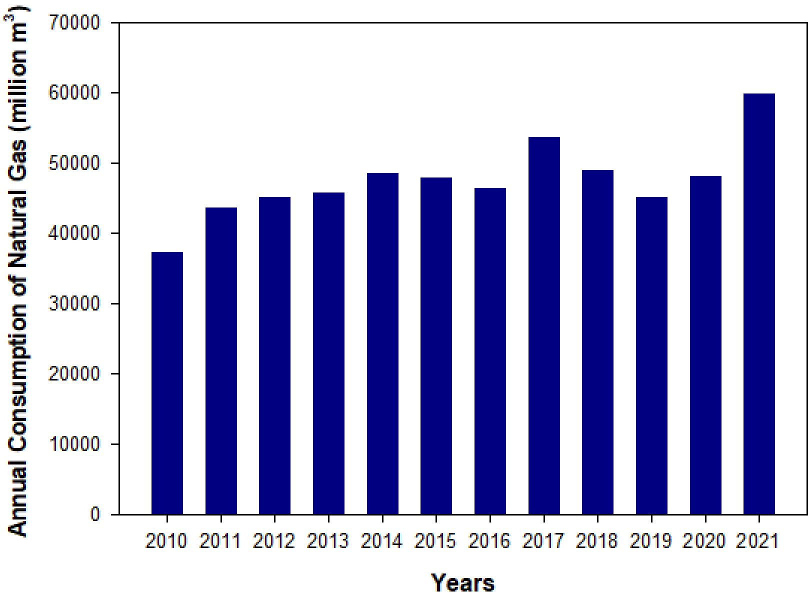

Fig. 1. The change in annual consumption of natural gas in Turkey (data compiled from EPDK (2023))

The main aim of this work is to design and analyze an integrated system that provides environmentally friendly employment of Black Sea natural gas reserves blending with hydrogen. Hydrogen is produced from hydrogen sulfide, extracted from the Black Sea deep water, and municipal solid waste gasification unit. Produced hydrogen is added into natural gas for lower natural gas consumption and therefore emissions. Different volumetric ratios of hydrogen in the blend are analyzed to compare the environmental impacts.

2. SYSTEM DESCRIPTION

The developed system includes a hydrogen sulfide electrolyzer and a municipal solid waste gasification plant to produce hydrogen separately. Also, hydrogen is blended into Black Sea natural gas, and the obtained blend can be employed for energy, conversion, housing, service, industry, and transportation sectors.

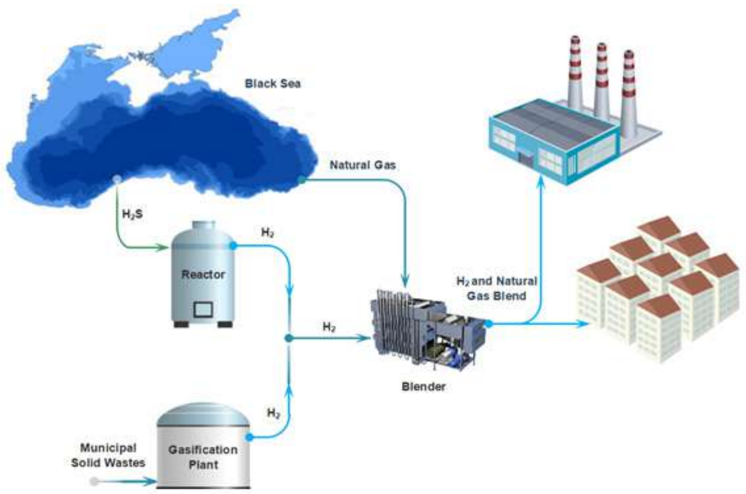

Fig. 2. Schematic view of the developed and analyzed system.

3. ANALYSIS

The Black Sea has a capacity of 4.6 billion tons of H2S when all prospective deposits are taken into account (Midilli et al., 2007). An exploration activities on Turkey's Black Sea coast turned up 710 billion m3 of natural gas as a result of exploration efforts (TCCB, 2023). The Aspen Plus software is used to investigate hydrogen production from H2S and municipal solid waste. Moreover, the SimaPro software is employed to analyze the environmental effect of natural gas savings with hydrogen usage.

4. RESULTS AND DISCUSSION

Fig. 3a shows the effects of hydrogen addition rate on volumetric lower heating value (LHV) and annual consumption of the blend. When the volumetric hydrogen ratio in the blend rises from 0 to 0.2, volumetric LHV decreases from 32.39 to 27.86 MJ/m3. For this reason, annual blend consumption increases from 59.85 to 69.58 billion m3 to be able to provide the same heat value. On the other hand, adding hydrogen to natural gas contributes to the lower usage of natural gas obtained in the Black Sea, as seen in Fig. 3b. Annual usage of natural gas decreases from 59.85 to 55.66 billion m3 while the utilization time of Black Sea reserves rises approximately one more year.

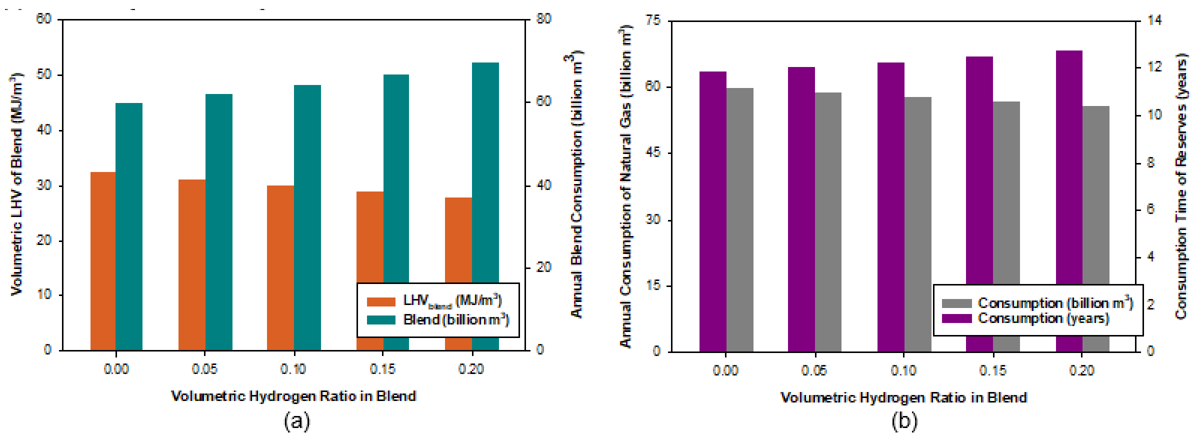

Fig. 3. Variation of (a) volumetric LHV and annual blend consumption and (b) natural gas consumption and reserves consumption time with hydrogen ratio in blend.

As the annual natural gas consumption diminishes with the addition of hydrogen, the emissions from the combustion of natural gas will also decrease. As a result, the variation of the global warming and acidification potential values obtained from the life cycle analysis is given in Fig. 4. When the hydrogen ratio changes from 0 to 0.2, the GWP and AP values decrease from 275 to 255 kg CO2 eq./year and from 0.32 to 0.29 kg SO2 eq./year, respectively.

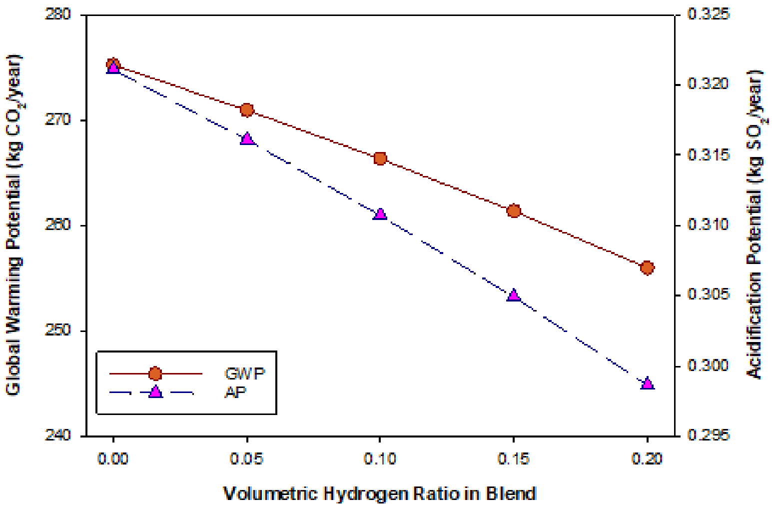

Fig. 4. The effect of hydrogen addition into natural gas on GWP and AP.

4. CONCLUSIONS

Some findings of the present study are given as follows: (i) The annual consumption of the blend increases from 59.85 to 69.58 billion m3 to provide the same heat value. (ii) The annual consumption of natural gas reduces from 59.85 to 55.66 billion m3 while the reserve consumption time of the Black Sea increases approximately one more year. (iii) When the hydrogen ratio rises from 0 to 0.2, the GWP decreases from 275 to 255 kg CO2 equivalents per year. (iv) The acidification potential diminishes from 0.32 to 0.29 kg SO2 equivalents per year when the volumetric ratio of hydrogen changes from 0 to 0.2.

NOMENCLATURE

AP acidification potential
GWP global warming potential
LHV lower heating value

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PERFORMANCE ASSESSMENT OF A SOLAR AND BIOMASS-BASED ENERGY SYSTEM HAVING METAL HYDRIDE-BASED THERMAL COMPRESSORS

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ABSTRACT
It is well known that renewable energy sources suffer from intermittency. Thus, they are often compensated using energy storage or by combining two or more such resources to ensure continuous operation. This paper presents a multi-generation system that integrates two renewable resources i.e. solar and biomass. The proposed system can produce five useful outputs which are electricity, oxygen gas, compressed hydrogen gas (up to 150 bar), and dried biomass (for off-season storage). The system consists of a Gas Turbine cycle running on biomass combustion. The gases at the turbine exit further support Rankine cycle primarily run on energy received by the solar parabolic trough collector (PTC). The excess electricity from the two sources is used to electrolyze water and produce hydrogen, and oxygen. A metal hydride bed (LaNi5) stores hydrogen which can be used to run fuel cells or is compressed via metal hydride-based thermal compressors. The thermal energy required for metal hydride beds is provided using hot water from the intercooler of the gas turbine cycle. Energy and Exergy analyses are used to analyse the complete system and the efficiencies of the subsystem are computed.
Keywords: Thermal, solar, biomass, metal hydride compressors, exergy.

1.INTRODUCTION
India is an agro-based country with much agricultural and forestry waste generated yearly. This waste, if not managed properly, can lead to environmental degradation and health hazards. However, if utilized effectively, this biomass can serve as a valuable resource for power generation. One such industry that dominates in using biomass as a resource is the sugar industry. Producing sugar from sugar cane generates large amounts of waste (bagasse) and other agricultural residues. Thus, it has been a common practice in sugar mills to burn bagasse to produce steam and generate electricity for plant's needs. The heat produced during this process can be used for various purposes, such as space heating or industrial processes, making it a co-generation system.

India emerged as the world's largest producer, consumer and world's 2nd largest exporter of sugar. Production of 5000 Lakh Metric Tons (LMT) sugarcane was recorded in the year 2021-22 (PIB, 2023). Government of India realized this potential and promoted policies to encourage power generation capacities of these mills to supply surplus electricity to national grid.
If the 550 sugar mills in the country were to adopt the most efficient and cost-effective methods of cogeneration for extracting power from the bagasse they produce, it is estimated that they could generate an additional 14 GW of power (BioEnergy, 2023). And thus many technical options are being explored to expand their capacities.

Few researchers have studied the integration of solar energy technology in sugar mills [Ghasemi et. al., Burin et. al.] and demonstrated that this combination might lead to making CSP economically feasible. Also, apart from boosting electrical output, multi-generation systems are currently being explored to produce a variety of other outputs such as alternate fuels, desalinated water, drying and other chemical products. Thus, solar and biomass (bagasse) based multi-generation is being proposed which can aid sugar mills to achieve this target and is thus thermodynamically studied in this paper.

2.SYSTEM DESCRIPTION AND ANALYSIS
The proposed multi-generation system shown in Figure 1 comprises of four parts namely; Biomass (Bagasse) based Gas power cycle, Solar (PTC) and waste heat-based Rankine cycle, Metal hydride hydrogen storage
and fuel cell as energy storage and metal hydride hydrogen compression system. The main outputs of the proposed system are electric power, compressed hydrogen gas, oxygen gas and dried biomass.

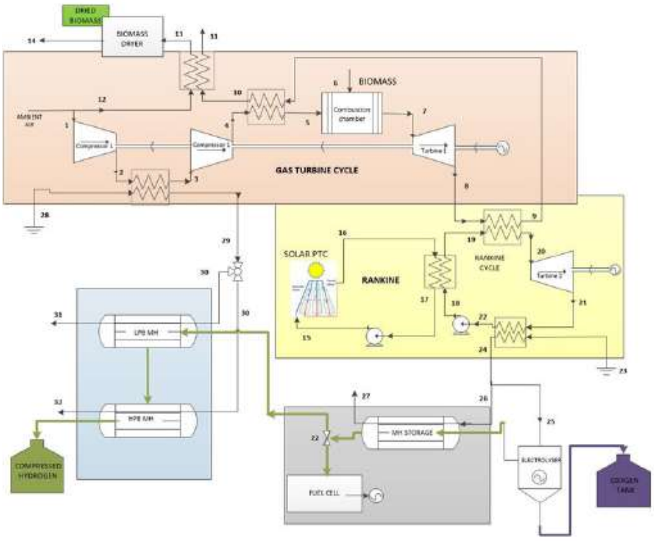

Figure 1. Schematic of the proposed multi-generation system

3.ANALYSIS

Following assumptions are invoked in the analysis:

•Enough biomass is available to generate constant power for 24 hrs throughout the year.
•Complete combustion of biomass under stoichiometric conditions.
•Solar PTC oil exit temperature reaches 380 ℃.
•Solar power generation is sized to produce enough hydrogen to run a fuel cell of 500kW.
•The changes in kinetic and potential energy and exergy terms are negligible.
•Concentration losses are neglected in calculations of electrolyser and fuel cell.

Following subsection, provides the expression for the energy and exergy efficiencies of the subsystems and overall system.

Gas Turbine Cycle

$$\eta_{en,GT} = \frac{W_{t1} - Wc1 - W_{c2}}{\dot{m}_6 \cdot LHV_f} \quad (1)$$

$$\eta_{ex,GT} = \frac{W_{t1} - Wc1 - W_{c2}}{\dot{m}_6 \cdot ex_f} \quad (2)$$

Electrolyser

$$\eta_{en,elect} = \frac{\dot{N}_{H_2O,out} LHV_{H_2}}{\dot{W}_{elect} + \dot{Q}_{heat,H_2O}} \quad (3)$$

$$\eta_{ex,elect} = \frac{\dot{N}_{H_2O,out} ex_{H_2}}{\dot{W}_{elect} + \dot{Ex}^{Q}_{heat,H_2O}} \quad (4)$$

4. RESULTS AND DISCUSSION

After performing the thermodynamic analysis on the developed system, we obtained the energy and exergy efficiencies of the gas turbine as 45% and 32%, respectively while the exergy and energy efficiencies of the electrolyser are 18.0% and 39.7%, respectively.

5. CONCLUSIONS

A new multigeneration system for electric power, compressed hydrogen gas, oxygen gas and dried biomass is proposed and studied thermodynamically. Simulation results show that one can achieve exergy efficiency of 43.6% with the fuel cell used in the study. The proposed system will open a new avenue and can be employed in already existing sugarcane industries running on bagasse-based co-generation systems especially in India to boost their power generation capacity and productivity.

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THE GEOSTRATEGIC AND ECONOMIC IMPACT OF TURKIYE'S HYDROGEN ENERGY VISION ON EUROPE

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ABSTRACT
The envisioned role for Türkiye in the context of Europe's energy strategies should be crucial. By promoting countries like Türkiye can contribute significantly to global efforts in advancing sustainable energy transitions. Moreover, Incorporating Türkiye into Europe's energy strategies can reduce reliance on external energy suppliers and enhance energy security. The findings of this study offer fresh perspectives on the intricacies of the energy system dynamics and make valuable contributions to the ongoing discourse surrounding transition routes. The study takes into account several key aspects, including the current state of hydrogen in Türkiye, the country's potential for renewable energy, the existing policy and regulatory framework, and the necessary infrastructure and market conditions required for the establishment of a hydrogen hub. These insights shed light on the feasibility and viability of hydrogen as an integral part of Türkiye 's energy landscape, offering valuable guidance for policymakers, industry stakeholders, and researchers involved in shaping the future of the energy sector.
Keywords: Energy Geostrategic, Hydrogen vision, Energy transition, Energy supply chains

1. INTRODUCTION
The European Union's active endeavors to decrease its dependence on Russian energy resources have fostered stronger relationships among its member states and yielded a remarkable reversal in the discussions surrounding the potential collapse of the EU. By prioritizing the exploration and utilization of alternative energy sources, as well as diversifying their energy portfolio, EU member states have collectively showcased a shared commitment to fortifying their energy security and diminishing vulnerability to external pressures. (Kısacık & Helvacıköylü, 2022). While many clean energy solutions are based on local resources such as wind and sun, the production of the necessary equipment and components still relies heavily on global supply chains.
The Hydrogen Council, a global CEO-led organization, projects that hydrogen has the potential to meet 18% of total global energy demand by 2050. According to the council, hydrogen could create a $2.5 trillion market with more than 30 million jobs in various sectors such as transportation, power generation, and heavy industry. China is projected to be the largest single market for clean hydrogen by 2050, with a demand for 200 million tons (MT) of clean hydrogen. This is due to the country's growing energy demand, and its efforts to reduce dependence on fossil fuels and decrease carbon emissions. Europe is also expected to have a significant demand for clean hydrogen, with a projected demand of 100 MT by 2050. (The Hydrogen Council, 2022)
The Asia-Europe energy transition route is a critical area for the development of hydrogen as a transportation fuel, given the large demand for energy in both regions and the need for clean and secure energy sources. In this context, Türkiye has the potential to play a significant role as a hydrogen hub, connecting Asia and Europe and facilitating the trade of hydrogen between the two regions.

2. THE GEOSTRATEGIC SIGNIFICANCE OF TÜRKIYE ON THE GLOBAL STAGE
Situated at the confluence of Asia, Africa, Russia, Iran, the Middle East, and Europe, Türkiye enjoys a strategically advantageous position. This geographical location has long accentuated the region's economic and strategic importance throughout history. Leveraging its position as a crossroads between Europe and Asia, Türkiye holds immense potential to emerge as a pivotal energy hub for the transportation of natural gas to Europe. Bolstered by its existing energy infrastructure, Türkiye is well-positioned to facilitate the flow of natural gas, capitalizing on its strategic location and fostering regional energy integration. As seen Fig. 1, Türkiye's aspiration to establish itself as a gas transit hub necessitates forging connections between gas suppliers from West and Central Asia and the European market.(Bne IntelliNews - Türkiye's Q2 Natural Gas Import Prices Set to Rise, Talks Launched on Iran Contract, n.d.). Over time, various proposals have emerged, both past and present, outlining the construction of pipelines that would link countries like Qatar, Iran, Turkmenistan, and Israel to Europe via Türkiye. These ambitious endeavors seek to enhance energy diversification, bolster regional cooperation, and promote economic integration. With its strategic position as a bridge between continents, Türkiye holds the potential to play a pivotal role in facilitating the seamless transportation of gas resources, fostering energy security, and strengthening ties between energy-producing nations and European consumers.

The expansion of Türkiye's hydrogen infrastructure is anticipated to bring about positive ripple effects on neighboring countries, potentially inspiring them to embrace and implement hydrogen technology themselves. Türkiye has proactively developed its own hydrogen strategies and roadmaps, clearly articulating its vision and plans for advancing hydrogen technologies and related infrastructure. These strategic efforts aim to facilitate the transition towards a low-carbon economy and establish Türkiye as a regional leader in the hydrogen industry, thereby influencing decision-making processes and shaping the future of hydrogen development in the region. Türkiye boasts a substantial network of transmission and distribution pipelines for natural gas, spanning approximately 10,000 km, which includes pipelines with significant diameters. This extensive infrastructure serves as a robust basis for the prospective expansion and integration of hydrogen into the energy landscape. The existing pipeline system presents the opportunity to transport hydrogen, either in its pure form or as a blend with natural gas(Sorgulu & Dincer, 2022). A thorough investigation has been undertaken to explore the potential of hydrogen production utilizing diverse renewable sources across all 81 cities within seven regions of Türkiye. This comprehensive study aims to assess the feasibility and viability of harnessing renewable energy resources for hydrogen production throughout the country. By examining the unique characteristics, availability, and suitability of different renewable sources in each region, valuable insights are gained regarding the potential for hydrogen generation from these sustainable energy options.(Dincer et al., 2022; Karayel et al., 2023)

Fig.1. Türkiye's natural gas pipelines

At present, domestic hydrogen consumption in Germany amounts to approximately 55 TWh. The primary driver of this demand lies in industrial processes, particularly within the production of essential chemicals and petrochemicals. According to estimates by the Federal Government of Germany, it is anticipated that the country will require approximately 90 to 110 TWh of hydrogen by the year 2030. (Cerniauskas et al., 2020; Reuß et al., 2019). France is resolutely committed to forging a path towards a greener future, and in its pursuit of sustainability, it has chosen excellence and green hydrogen as key catalysts for change. France's resolute commitment to carbon neutrality is exemplified through its substantial investment of €30 billion, aimed at structuring a comprehensive strategy and propelling the ecological and digital transitions according to France 2030 plan. (#France2030: 7 Billion Euros for Hydrogen - Business France Nordics, n.d.; HYDROGEN POLICY: France to Have New National Hydrogen Strategy by the End of H1 2023 | ICIS, n.d.). Lastly, as seen Figs. 2 and 3, The European Hydrogen Backbone (EHB) initiative brings together a consortium of thirty-two energy infrastructure operators, bound by a common vision of achieving a climate-neutral Europe through the development of a robust renewable and low-carbon hydrogen market. By joining forces, these operators aim to establish a comprehensive hydrogen infrastructure network spanning across Europe, enabling the efficient production, transportation, and utilization of hydrogen. According to the report, the proposed European Hydrogen Backbone for 2040 spans a distance of 53,000 km and is projected to require a significant investment of €80-143 billion. The backbone utilizes a combination of repurposed natural gas pipelines, accounting for 60% of the infrastructure, and new pipeline stretches making up the remaining 40%. (The European Hydrogen Backbone (EHB) Initiative | EHB European Hydrogen Backbone, n.d.).

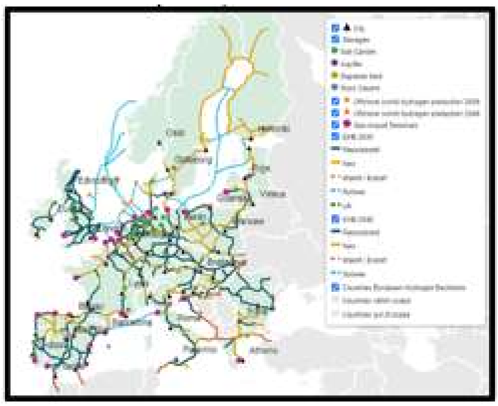

Fig.2. The European Hydrogen Backbone

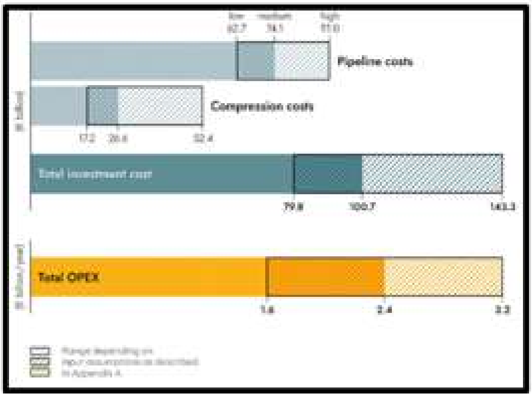

Fig.3.Costs of The European Hydrogen Backbone

4. TURKIYE'S STRATEGIC HYDROGEN INITIATIVE: A SOLUTION TO EUROPE'S ENERGY CRISIS AND SECURITY CHALLENGES

"The energy crisis poses an immense challenge that no European state can navigate alone". (Beating the European Energy Crisis, n.d.). It is evident that Europe's capacity to generate sufficient green hydrogen domestically to achieve net-zero emissions is highly unlikely. To meet its green hydrogen demands, Europe will inevitably have to rely on imports from regions such as Australia, Africa, Latin America, and the Middle East, where suitable land and weather conditions exist for renewable power generation, particularly solar power. In order to facilitate the import and distribution of hydrogen, Europe must make significant investments in the development of robust infrastructure networks. Especially, Europe need one viable approach to optimizing existing infrastructure is to repurpose the existing gas pipelines for the transportation and distribution of hydrogen, thereby maximizing their potential and minimizing the need for extensive new infrastructure. (Europe's Energy Crisis Is Boosting Green Hydrogen. Is It Finally a Real Alternative? | Euronews, n.d.). The development and implementation of Europe's hydrogen infrastructure is estimated to require a significant investment of approximately €1.3-1.5 trillion. Even for Europe, the need for infrastructure for this green hydrogen is really exceptionally high and despite notable progress, there remains a considerable supply gap that needs to be addressed in order to meet the growing demand for hydrogen. The levelized cost of hydrogen (LCOH) production using steam methane reforming (SMR) ranged from USD 1.7 to 2.4 per kgH2, based on average natural gas prices. The levelized cost of hydrogen production using solar PV-powered electrolysis was estimated to be around USD 8 to 11 per kgH2. However, leveraging the wind power potential in the region, the estimated levelized cost of hydrogen production using wind power-based electrolysis was approximately USD 5 per kgH2 for onshore wind and slightly over USD 6 for offshore wind. Furthermore, gas-based supply with carbon capture, utilization, and storage (CCUS) had an estimated levelized cost of hydrogen production of about USD 2.5 to 3 per kgH2. Despite this, low-emission hydrogen production methods were still not economically competitive with unabated production in Europe. (Northwest European Hydrogen Monitor – Analysis - IEA, n.d.). Türkiye's impressive natural gas transmission and distribution pipeline network spanning a vast distance and with pipelines of significant diameters lays a solid foundation for future growth and the seamless integration of hydrogen into the country's energy infrastructure.

The exploration and development of the Sakarya gas field in the Black Sea has the potential to provide blue Hydrogen. Moreover, transporting the recently discovered natural gas reserves in the Eastern Mediterranean to global markets is a key priority that remains high on the agenda for stakeholders in the region. The Government of Türkiye has recently unveiled its Hydrogen Technologies Strategy and Roadmap, underscoring the pivotal role of green hydrogen in realizing the nation's ambitious net-zero emissions targetTürkiye will thus become the green powerhouse for Europe's energy system with Hydrogen production and transport potential. Hence, by strategically positioning itself and leveraging its natural resources, Türkiye has the potential to not only capture a substantial market share but also enhance the intrinsic value of its vast territory.

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THERMAL STORAGE UNITS AS A PEAK SHAVING PRODUCT FOR ENERGY AND BUILDING SECTOR INTEGRATION

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ABSTRACT:
Buildings are responsible for a significant share of use of a thermal storage system as a peak shaving product defined in revised EU Electric Market Design. An office building in İzmir, Turkey is used as a case study to analyze performance of such system against scenarios satisfying both current national targets and nZEB definitions within current market available options and legislations for a case office building located in İzmir. Life cycle cost (LCC) and GWP (global warming potential) are added to current national methodology to show benefits of low emission alternatives with a cost-effective methodology.
Keywords: building energy efficiency, life cycle cost, life cycle emissions, global warming potential, peak shaving product

1. INTRODUCTION
Energy and construction sectors are closely linked and key actors in solving environmental problems and greenhouse gas emissions. Buildings in the European Union consume about 40% of the total energy [European Commission 2010] and 35% of the total greenhouse gas emissions are caused by the buildings [2.European Commission 2017]. Thus, Life Cycle Assessment of building systems has become a critical tool for multicriteria decision tool to reach economic and environmental targets [Delavar et al., 2020]. This approach has been applied by many political, economic, and social authorities such as the European Union to develop their environmental targets decisions, practices, and strategies [Umdu et al., 2020]. In European case these directives, strategic sector plans, climate action plans and regulations it has issued [Umdu et al., 2020, Moazzen et al., 2020] that are issued has wider impact by covering associated countries such as Turkey. Within this context sector integration of energy and buildings through a thermal storage unit is investigated in this paper. The storage unit acts as peak shaving product for the electrical grid and supplying heat to the building. An existing office building in İzmir Turkey is used as a case to evaluate the calculation methodology stated in national standard TS825 to find reduction in energy needed for heating and cooling purposes and further analyzed life cycle cost and emissions to determine benefits for the building user.

2. MATERIALS AND METHODS
Energy calculations are done by the methodology stated in EN TSE 825 Thermal Insulation Rules in Buildings Standard which is the main methodology behind the national building energy calculation software BEP-BUY and BEP-İS. Entire calculation steps are evaluated in MS Excel for building envelope scenarios of 225 cases. The building used as a case is in İzmir. It is the office building of Yaşar University Faculty of Engineering. The ground floor of this 3-storey building is designed as laboratories, and the last two floors as the offices of faculty members. The building is located along the southwest and northeast plane. Heating degree days (HDD) and cooling degree days of the city are 1385 and 700 respectively for comparison with other cases [Büyükalaca et. al., 2001]. Building properties are summarized in Table 1.

Table 1. Properties of reference building.

Number of stories	3	Total heat loss area of the building (A_{total}) (m²)	2050.8
Story height (m)	3.5	Total window area (A_i) (m²)	103.8
Width (m)	46	North facing windows total area (A_{north}) (m²)	38.7
Length (m)	9.6	South facing windows total area (A_{south}) (m²)	62.1
Useful building area (A_n) (m²)	1324.8	West and east facing windows total area ($A_{west/east}$) (m²)	3.0
Gross volume of building (V_{gross}) (m³)	4636.8	External door area (m²)	11.1

Building insulation, glazing and wall materials are the parameter groups that are changed in building envelope design. There are 5 scenarios for insulation with four different insulation materials; XPS, glass wool, glass foam and ceramic fiber, and without insulation since resulting U values for the case are satisfactory for the national standard. Further three different wall materials are considered for the envelope; hollow clay brick, clay brick and aerated air concrete where all are locally available. And 12 different glazing alternatives are considered for the scenarios. A total of 225 calculations are evaluated to find the optimum envelope conditions, and later the lowest LCC and GWP option is further investigated for 4 different heating and cooling system scenarios and 5 different insulation thickness alternatives. Total energy demand was found by summing heating and cooling needs through each month. The material properties are gathered from EPDs (Environmental product declarations) of Turkish companies and cost data used is based on approximate unit building costs in 2021 published by Turkish Ministry of Environment and Urbanization [Ministry of Environment, Urbanization and Climate Change 2021]. After building shell optimized 4 common heating equipment alternatives are compared with application of a thermal storage unit operating as a peak shaving product in two different operational modes; services to support customer energy management and services to support distribution infrastructure. The storage unit in the study is a sensible heat storage unit which uses steel as storage material.
Based on new European Union recommendations CAPEX, OPEX and TOTEX (Total operational expenses) were calculated for decision making by using hourly energy costs for heating and cooling. Thermal comfort range temperature is used as 20 ± 1 °C mandated by the related national standards. The net present value (NPV) formula was used for discounting future cash flows to present values in the LCC calculation.

$$NPV = \frac{\text{Cash flow}}{(1+d)^t} \tag{2}$$

where present value, PV; time in unit of year, which is 40 years in this case, t; future cash amount that occur in year t and discount rate used for discounting future cash amounts to the present value which is %15.75 as reported by Turkey Central Bank for the same period, d. Similarly annual GWP based on CO2 emissions are calculated by using energy demand for heating and cooling and individual system CO2 emission rates, Es,i and embodied CO2 emissions.

$$GWP = \sum E_a = \sum \frac{Q_h}{\eta_{es,h}} E_{s,i} + \frac{Q_h}{\eta_{es,h}} E_{s,i} \tag{3}$$

3. RESULTS AND DISCUSSION

Based on calculations optimum isolation material thickness was found as 4 cm for all materials. Further it is found that improvements in only one parameter; either glazing, wall material or isolation do not result in decrease in the total energy requirements even they are improved to the extremes. Optimum building shell requires higher capital investment for building envelope, 628,014 TL, compared to minimum conditions stated in standards, 432,998 TL. The optimized condition is just 6.7% higher than the construction costs stated by the Ministry of Environment and Urbanization [Grieder et al. 2021]. This small cost difference leads to 10% lower energy demand and 28 times decrease in LCC calculated. Adaptation of LCA approach in other building systems other than building envelope can leads to further improvement in potential of GWP up to 22% [Hamida et al. 2021]. In the studied case the share of embodied emissions increased 16 times and reached 0.9% of lifetime cumulative operational emissions compared to minimum base case can be applied by the TS 825 standard. One of the important findings of the study is low emissions, 33% of baseline, are possible withing lowest cost regions with no additional capital investment but just changing building practices and tailoring building design parameters of the envelope. The building performance can be further improved by increasing insulation thickness of ceramic fiber insulation. The building energy requirements for heating and cooling 127.04 to 92.03 kW/m2.a by increasing thickness from 4 cm to 10 cm. This is also reflected with a 40% drop in GWP and 46.5% drop in LCC. This way both GWP and LCC can be decreased approximately 30%. It is possible to achieve 61% increased performance, 77.24 kWh/m2.a, compared to average energy demand of office buildings in Turkey which is 125.6 kWh/m2.a based on TUİK data. Alternative to conventional approach the thermal storage system which charge in low tariff or low day ahead market prices base on operator capability is investigated. The main benefits of the system are the availability of low-price electricity and more importantly the capability of using off site off-demand renewable energy from local grid. This way zero emission energy is available to heat the building to achieve not only near zero but also close to real zero emissions with similar economic costs with both natural gas boilers and heat pumps. It must be stated that using energy storage units also decreases peak demand electric transformer load approximately 25% during peak times.

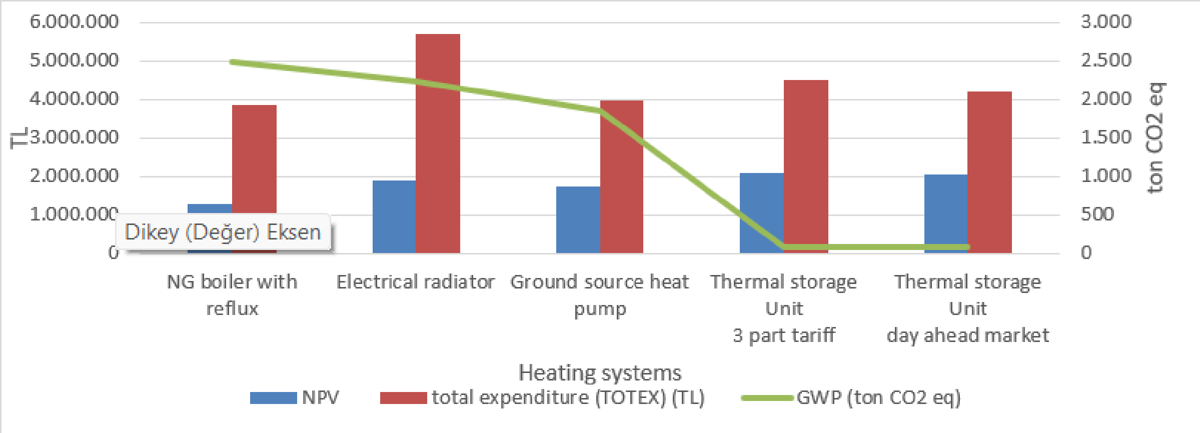

Fig.1. Economical and environmental performances of different heating systems

4. CONCLUSIONS

Apart from building envelope improvements, which is the best way to decrease total demand, heating and cooling systems are significantly affecting the emissions based on their energy sources. In this context, national standard TS825 and other related regulation used to define limits on the alternative scenarios for building envelope and heating/cooling systems of public buildings in a case located in İzmir, Turkey. Results of the calculations show that improvements in only one building envelope parameter; either glazing, wall material or isolation do not result in significant decrease in the total energy requirements even they are improved to the extremes. Multiple parameters need to be considered in a synergistic approach and this leads to 33% lower life cycle GWP. Changing common building practices and tailoring building envelope design parameters for individual cases can lead to better energy and related GWP performances even within lowest capital cost alternatives. Further using energy storage systems as an alternative to conventional heating systems it is possible to enable zero emission performance by utilizing off-demand renewable energy from the grid. Such a change does not need higher cost to the operators compared to low-cost conventional systems but a change in grid integration practices for the buildings to enable sectoral integration.

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METAL ORGANIC FRAMEWORKS LOADED MEMBRANE FOR MICROBIAL FUEL CELL APPLICATION

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ABSTRACT
With the increasing population, urbanization and industrialization, energy demand is also increasing. Due to the depletion of energy resources and the problems of fossil-based energy resources such as global warming and climate change, it has become necessary to carry out important studies in this field. However, another problem that arises is waste. The result of every reason that increases the energy requirement is waste. Therefore, there is a need for innovative solutions that will both meet the energy demand without harming the environment and reduce waste generation and provide waste management. Microbial fuel cells (MFCs) are an important tool that generates electricity from waste biomass with the help of bacteria. While many resources are used as waste, from waste water to animal waste, the amount of energy produced varies according to the type of waste, fuel cell type and conditions. The most widely used MFC type is the H-type membrane fuel cell.
In this study, zirconia based metal organic frameworks (Zr-MOF) doped porous membranes for use in H-type MFC were produced, characterized and used to generate electricity from animal manure. It was observed that the electrical voltage values produced increased with the increase of MOF ratio in the membrane. It was also observed that the cation exchange capacity and water retention value of the membrane increased with the increase in MOF. As a result, the voltage value was recorded as 0.49 in the membrane containing 3% MOF. This value is very close to the value obtained with the Nafion membrane in the literature.
Keywords: Microbial fuel cells, Zr-metal organic framework, electric production

1. INTRODUCTION
Today, the world's population is increasing rapidly and as a result, the need for energy occurs. In order to meet this need, alternative clean energy sources have been sought due to the decrease in natural resources due to the use of fossil fuel energy sources such as coal, oil and natural gas, which are primary energy sources, and the negative effects of harmful gases released to the environment during the energy production phase. Among these alternative energy sources are Microbial Fuel Cell (MYH) systems, which are accepted as a new technology. MFCs are systems that directly convert the chemical energy in organic wastes into electrical energy as a result of the metabolic activities of microorganisms. There are many scientific studies on this technology. MYH technology offers a clean and environmentally friendly alternative to fossil fuel energy sources. Studies on MFCs were mostly carried out as wastewater treatment and electricity generation.

Microbial fuel cells (MFCs) are biochemical systems that directly convert chemical energy into electrical energy by catalytic reaction as a result of the interaction of microorganisms in biomass or organic waste (Ghasemi et al. 2013). Although there are many types, the most widely used are H-type MFCs using cation exchange membranes. A typical Microbial fuel cell consists of three main parts. These are anaerobic anode compartment, aerobic cathode compartment and membrane. The anode and cathode compartments are separated by a membrane that allows protons to pass from the anode to the cathode. The working mechanism of MFC is that the microorganisms in the anode compartment oxidize the nutrient such as organic matter or biomass, and as a result they produce protons and electrons. While protons pass to the cathode through a membrane, electrons are attached to the electrode surface in the anode compartment and are transmitted to the cathode by an external circuit element (Mohan et al. 2008; Santaro et al. 2017). If there is an electron acceptor in the cathode compartment, the electrons in the anode compartment pass through a membrane towards the cathode. Here, water is formed as a result of the interaction of hydrogen and oxygen. Since the positively charged H+ (protons) passing from the anode through the membrane are consumed at the cathode, continuity is ensured by providing a permanent H+ (proton) transition from the anode to the cathode. After the continuity of the electrons passing from the anode to the cathode is ensured, the electricity produced becomes actively usable after a resistance is attached to the circuit, such as a lamp fan. There must be no electron acceptor in the anode compartment for electricity generation to occur. For this the anode chamber has to be anaerobic.

One of the most important components affecting the performance in these systems is membranes. The membrane should be porous, chemically and biologically resistant, have good water retention, and have high hydrogen (proton) permeability. Just like other fuel bag applications, commercial Nafion is mostly used in MYHs. However, the effect of membranes has not been investigated much since MFC systems produce less energy compared to fuel cells and more limited studies have been done on them.

In this study, porous polyvinyl difluoride (PVDF) membranes was produced and their performance in MYH was examined. PVDF is an inexpensive engineering polymer with high chemical stability. To produce the PVDF polymer in a porous form, polyvinyl pyrrolidene (PVP) will be added in it. This will also increase the hydrophilicity of the membrane. In order to increase the proton conductivity of the membrane, MFC performances was tested by adding Zirkonia based MOFs (Zr-MOF) at different rates.

2. MATERIAL AND METHODS

Zr-MOF preparation

Zr-based MOF production has been described in detail before (Nigiz, 2021). 35 ml DMF, 0.32 ml acetic acid, 0.06 mol terephthalic acid, and 0.03 mol zirconium chloride were combined and heated to 220 °C. At least five hours were spent stirring the mixture. The solvent was cooled to room temperature, washed with methanol, agitated continuously for an extended period of time, and then filtered.

Membrane preparation

The nanocomposite membrane was synthesize by phase inversion technique. 1.6 g of PVDF and was dissolved in DMF and acetone (vol%50). The solution was mixed for 2 hours at 60 oC temperature. 1-4 wt. % of Zr-MOF was dissolved in DMF and added to the polymer solution. The mixture was poured onto a glass plate using automatic film applicator. Then the membrane immersed in a deionized water for ten minutes to form porous structure.

Cation exchange capacity (CEC) Calculation

The CEC of the nanocomposite membrane was calculated using acid-base titration method. The 0.1 g of membrane samples were submerged in 0.1 M NaOH solution for 24 hours at room temperature. The H+ in the membrane was replaced with Na ions in the solution. Then the amount of H+ ions were then quantified by titration against 0.1 M HCl solution using phenolphthalein indicator.

MFC Set-up

A double-chamber H type MFCs media with MOF loaded membrane was prepared. The anode and cathode electrodes were made of carbon rods. Animal manure (pH:7.2, temperature: 24 oC) was used to inoculate the MFC anodes, whereas the pure water was used in the cathodes. The system was operated with and without resistance for 24 hours.

Figure 1. MFC Set-up

MFC Analysis

Through the use of MFC, a digital voltage recorder monitored the cell voltage as a function of time. After allowing the MFCs to reach their steady-state OCV, the polarization curve was calculated by applying various external resistances. Using the information from the polarization curve, Ohm's law was used to compute the current (I) and power (P)

V=I.R

P=V.I

3. RESULTS AND DISCUSSION

Figure 2 shows the result of scanning electron microscope analysis of the produced membrane. The porosity of the membrane produced here and the homogeneity of the pore structure are of great importance for the proton transition mechanism. While the proton atoms (hydrogen) passes through the membrane, electricity passes through the circuit. Meanwhile, more proton transfer cause more electrical energy. As seen in Figure 2, the membrane structure is porous and these pores are homogeneous. Also, as seen in Figure 2b, the Zr MOF materials are dispersed through membrane. Zr-MOF material both provided strength to the membrane and increased the proton conductivity, causing an increase in the electric current (Liu et al. 2020; Gorban et al. 2023; Galei et al. 2019) .

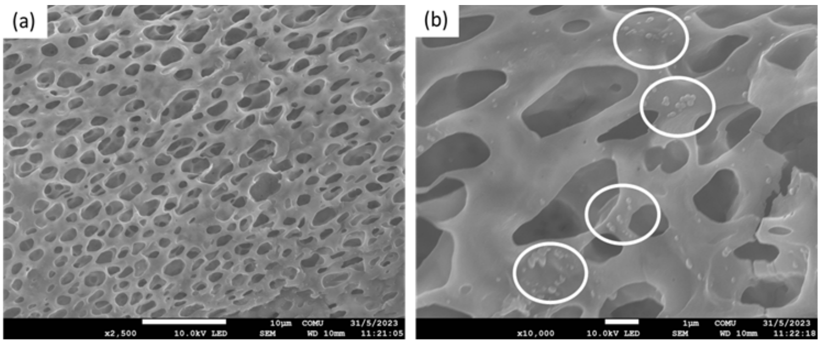

Figure 2. SEM analysis of Zr-MOF loaded membrane.

Figure 3 shows the effect of Zr-MOF content to the electrical energy produced. As seen in the Figure 3a, as the MOF was added to the membrane, the electrical energy produced increased significantly. This is because the MOF material increases the diffusion selectivity of the hydrogen across the membrane. Even if there is no direct interaction between MOF and hydrogen, it is thought that the hydrogen transfer rate, and therefore the proton transition rate, increases due to the lattice width of the MOF material (Liang et al. 2013; Xin et al. 2021; Li et al. 2022). The other reason is that the hydrophilicity and water adsorption capacity of the membrane increase with increasing MOF ratio. It is a well-known fact that the water absorption of the membrane causes its pores to be more permeable and its conductivity to increase.

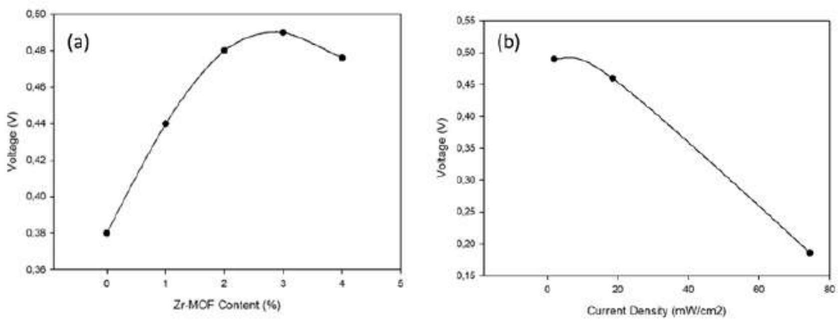

Figure 3. Effect of MOF ratio on MFC performance (a) and effect of current density on MFC performance (b)

4. CONCLUSIONS

In this study, microbial fuel cell was designed to generate electrical energy from animal manure, composite membranes were prepared and its performance was tested. Within the scope of the study, porous membranes were used and the effect of MOF added to the membranes on MFC efficiency was determined. Accordingly, the MOF material increased the water uptake and cation exchange capacity of the membrane. Under constant resistance conditions, the voltage value produced increased from 0.38 V to 0.49 V as the MOF ratio increased. It has also been observed that there is no fluctuation in the obtained electricity value and a stable efficiency is obtained. It has been seen that this membrane, which was synthesized for the first time in the literature, can be used as an alternative to Nafyon and other commercial membranes.

Acknowledgement
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EDUCATION ON METAVERSE PLATFORMS EFFECTS ON CO2 FOOTPRINT REDUCTION: ISTANBUL SCHOOL OF METAVERSE CASE

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ABSTRACT
The carbon dioxide footprint is seen as one of the most important parameters of environmental sustainability and is considered worthy of monitoring. For a sustainable system, it is seen that an approach that pollutes the environment the least in greenhouse gas production is adopted at every stage of the supply chain. Its effect on greenhouse gas production is also being investigated for technological and digital transformation. A sustainable transformation is frequently discussed with its circular economy, social and environmental dimensions.
In this study, an investigation the environmental sustainability of projects for the use of metaverse platforms based on VR/AR technologies as an active component in digital transformation in education. The same effects may be seen at other service sectors such as health, sport, entertainment, tourism etc. The methodology of the study is to compare the greenhouse gas emissions of a system that will be built on the metaverse instead of traditional education services. During the study, a bibliometric analysis has been reported and displayed on these research keywords. So the overall methodology is called mixed-methodology.
Considering the results of the study, the use of metaverse platforms provides a great advantage in the field of education. The project of supporting the system with renewable energy will carry this advantage to a much higher level. It is seen that the Istanbul School of Metaverse projects first applications during a semester creates environmental advantage for sustainability. The issue to be discussed should be the social and accompanying economic impacts of the system on resource efficiency, human resources, employment and post-humanist approaches beyond the environmental and sustainability of the metaverse system.
Keywords: Istanbul School of Metaverse, ISoM, Sustainability, Metaverse, CO2 Footprint

1. INTRODUCTION
Metaverse Applications: At the beginning of the 21st century, when technological and digital transformation is intense, it is seen that one of the most important transformation components is the block chain. With the relationship of block chain, virtual reality (VR) and augmented reality (AR) combine with artificial intelligence (AI), bringing much more effective phenomena. One of the most important areas of these phenomena is Metaverse platforms. Metaverse platforms have supported finding alternative meeting and social interaction opportunities, especially during the Covid-19 pandemic, when people are confined to their homes. Avatars, who entered the platform with high-resolution and high-priced glasses with curious eyes, started to organize events on the platforms after a while. While the system, which also enables the buying and selling of NFT-style designs, is on the way to create an important ecosystem, it has fallen off the agenda due to expensive equipment, the decline of digital money, negative interaction examples, and deficiencies in the legislation of the issue.

The ISoM project is a project that was produced while continuing the education of people who closed their homes after Covid-19, which showed its effect all over the world after November 2019, with remote online systems. The main purpose of the project is designed to increase the efficiency of distance online training and to make the interaction between the parties of communication more effective. The reproach of many lecturers that we teach “as if we are talking to a wall” has been considered because of the inability of many students to focus due to opening the lesson and leaving the screen or dealing with other issues. Communication is very important in education. The environment between the receiver and the donor is expected to be suitable for communication. The inability of students to focus on education causes them to move away from the real purpose of education. Especially in applied sciences or courses that require labs, the efficiency is at much lower levels.

At this point, ISoM is expected to succeed in clearly increasing the interaction of the parties mentioned above. ISoM brings together students and teachers, that is, the receiver and the donor, on the same platform. Students and teachers who can enter the environment can reach the highest level of interaction and the lowest level of distraction if they enter the system with their glasses. Students or teachers can feel themselves exactly in the environment they are in, since their visual communication with the outside world is cut off.

Even without glasses, it is possible to log in to the system via the internet or mobile phones. However, in this case, the focus is not as clear as with glasses.

Sustainability and CO2 Footprint: Three different dimensions are considered in the sustainability of a system. The first dimension is the economic structure of the system. The system should be economically sustainable, that is, it should have a profit-making understanding. The second dimension is social structure. In order to understand the social sustainability of a system, it should be looked at whether it creates social benefit or not. The last dimension is the environmental dimension. During the operation of an environmental sustainability system, besides how efficiently it uses natural resources, it is aimed that the damage it causes to nature is minimal and if possible zero.

While parameters such as carbon dioxide production, transportation-logistics, electricity (used devices and lighting) consumption, internet usage in a system are considered as variable parameters, fixed parameters consist of the sum of carbon dioxide emissions resulting from the production of used devices. When calculating the amount of carbon dioxide released into the environment, it is necessary to take into account the type of vehicle, device types and country standards.

2. METHODOLOGY

2.1.Literature Review

First glance, "Dergi Parkı" in Turkey has been checked. And than reviewed web of science during this study. Dergi Parkı, included few studies (with the query, [title: "metaverse" OR title: "eğitim" OR title:"AR/VR") AND title: "Sürdürülebilirlik"] gives 7 results) Metaverse and education under sustainability. However, Web of Science with a query (TS=(metaverse) OR TS=(AR) OR TS=(VR) OR TS=("Augmented Reality") OR TS=("Virtual Reality")) AND TS=(sustainability) results 697 documents.

It is seen that AR and VR Technologies are studied on many sectors. Beyond education, health, design, health sector, urban planning, cultural heritage, logistics, climate change, gamification, tourism and some industrial area in both Dergi Parkı (CiZmeci ÜmiT, 2022; Dönmez Polat & DemiR Harputluoğlu, 2017; Hepaktan & ŞiMşek, 2022; İbrahimoğlu et al., 2011; MERVE GÜNEŞ, 2019; Özkul & Özkul, 2018; Tonguç & Özbayraktar, 2017) and much more in web of science (Ardito et al., 2019; Ayer et al., 2016; Bilal et al., 2022; Bucea-Manea-Țoniş et al., 2020; Ehizuelen & Abdi, 2018; Esmaeilian et al., 2020, 2020; Ghobakhloo, 2020; Hart & Pomponi, 2021; Jarwar et al., 2018; Kamble et al., 2018; Lazaro et al., 2021; Li, 2016; Toker & Görener, 2022; Wu et al., 2018; Yadav et al., 2020)

2.2. Bibliometric Analysis

A bibliometric analysis has been made on the component of digital transformation units AR VR Technologies and related with sustainability under Education. As illustrated above, there are 697 studies as of 31th of May 2023. Under that data, which have been exported and analyzed at vosviewer program the overlay visualization is obtained as Fig. 1.

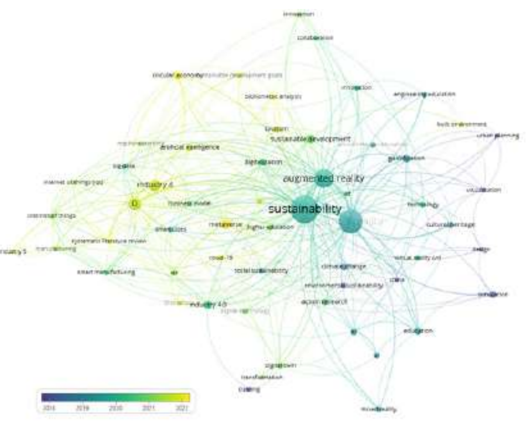

Fig 1: Overlay Visualization of the Query on Vosviewer

Fig. 1 depicted, studies on digital transformation have been handled more recently, whereas sustainability, Virtual Reality, Augmented Reality and education it self studied before 2020. So this shows that a gap is occurring on study in education related with sustainability and metaverse. This implies that the study is distinguished one.

2.3. Application

The Project which has been applied during last 3 semesters in BeTa Science Association, the number of students who were participated to the lectures, conferences and facilities are compared with the traditional application before the 3 semesters, and calculated the foot print of CO2 and compared to each other. Since the above bibliometric analysis and literature review would be made, the methodology cold be called as mixed methodology.

3. FINDINGS DISCUSSIONS AND RECOMMANDATIONS

The ISOM project, the use of metaverse, can be compared in many respects with its advantages and disadvantages. Considering the sustainability dimension with reference to the education sector, it is seen that studies with the metaverse are more appropriate in terms of both carbon dioxide footprint and communication efficiency and resource efficiency. The carbon dioxide footprint was found to be considerably lower in applications compared to the traditional application in metaverse and online education. Due to the course repetition and time savings revealed by the communication efficiency, it is seen that the metaverse has a more sustainable structure compared to online trainings.

Metaverse platforms are capital-intensive, problems arising from the fact that their software and accessibility have not yet spread to the base, and especially if synchronization is provided, the possibilities of use in many areas will increase. It is suggested that besides investment on the real sector side of the issue, regulation of norms on the public side and sustainability on the academy side, work should be done in many fields and in different sectors.

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MOF-DOPED MXENE FOR CO2 ADSORPTION

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ABSTRACT
The aim of this work is to develop hybrid materials based on MXene and metal organic frameworks (MOFs) for the CO_2 adsorption and water treatment. The targeted hybrid was $Ti_3C_2T_x$/ZIF-8. Its physical and chemical properties were characterized via SEM, EDX, XRD and spectrophotometry. Surface area of the hybrids were characterized with BET theory, pore size distribution was determined by BJH model and adsorption energy was calculated with DR equation. CO_2 adsorption was analyzed with gravimetrical method and azo dye adsorption was tested with UV-Vis spectroscopy.
Keywords: MXene, MOF, CO2.

1. INTRODUCTION
Today, the development of efficient and sustainable gas separation and purification technologies is a critical and challenging global concern since, currently, chemical gas separation is a very energy-intensive process. To address this issue, porous adsorbents, such as metal-organic frameworks (MOFs), can be applied. Using MOFs, an alternative approach to separating hydrogen and gaseous hydrocarbons can be developed (Jia, Gu et al. 2022). MOFs are porous materials with high crystallinity and ultra-high specific surface area. They consist of metal ions or clusters and organic ligands that form framework structures with tailored pore size and functionality, which makes them suitable for storage and separation of target gases from mixtures (Ayati, Shahrak et al. 2016). An almost infinite number of combinations of different metals/clusters and organic linkers exists; therefore, numerous MOFs with unique and tunable properties can be designed and developed. The application of MOFs in gas storage and separation has undergone considerable advancement over the last decade.
MXenes are a new type of two-dimensional (2D) layered material. They have attracted significant attention in different applications over the last few years because of their unique features, namely their high specific surface areas and thermal stabilities (Hwang, Kang et al. 2020). Their negatively charged surfaces make them promising substrates for firmly anchoring metal ions and, therefore, efficient substrates for MOFs. They are used to enhance MOF electrocatalytic activity and to negate MOF toxicity caused by its nano size. The low Li^+ diffusion barrier properties, outstanding electroconductivities, and high electronegativities of MXenes enhance MOF electrochemical performance (Hwang, Kang et al. 2020).

2. MATERIAL AND METHODS
All the used chemicals were purchased from Sigma-Aldrich Co. and used as received. The $Ti_3C_2T_x$ nanosheets was synthetized using direct etching and mild approaches, according to the reported method in the literature (Alhabeb, Maleski et al. 2017) and the $Ti_3C_2T_x$/ZIF-8 hybrid was synthetized similar to the method used by Torad et al. (Torad, Hu et al. 2013) .
The prepared MX, ZIF-8, and hybrid MX/ZIF-8 samples were analyzed using various techniques. The X-ray diffraction (XRD) patterns were obtained using Cu Ka (k = 1.54 Å) radiation and a Bruker PHASER K2 (Germany) diffractometer. The N_2 adsorption- desorption isotherms were attained by a Quantachrome NOVA 1200e (USA) sorptometer using liquid nitrogen at 77 K. The specific surface areas and pore size distribution of the solid samples were calculated using the Brunauer, Emmett and Teller (BET) method. In addition, the morphological features of the samples were examined using scanning electron microscopy (Tescan VEGA 3, Czech Republic).

3. RESULTS AND DISCUSSION
MXenes, a new type of 2D layered materials, became a hot topic in water treatment research in these years, because of their unique features, such as high specific surface area, thermal stability, and good hydrophilicity while most other 2D materials have hydrophobic properties (Hwang, Kang et al. 2020). Their negatively charged surface made them a promising substrate to firmly anchor metal ions and therefore they have been used to enhance the MOFs electrocatalytic activity (Hwang, Kang et al. 2020).
Both Zinc and Cobalt metal ions bind with 2-methylimidazole ligands to form zeolitic framework structure. In this work, MXene ($TI_3C_2T_x$) was doped with ZIF-8 in order to increase the adsorption sites, improve the chemical adsorption rate and therefore enhance ZIF adsorption performance.

The prepared ZIF-8/MXene was characterized using different approaches. The XRD pattern and SEM image of ZIF-8/MXene are shown in Fig.1. The XRD pattern (Fig. 1a) of TI3C2/ZIF-8 (Fig. 1a) demonstrates successful etching of Al and formation of TI3C2T. Moreover, the TI3C2/ZIF-8 pattern shows that the high crystallinity of ZIF-8 with MXene peaks still present [1]. EDX image (Fig. 1b) determines elemental distribution, particularly Zn atoms. N2 adsorption curves indicate superior adsorption capabilities of MXene/ZIF-8 with surface area 758 m2/g compared to pure MXene with surface area 4 m2/g.

In recent years, MOFs with zeolite-like topology - Zeolitic Imidazolate Frameworks (ZIFs), proved to be promising adsorbents (Ayati, Shahrak et al. 2016, Ranjbari, Ayati et al. 2023). They combine well developed porous structure and large surface area of MOFs with high chemical and thermal stability of zeolite materials. Numerous studies have been reported to improve the adsorption performance of ZIFs towards various organic and inorganic pollutants (e.g., dyes, heavy metals) through modification or material compounding. Resulting ZIFs had bigger specific surface area, specific pore size and shape and enhanced adsorption force (Ahmadian, Derakhshankhah et al. 2023). In this work, the performance of MOF/MXene conjugates in gas separation was studied, revealing their suitability for this application.

MXene/ZIF in CO2 adsorption tests demonstrated greater capacity than pristine materials, for example Ti3C2Tx/ZIF-8 has a capacity of 12.49 mmol/g compared to ZIF-8 0.91 mmol/g and pristine MXene derived from the same synthesis with 1.02 mmol/g. At the same time, Ti3C2Tx/ZIF-8 was able not only adsorb CO2 but also store it for an extended period of time. According to the results of spectroscopy, the Ti3C2Tx/ZIF-8 had adsorbed 94% of methylene blue outperforming both pristine ZIF-8 and Ti3C2Tx. Low adsorption of ZIF-67 may be explained by low stability of MOFs in acidic solution, after 30 minutes of stirring the specific purple color of ZIF-67 has faded from solution and became greenish (pH of methylene blue was 4.01).

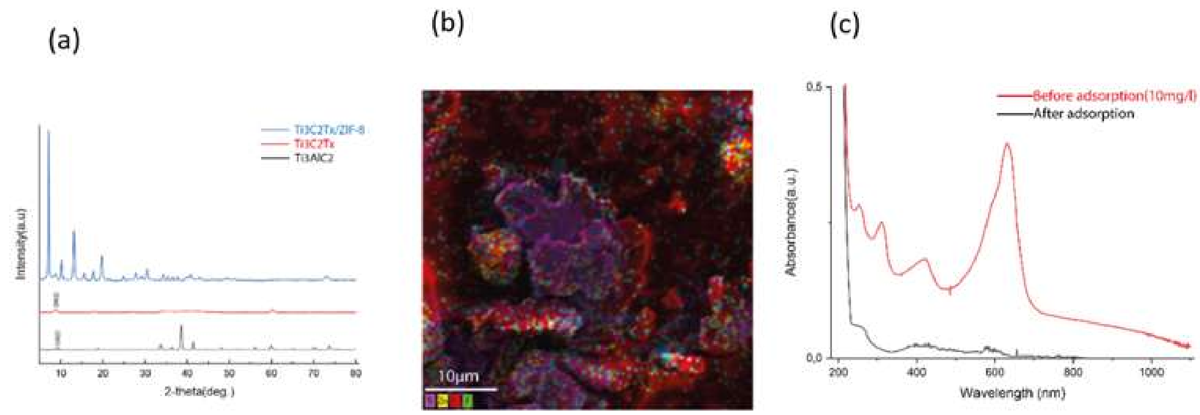

Figure 1. Material characterization: a) XRD pattern comparing MAX phase, $Ti_3C_2T_x$ and $Ti_3C_2T_x$/ZIF-8; b) EDX map of $Ti_3C_2T_x$/ZIF-8, c) UV spectrum of MB solution after addition of adsorbent.

4. CONCLUSIONS

Thus, it can be concluded that there is at least a threefold increase in the adsorption capacity of MXene/ZIF-8 compared to pristine MOFs and MXenes. At the same time, hybrids showed excellent stability under low pressure, retaining adsorbed carbon dioxide for at least a week. Additionally, hybrids have showed greater adsorption of cationic azo dyes in the water solution. This study demonstrates the potential for environmental application of MXene/MOFs hybrids as effective and simple adsorbents for CO2 gas and azo dyes. Research has shown, synergistic effect between conductive and hydrophilic MXene and MOFs with large specific area, opening up new opportunities for the development of highly specific and highly effective carbon dioxide adsorbents with the possibility of its storage, as well as in the form of a new generation of water purification methods.

SIMULATION-BASED STUDY OF NATURAL GAS TO HYDROCARBON LIQUIDS (GTL) PROCESS USING FISCHER-TROPSCH SYNTHESIS: A CASE STUDY OF NEEM FIELD IN WESTERN SUDAN

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ABSTRACT
This study presents an investigation of the natural gas to hydrocarbon liquids (GTL) process using Fischer-Tropsch synthesis, with a particular focus on the Neem field in western Sudan as a case study. The process involves an auto-thermal reforming reactor (ATR) for syngas production and a multi-tubular fixed bed reactor (MTFB) for the conversion of synthesis gas to long-chained hydrocarbons. Aspen HYSYS software was utilized to simulate the process, with Peng-Robinson (Equation of States) fluid package selected for oil and gas in the Simulation Basis and Reference Guide, and Acid Gas basis for natural gas treatment and sour gas sweetening. The GTL base case was modelled under steady-state conditions, with the feed composition matching that of the Neem field. Various scenarios were optimized using different molar flow rates of oxygen and steam, and different reactor volumes. The findings of this study demonstrate the feasibility of using Fischer-Tropsch synthesis for the conversion of natural gas to hydrocarbon liquids, with the Neem field serving as a viable case study. The simulations show that the use of ATR and MTFB reactors, along with optimization of molar flow rates of oxygen and steam, and reactor volumes can significantly enhance the efficiency of the GTL process. The research provides valuable insights into the design and optimization of GTL processes, which can contribute to the sustainable production of hydrocarbon liquids from natural gas.
Keywords: Natural gas to hydrocarbon liquids (GTL) process, Fischer-Tropsch synthesis, Optimization of GTL process.

1. INTRODUCTION
Energy plays a pivotal role in facilitating societal welfare and economic development. However, the environmental impact of energy-related activities necessitates the provision of an energy system that meets economic needs while mitigating harm to the environment. Oil, as a finite resource, will eventually be depleted, and there is ongoing debate and projection based on consumption rates regarding the timing of this depletion. The International Energy Agency (IEA) projects the earliest peak oil consumption to occur by 2035, while other studies suggest the peak may have already passed or will happen sooner. As energy demand continues to rise and the most crucial energy source diminishes, the need for alternative fuels becomes evident, particularly in the transportation sector where oil is a primary feedstock (Strielkowski et al., 2021).
Natural gas, the second-largest energy source for power generation, currently accounts for 22% of global electricity generation and is expected to play an increasingly important role in primary energy consumption. Despite certain challenges related to its volume, natural gas offers several advantages over other fossil fuels. It burns cleaner, emits fewer pollutants, and has a higher heat of combustion relative to the amount of CO_2 formed. Compared to coal, natural gas produces 45% less CO_2 for an equivalent amount of energy and significantly lower amounts of NO_x and SO_x emissions (UNECE, 2019).
While natural gas reserves are abundant worldwide, transportation and storage present logistical challenges. Gas-to-Liquids (GTL) conversion has emerged as a solution to these challenges by transforming natural gas into a liquid form that is easier to transport and store. This process enables the production of high-quality liquid fuels and other valuable products, thereby offering new possibilities for utilizing stranded or remote natural gas reserves. GTL conversion provides numerous advantages. Firstly, the resulting liquid fuels, such as diesel or synthetic crude oil, exhibit properties similar to their petroleum-based counterparts, allowing seamless integration into existing infrastructure and engines without significant modifications. Secondly, GTL conversion offers environmental benefits, as the produced liquid fuels have lower sulfur content and reduced emissions compared to conventional fuels, leading to improved air quality and reduced greenhouse gas emissions. Furthermore, GTL conversion offers flexibility in utilizing natural gas resources that would otherwise remain untapped or underutilized, allowing for the monetization of stranded gas reserves and extending the lifespan of mature natural gas fields (Behroozsarand & Zamaniyan, 2016).
To maximize the value and utilization of natural gas resources, various processing techniques can be employed, including gas treatment, natural gas liquids (NGL) recovery, liquefied natural gas (LNG) production, compressed natural gas (CNG), and GTL conversion. Each alternative offers distinct benefits and serves specific purposes in optimizing the utilization of natural gas resources. Fischer-Tropsch synthesis (FTS) is a crucial industrial process that converts syngas, a mixture of carbon monoxide and hydrogen, derived from natural gas or coal into hydrocarbons and oxygenates.

The GTL process utilizes Fischer-Tropsch technology, starting with the conversion of natural gas into syngas through a reforming step, followed by the conversion of syngas into long-chained hydrocarbons via the Fischer-Tropsch reaction. Finally, an upgrading unit cracks the long-chained hydrocarbons into products with the desired chain length (Shao et al., 2015).

In summary, the depletion of conventional oil reserves and the increasing energy demand necessitate the exploration of alternative fuels. Natural gas, with its versatility and abundance, offers a viable option. GTL conversion using Fischer-Tropsch synthesis provides a pathway to transform natural gas into high-quality liquid fuels and other valuable products, addressing logistical challenges and enhancing environmental performance. This study focuses on simulating the GTL process using the Neem field in western Sudan as a case study, utilizing Aspen HYSYS software to optimize various parameters. The findings of this research contribute to the design and optimization of GTL processes, facilitating the sustainable production of hydrocarbon liquids from natural gas.

2. PROCESS DESCRIPTION AND PROPOSED ARRANGEMENT FOR GTL TECHNOLOGY

The Gas-to-Liquids process involves three units: syngas generation, Fischer-Tropsch synthesis, and product upgrading.

2.1. SYNGAS GENERATION

In the syngas generation unit, natural gas is purified and converted into syngas using various equipment such as reactors, separators, and a fired heater. The pre-reformer reactor breaks the carbon-hydrogen bond, producing carbon monoxide (CO) and hydrogen (H2). The autothermal reforming (ATR) reactor converts methane into syngas through steam reforming, partial oxidation, and the shift reaction. Water and CO2 are removed from the syngas, and it is then heated before entering the Fischer-Tropsch reactor.

$$C_nH_m + nH_2O \rightarrow nCO + \left(\frac{n+m}{2}\right)H_2 \quad (1)$$

$$3H_2 + CO \rightarrow CH_4 + H_2O \quad (2)$$

$$CO + H_2O \rightarrow CO_2 + H_2 \quad (3)$$

2.2. FISCHER-TROPSCH SYNTHESIS

The Fischer-Tropsch synthesis unit converts the syngas into long-chain, heavy paraffinic liquid products. Iron-based or cobalt-based catalysts are commonly used, and different reactor types can be employed. The specific operating conditions depend on the desired product mix, catalyst type, and reactor design. The FT reaction generates heat and produces water as a byproduct. The resulting FT products are sulfur-free and have a composition that depends on the catalyst and operating conditions.

2.3.Product Upgrading

The product upgrading unit refines the hydrocarbon products obtained from the FT reactor. Light hydrocarbons, olefins, liquid hydrocarbons, and waxy paraffinic molecules undergo further processing to produce naphtha, kerosene, diesel, and specialty products like solvents, wax, and lube oils.

A GTL plant also includes a utility plant, offsites, and infrastructure. It requires significant energy consumption and power generation. The integration of multiple technologies is necessary, including gas processing, syngas generation, catalytic reactors, refining, power generation, and effluent treatment.

3. RESULTS AND DISCUSSION

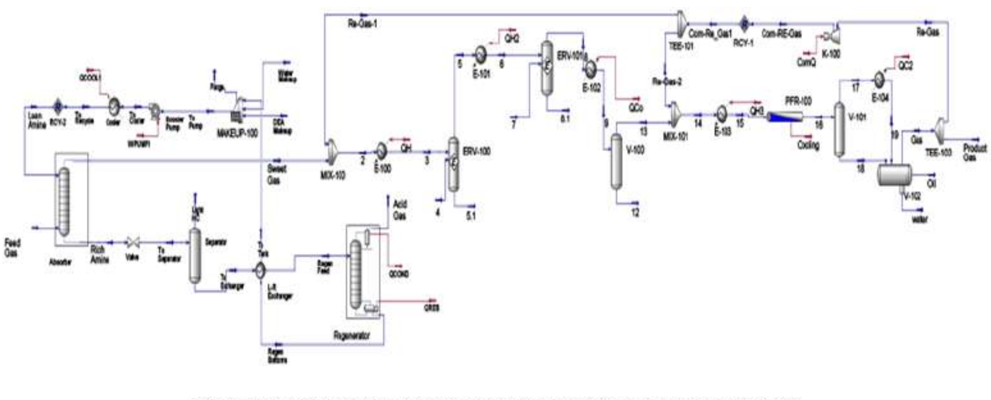

Fig. 1: Schematic of GTL process in Aspen HYSYS software environment.

The schematic of the GTL process in Aspen HYSYS (Fig. 1) offers a comprehensive overview of the interconnected units and their respective functionalities. To complement the schematic representation, we provide a detailed stream table that outlines the most important features and composition of the modelled base case (Table 1.). This stream table encompasses key parameters such as flow rates, temperatures, pressures, and composition for the relevant streams involved in the GTL process. Analysing the stream table allows for a comprehensive understanding of process performance, efficiency, and product composition, enabling informed assessments and comparisons.

Table 1. The Photocatalytic H2 evolutions and the apparent quantum yields.

Stream	T [°C]	Pressure [kPa]	Molar flow [kgmol/h]								
			Total Kgmol/h	Pure	CO	H_2	Light ends	LPG	Gasoline	Diesel	Wax
1	73.18	3535	1899	-	-	-	1178.90	188.38	54.12	-	-
2	67.03	3301	2546	-	84.78	78.42	1226.41	196.04	58.30	-	-
4	252	4045	3885	H_2O	-	-	-	-	-	-	-
5	404.1	3301	6696	-	0.67	18.08	2165.45	-	0.13	-	-
7	200	3000	2635	O_2	-	-	-	-	-	-	-
8	939.7	3000	10830	-	2007.88	3883.64	99.64	-	-	-	-
13	25	3000	7290	-	2.01	3882.65	99.87	-	0.73	-	-
15	300	3101	7937	-	2091.40	3960.56	147.63	7.14	4.76	-	-
16	210	3101	4439	-	344.02	291.2	177.12	33.74	64.81	35.51	20.86
17	210	3101	4394	-	344.05	290.88	177.07	33.39	62.39	18.89	-
18	210	3101	45.61	-	0.23	0.15	0.21	0.15	2.44	16.37	1.31
Water	44.6	3101	269.9	H_2O	-	-	-	-	-	-	-
OIL	44.75	3101	139.8	-	1.23	0.47	1.69	4.08	47.68	34.94	20.97
Product gas	44.75	3101	1270	-	171.15	145.29	87.76	14.86	8.38	-	-

From fig 2. (a, b) the case studies conducted on the GTL process revealed that the oil production decreases linearly after reaching an oxygen flow of 25 MMSCFD. Therefore, it is recommended to limit the molar flow of oxygen to this value for optimal operation. Additionally, investigating the effects of oxygen addition on the H2/CO ratio highlighted the need to maintain the molar flow of oxygen below 25 MMSCFD to ensure a desirable outlet stream with a ratio above 2. Adhering to this restriction preserves the desired composition and performance of the GTL process. Careful control and optimization of the molar flow of oxygen are crucial for maximizing product yields and achieving optimal operation. From fig 2. (c, d) the optimization of steam in the GTL process was examined, revealing that increasing the molar flow rate of steam led to a rise in the molar flow of oil up to around 90 MMSCFD. However, beyond this point, there was a decrease in liquid product. To maintain optimal operation, the molar flow of steam should not exceed 90 MMSCFD. Furthermore, the addition of steam affected the H2/CO ratio, with an increase in H2 and a decrease in CO. To maintain a desirable ratio above 2 in the outlet stream, it is recommended to ensure the molar flow of steam exceeds 80 MMSCFD.

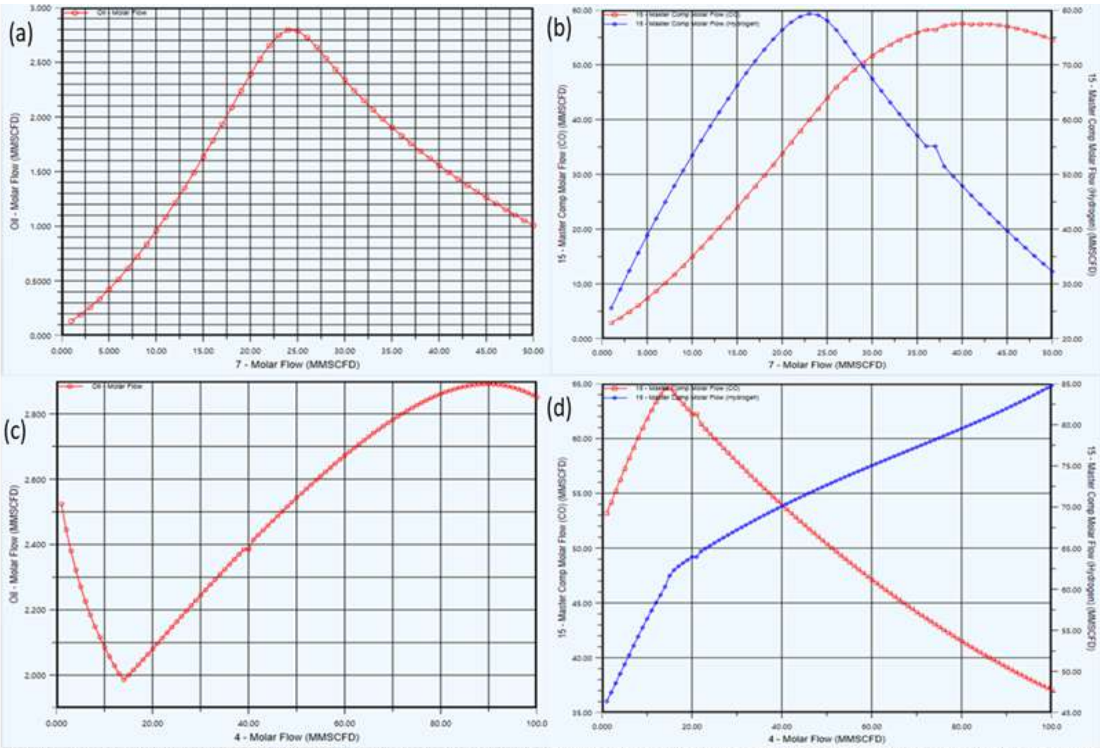

Fig. 2: (a) Molar flow of product to upgrading as a function of molar flow of oxygen in the range 1-50 MMSCFD, added to the ATR, (b) H_2 and CO as function of molar flow of oxygen, (c) Molar flow of product to upgrading as a function of molar flow of oxygen in the range 1-100 MMSCFD, (d) H_2 and CO as function of molar flow of steam.

4. CONCLUSIONS

In conclusion, this study focused on investigating the natural gas to hydrocarbon liquids (GTL) process using Fischer-Tropsch synthesis, with a specific emphasis on the Neem field in western Sudan as a case study. Through the utilization of Aspen HYSYS software and rigorous simulations, the feasibility of converting natural gas to hydrocarbon liquids was demonstrated. The optimization of molar flow rates of oxygen and steam, as well as reactor volumes, revealed significant enhancements in the efficiency of the GTL process. The findings underscore the importance of careful control and optimization of the molar flow of oxygen to not exceed 25 MMSCFD, ensuring desirable oil production and a H2/CO ratio above 2 in the outlet stream. Similarly, the molar flow of steam should not exceed 90 MMSCFD to maintain optimal operation, while surpassing 80 MMSCFD is recommended to maintain the desired H2/CO ratio. These insights contribute to the design and optimization of GTL processes, facilitating the sustainable production of hydrocarbon liquids from natural gas, with implications for the development of the Neem field and other similar gas resources.

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THE EFFECT OF GENERATIVE AI ON THE DIGITIZATION OF THE ENERGY SECTOR

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ABSTRACT
Artificial Intelligence (AI) technologies are rapidly changing and finding their place in different sectors worldwide, leading to exciting new areas of study and practical use. This paper dives into an in-depth study of Generative AI - a specific type of AI technology - and its influential role in the ongoing digital transformation of the energy sector. At the core of our investigation is Generative AI's unique ability to build detailed simulations of energy systems and foresee their behaviour under different conditions. By harnessing these capabilities, this technology offers a wealth of opportunities for boosting operational efficiency, strengthening risk management tactics, and enriching strategic planning in the energy sector.

Our study carefully examines these abilities and their implications through a close look at relevant real-life cases. We analyze scenarios such as incorporating renewable energy sources into existing power grids and the reactions of these grids to intense weather conditions. These examples serve to showcase the benefits of Generative AI in the energy sector. However, despite the immense potential of Generative AI, deploying this technology is not without its challenges. These hurdles include concerns over data security, the necessity for large quantities of high-quality data for training AI models, and the complexities involved in blending AI with existing energy infrastructure.

This paper explores these challenges in detail, providing insights into possible strategies to overcome them. As we look to the future, the paper ponders on the potential paths of Generative AI within the energy sector, emphasizing its increasing importance as digital transformation continues to gain momentum. In this way, our study offers a thorough examination of the potential of Generative AI in reshaping the energy sector, adding to the current academic conversation and paving the way for further research.
Keywords: Generative Artificial Intelligence (AI), Energy Sector Digitization, Complex System Simulations
Predictive Analysis, Implementation Challenges

1. INTRODUCTION
The energy sector, a critical pillar of modern infrastructure and economic development, is currently undergoing a significant transformation propelled by digital technologies (Brock et al., 2019). From generation to transmission and distribution, every segment of the energy value chain is witnessing unprecedented innovation, efficiency, and sustainability (Russell & Norvig, 2016). The driving force behind this transition is the incorporation of sophisticated technologies, one of which is Generative AI. A subset of machine learning, Generative AI has been gaining traction for its potential to revolutionize industry practices and contribute to the digital metamorphosis of the energy sector.

Generative AI uses algorithms to generate new data instances that resemble the input data. Its applications span various domains, from creating realistic images, enhancing cybersecurity, to predicting complex system behaviors (Goodfellow et al., 2014). In the energy sector, these capabilities could be harnessed for optimizing operations, developing strategic foresight, and managing risks. For example, Generative AI can construct intricate simulations of energy systems, enabling operators to test different scenarios and understand how the grid would react to them (Deng, 2014).

The inherent complexity and interdependency of modern energy systems necessitate such advanced modeling and prediction tools. Generative AI's ability to predict an entire power grid's behavior based on historical data and current conditions can empower energy companies to anticipate and mitigate potential challenges (Russell & Norvig, 2016). From predicting performance under standard conditions to understanding system responses to disruptions, Generative AI is poised to deliver significant value in managing and planning energy systems.

This paper aims to investigate the role and potential of Generative AI within the digital transformation of the energy sector. Through examining current applications, exploring challenges, and envisioning future developments, this paper seeks to provide a comprehensive understanding of the intersection of Generative AI and the energy sector's digitization process.

2. METHODOLOGICAL FRAMEWORK

The methodology of this research is qualitative in nature, primarily relying on the synthesis of existing knowledge through academic literature, industry reports, case studies, and expert opinions. This approach is frequently adopted in studies seeking to understand complex phenomena, such as the application of Generative AI in the energy sector, where empirical data may be sparse or proprietary (Denzin & Lincoln, 2011). Through a comprehensive review of the literature, we seek to consolidate the current understanding of the subject, pinpointing both the potential and the challenges inherent in this technology's application in the energy sector.

Our primary focus revolves around the predictive and simulation capabilities of Generative AI. We pay special attention to the application of these abilities in the energy industry's scenario analysis and planning process. Scenario analysis using Generative AI offers decision-makers a platform to observe system reactions under different conditions, a tool that could prove invaluable in strategic planning and risk management (Brock et al., 2019).

To illustrate the practical implications of Generative AI, two case scenarios are employed. The first scenario examines the integration of a new solar farm into the power grid, a common challenge in the industry as renewable energy sources become more prevalent (Russell & Norvig, 2016). The second scenario explores the grid's response to a severe weather event, a situation that has gained relevance in light of increasing climate change-related natural disasters (Goodfellow et al., 2014).

These case scenarios serve as practical lenses through which the capabilities of Generative AI can be observed and analyzed. By employing real-world scenarios, this research seeks to move beyond theoretical analysis and provide practical insights into the potential of Generative AI in the energy sector.

3. RESULTS AND DISCUSSION

The application of Generative AI in the energy sector has yielded promising results, particularly in predictive analysis. Utilizing historical performance data and considering current operational conditions, Generative AI offers a robust framework for forecasting power grid behaviors (Goodfellow et al., 2014). These predictions range from regular operational performance under typical conditions to system responses to extraordinary events, thereby enhancing operational foresight and informing risk management strategies.

Take the example of grid stability during severe weather conditions. As climate change exacerbates the frequency and intensity of such events, the ability to predict grid instability is of paramount importance. Generative AI, with its adept predictive capabilities, can analyze weather data and anticipate potential disruptions to grid performance. Such predictions can facilitate timely preventive actions and efficient contingency planning, ultimately minimizing disruption to energy services (Brock et al., 2019).

Simultaneously, Generative AI's simulation capabilities provide invaluable assistance in comprehensive scenario analysis. Detailed energy system simulations can help operators understand the potential impacts of different operational decisions. For instance, consider the integration of a new solar farm into the power grid - a pertinent issue given the ongoing shift towards renewable energy sources.

By simulating this integration process, Generative AI can predict how the addition of the solar farm would impact overall grid performance. It can anticipate fluctuations in power generation, potential grid instabilities, and the implications of integrating intermittent power sources. These insights can inform strategic planning, decision-making, and resource allocation, thereby optimizing grid performance while minimizing potential disruptions (Russell & Norvig, 2016).

Despite the numerous benefits, the implementation of Generative AI in the energy sector presents unique challenges. Key among these is data security. Given the sensitive nature of energy data, protecting this information while harnessing its value for AI training is a delicate balancing act (Deng, 2014).

Furthermore, Generative AI systems necessitate extensive, high-quality data for effective model training. The collection, management, and analysis of such data require significant resources, and pose challenges related to data privacy, storage, and processing capabilities.

Lastly, the complexity of integrating AI systems with existing energy infrastructure cannot be overlooked. Operators must navigate technical hurdles, regulatory frameworks, and potential resistance from traditional industry players. Effective integration also demands a thorough understanding of both AI technology and energy system operations - a requirement that underscores the need for interdisciplinary collaboration and expertise (Denzin & Lincoln, 2011).

In conclusion, while Generative AI holds immense potential for digitizing the energy sector, its successful implementation hinges on addressing these challenges. With the right strategies and resources, Generative AI could drive significant advancements in the energy industry, revolutionizing how we manage and interact with energy systems.

4. CONCLUSION

The findings of this study underscore the transformative potential of Generative AI in the ongoing digitization of the energy sector. With its capacity to build complex simulations of energy systems, Generative AI promises to bring about significant changes in how we manage and interact with power grids. The technology's predictive analysis capability, bolstered by the integration of large amounts of data, can result in considerable improvements in operational efficiency, risk management, and strategic planning.

However, the implementation of Generative AI is not without challenges. Data security, the complexity of integrating AI with existing systems, and the need for extensive, high-quality data for model training are among the significant hurdles to be addressed. To navigate these challenges effectively, stakeholders need to foster interdisciplinary collaboration and develop robust strategies. Additionally, regular reviews of privacy policies, continual monitoring of AI systems, and building scalable and secure data infrastructure should form part of these strategies.

Given the ongoing shift towards renewable energy sources and the increasing demand for reliable, resilient, and efficient energy systems, the role of Generative AI in the energy sector will undoubtedly become increasingly central. Its ability to simulate potential scenarios, predict system behavior, and aid in strategic decision-making can have far-reaching impacts on grid stability, system efficiency, and the overall advancement of the energy industry.

In conclusion, while the implementation of Generative AI in the energy sector presents unique challenges, its potential benefits are substantial. Careful and informed navigation of these challenges is critical to fully realize this potential. As the energy sector continues to digitize, it is essential to keep exploring and harnessing the capabilities of Generative AI. By doing so, we could witness significant advancements in energy systems management, paving the way for a more sustainable and resilient energy future.

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PHOTOCATALYTIC REDUCTION OF CARBON DIOXIDE INTO METHANOL OVER COPPER BASED METAL ORGANIC FRAMEWORK

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ABSTRACT
The increase in carbon dioxide (CO2) gas in the atmosphere caused by the rapidly increasing population, industrialization and burning of fossil fuels is a major problem threatening ecosystems. CO2 gas, one of the main sources of greenhouse gases, causes global warming and climate change. Therefore, the level of CO2 at atmosphere should be reduced immediately. Adsorption, absorption, soil retention, cryogenic methods and converting to valuable chemicals are several methods for CO2 reduction. Photocatalytic reduction of CO2 into methanol is one of the best technique both environmental and chemical point of view.

In this study, photocatalytic reduction of CO2 into methanol over copper metal-organic framework (Cu-MOF) based photocatalysts was investigated. It is aimed to both reduce the amount of CO2 and convert it into valuable products. For this purpose, titanium dioxide doped copper based MOF was synthesized and used for photocatalytic reduction. As a result, at ambient conditions, 986.3 µmol/g cat methanol was obtained. Compared to the literature, higher methanol content was achieved.
Keywords: Photocatalytic reduction of carbondioxide, metal organic frameworks,

1. INTRODUCTION
Carbon dioxide is one of the most important greenhouse gases that cause global warming and climate change. Due to its increasing concentration day by day, it affects both the health of living things and the environment negatively. Therefore, it is necessary to reduce the rate of carbon dioxide in the atmosphere.

In order to reduce the increasing amount of CO2, converting CO2 into high value-added fuels and chemicals is a viable method in terms of renewability and sustainability. Methanol (MeOH) is one of the products that can be obtained from CO2 reduction. It is an important raw material and alternative energy source for the chemical, petrochemical, pharmaceutical and polymer industries. It is a primary raw material source for many organic compounds and an important intermediate for various chemicals such as paints, silicones and plastics.

Many methods have been developed to convert carbon dioxide, such as chemical, electrochemical, biochemical and catalytic methods. With metals, CO2 can be reduced chemically at extremely high temperatures.

Photochemical reduction is a method to product valuable chemicals from CO2.The amount of product obtained vary according to the properties of catalyst and wavelength. Electrochemical, chemical and biological methods require high temperature and high energy input while the photocatalysis method does not require. However, product selectivity and photocatalytic activity can be low. These problems can be solved by two ways: developing new photocatalysts and designing the photoreactor (Yaashikaa et al., 2019). Pore modification, surface refinement, and band gap improvement are a few techniques used to develop photocatalysts (Yaashikaa et al., 2019).

The main purpose of this study is to reduce CO2 to methanol photocatalytically by developing a MOF-based photocatalyst. In recent years, a new class of crystalline porous materials, metal-organic frameworks (MOFs), has emerged. MOFs are formed by the bonding of metal ions and organic ligand groups. Researches are carried out in many application areas such as gas storage, separation, catalysis and drug release with MOFs (Güçlü, 2020). The main features of MOF-based materials are high porosity, high surface area, tunable structure and multiple active sites (Idris et al., 2022). Synthesizing MOFs can be designed depending on the metal ions and organic ligands come together in their structures. Thus, the structures and properties of MOFs can be adjusted during synthesis. Various studies have been conducted on the reduction of CO2 with MOFs. Some important information about MOF photocatalysts have been obtained from the studies. Combining broad light-absorption ligands for MOFs is very important for their development as photocatalysts. In particular, ligands with NH2- group, porphyrin/metal-pophyrin and metal complex shift MOFs to the visible light region and are widely used in the production of MOF photocatalysts (Li and Zhu, 2020).

In this study, it is aimed to synthesize Titania doped copper (Cu)-based MOF (BDC-NH2) as a photocatalyst. In addition, literature studies; It has been confirmed that TiO2 is a photocatalyst used in the photocatalysis reduction method but needs to be developed. However, literature studies have also shown that MOF can be used to improve TiO2. Accarding to the authors knowledge, this MOF type is synthesized for the first time. The reason for choosing the MOF based on copper is that copper increases the methanol conversion in the literature. Therefore, it is aimed to reduce CO2 under light and increase the conversion efficiency to methanol.

2. MATERIAL AND METHODS

MOF preparation

0.7 g titanium dioxide (TiO2), 1.644 g aminoterephthalic acid (BDC-NH2) and 0.724 g Copper (II) nitrate trihydrate, N,N-dimethylformamide (DMF) and methanol (36/4) in 40 ml of mixed solvent for 30 minutes dissolved under magnetic stirrer. Then, the solution was taken to a hydrothermal reactor and heated at 150 C for 72 hours. The solid product was then filtered. Washing was done three times with DMF and methanol. Finally, the obtained powder was dried in an oven at 80 C for 12 hours.

Reduction of Carbon Dioxide to Methanol

Photocatalytic reduction of CO2 to methanol was carried out in a photoractor system. 400 W UV light was used as the light source. The process was carried out in a closed-system quartz reactor placed in a circulating cold water bath equipping. 0.05 g of photocatalyst was added to 50 ml of distilled water. Pure CO2 was bubbled in the reactor for at least five minutes to saturate the solution before the light was turned on under magnetic stirring. Magnetic stirring and CO2 flow continued continuously after the light was turned on. The CO2 flow rate is about 100 ml/min and the illumination time is three hours. In addition, circulating water cooling has been used to keep the reactor at room temperature while photocatalytic reduction of CO2 takes place. Schematic representation of the reactor is given in Figure 1. The amount of methanol was determined by using GC-MS equipment.

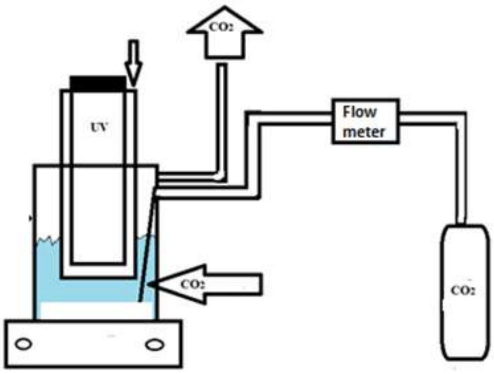

Figure 1. Reaction Set-up

3. RESULTS AND DISCUSSION

Figure 2 shows the XRD patterns of the photocatlyst with and without titania. XRD analysis of the synthesized catalyst is given in figure 2. Accordingly, the crystalline structure of the catalyst is seen. Since there is no similar catalyst in the literature, only the peaks related to Cu-BDC were compared and it was seen that they were identical.

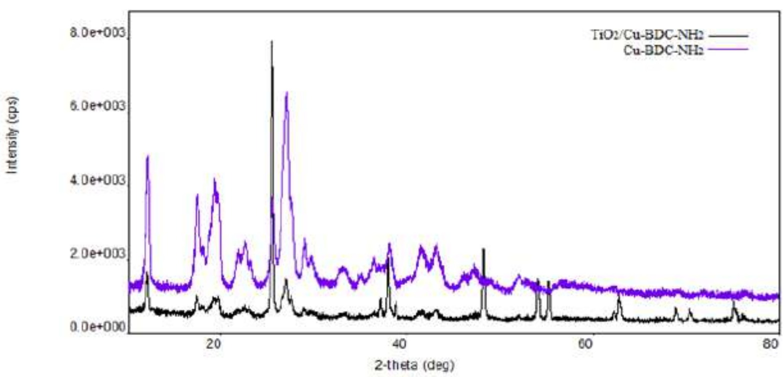

Figure 2. XRD pattern of photocatlysts.

The morphological structure of the TiO2/Cu-BDC-NH2 photocatalyst at 1 μm can be observed from the scanning electron microscope (SEM) image. According to the SEM images, the TiO2/Cu-BDC-NH2 photocatalyst has a layered structure with different geometric shapes. Geometric structures are mostly roughly quadrangular. However, as shown in Figure 2a, circular structures can be observed in between. The rounded structures are similar to the SEM image of TiO2. The SEM image of TiO2 in Figure 2b shows the spherical shape of TiO2.

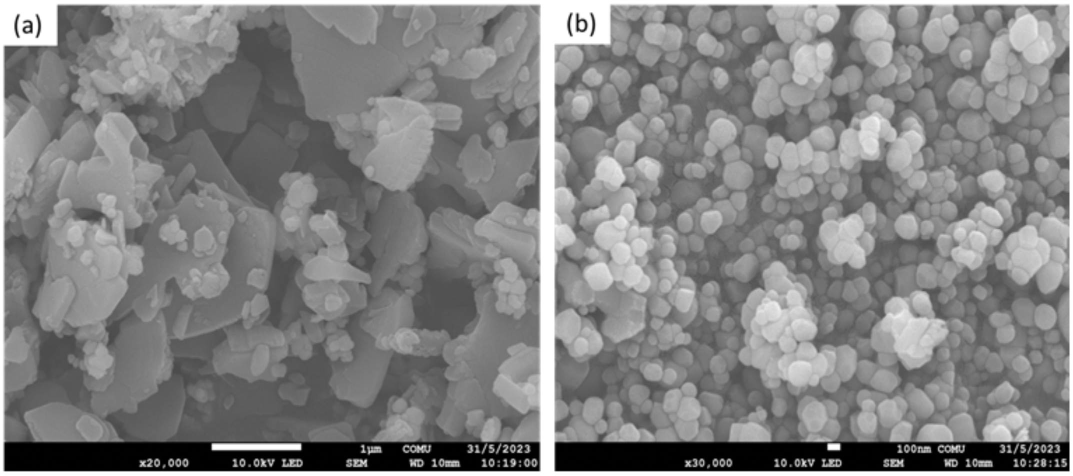

Figure 3. SEM analysis of TiO2/Cu-BDC-NH2 photocatalyst (a) and TiO_2 (b)

According to Brunauer-Emmet-Teller (BET) analysis results for TiO2/Cu-BDC photocatalyst, the surface area is 479.368 m2/g and the pore volume is 0.227 cm3/g.

As a result of the photocatalytic reduction using Cu-BDC photocatalyst, the presence of methanol was not observed. As a result of photocatalytic reduction using TiO2, it is 4.1 μmol/g cat. In the photocatalytic reduction results performed using the TiO2/Cu-BDC-NH2 photocatalyst synthesized for the first time in this study, 986.3 μmol/g cat was obtained when compared to other photocatalysts.

4. CONCLUSIONS

In this study, a new MOF based on copper and titanium was synthesized for the photocatalytic reduction of carbon dioxide. According to the characterization results of the material, it was observed that it was synthesized in microporous and crystalline structure. The crystalline structure and titanium distribution were also seen in SEM analysis. As a result of the photocatalytic reaction, while there was not much production in the MOF material without titanium added or the titanium without MOF added, the photocatalyst produced gave a very high methanol conversion result of 986.3 μmol/g cat.

Acknowledgement

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A study on global warming effect of Gas Turbine Power Generation Process

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ABSTRACT
In this study, global warming effects of the Daura/Rasheed gas turbine power plant in Iraq was investigated. In this regard, two system models for power generation were considered by taking the required assumptions into account, which are (i) a simple cycle gas turbine power generation in the first model and (ii) improved gas turbine cycle in the seconed model. It is noticed that the model 2 produces the best results based on the findings from the study of the indicators. When the models are compared it is, from the calculations, found out that the total waste exergy ratio decreases from 66.3% to 50.6%, the environment effect factor goes down from 1.967 to 1.09, the exergetic sustainability index increases from 0.508 to 0.918 and the global warming effect decreases from 610 to 444 kg CO2/MWh. As a result, it can be said that model 2 is an environmentally friendly, sustainable, and global warming effect (low emission) system that can serve as a valuable reference for the Daura/Rasheed gas power station in Iraq based on the findings of the analysis. Consequently, it can be stated that such a system might be used to improve environmental sustainability while lowering the effects of CO2 driven global warming.
Keywords: global warming effect, improved gas turbine cycle, energy, exergy.

1. INTRODUCTION
Increasing energy use and a heavy reliance on oil and other fossil fuels that pollute the air, water, and land have led to a persistent energy crisis around the world [1]. Increased pollution-related health concerns and high carbon dioxide emissions all contribute to climate change and global warming [2]. The most significant sources of carbon dioxide are thought to be power plants, both steam and gas turbine types. To address the energy shortage and lessen pollution, it has become essential to develop specific solutions and restrictions. To get around the shortage, some power producing methods and technologies can be applied [3]. One of the methods used to address this energy need is the usage of gas turbines. The efficiency of a current basic cycle gas turbine ranges from 35 to 45%, while that of a cooled, heated, and regenerated cycle gas turbine is around 50% [4].

2. MATERIAL AND METHODS
In order to compare the best performance of these models in terms of fuel consumption, electric power production, and CO2 production, improved model of power cycle based on a simple gas turbine cycle (Daura-Rasheed gas power station in Iraq) is designed and analyzed through the energy and exergy approaches in this study. These models are (i) a simple cycle gas turbine in the first model [5], (ii)The second model's improved gas turbine cycle has been developed by integrating the intercooler, reheat, and recuperator with the first model.

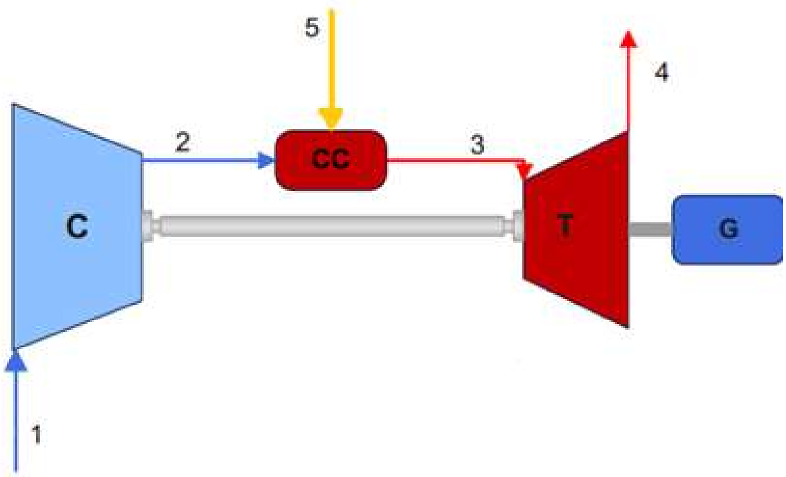

Fig.1. model 1 simple cycle gas turbine

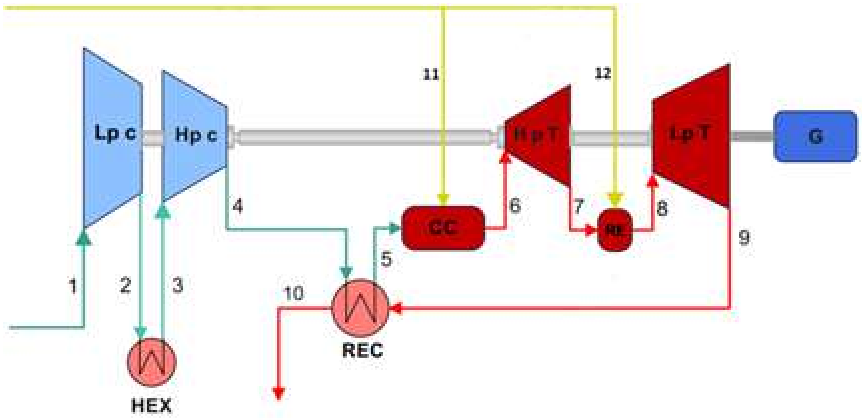

Fig.2. model 2 Improved cycle gas turbine.

2.1 general assumptions

The general assumptions for the analyses [6]:

•heat losses and pressure drop in all system components are negligible.

•All equipment is well insulated and hence is taken as adiabatic.

•Steady-state, steady-flow, and processes conditions exist.

•Potential and kinetic energy changes can be negligible.

•The air and combustion gas flows in the cycle are supposed to behave ideally.

•3 kg of CO2 is almost produced from the combustion of 1 kg of CH4 [7].

2.3 Thermodynamic analysis

Exergetic Sustainability and global warming effect equations.

A.Exergetic Sustainability indicators [6].

$waste\ exergy\ ratio (WER)$

$$(WER) = \frac{waste\ exergy\ output}{Total\ exergy\ input} \quad (1)$$

$Environmental\ effect\ ratio\ (EEF)$

$$(EEF) = \frac{Waste\ exergy\ ratio}{Exergetic\ efficiency} \quad (2)$$

$Exergetic\ sustainability\ index\ (ESI)$

$$(ESI) = \frac{Exergetic\ efficiency}{Waste\ exergy\ ratio} \quad (3)$$

B. Global Warming Effect (GWE) per power generation [8].

$$GWE = GWP_{CO_2} * \frac{\dot{m}_{CO_2}}{\dot{W}_{net}} * 3600 \quad (TonCO_2e/MWh) \quad (4)$$

3. RESULTS AND DISCUSSION

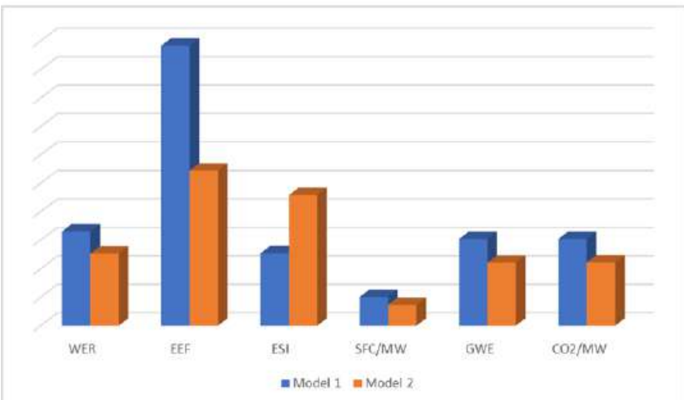

Fig.3. qualitative illustration of global warming effect and exergetic sustainability comparison between 2 models

4. CONCLUSIONS

The values for the global warming effect and CO2 production per power generation of model 2 were estimated to be 443 kg CO2/MW per year and 209 kTon CO2/year, respectively while the exergetic sustainability index was calculated to be 0.918. Accordingly, it is said that model 2 is more exergetically sustainable system and has less global warming effect than the model 1 in terms of CO2 production.

Acknowledgement

The authors would like to thank Yildiz Technical University and The State company Electricity Production Middle Region- Daura/Rasheed gas turbine power station for technical support.

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A study on global warming effect of Combined Cycle Power Generation Process

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ABSTRACT
In this paper, global warming effects of the Al-Musaib thermal power plant in Iraq was inspected. In this regard, two system models for power generation were taken into consideration while accounting for the necessary assumptions. The two models are (i) simple cycle steam turbine power generation in the first model and (ii) combined cycle power generation. According to the outcomes of the indicator study, model 2 produced the best results. As a result, the total waste exergy ratio decreased from 79.24% to 68.86%, the environment effect factor decreased from 3.824 to 2.216, the exergetic sustainability index increased from 0.262 to 0.451 and the global warming effect decreased from 0.804 gCO2e/kWh to 0.616 gCO2e/kWh. Based on the results of the analysis, it can be concluded that model 2 is an eco-friendly, long-lasting, and low-emission (global warming effect) system that can be a useful reference for the Al-Musaib thermal power station in Iraq. As a result, it can be said that a system like this may be employed to increase environmental sustainability while reducing the effects of CO2 driven global warming.
Keywords: global warming effect, combined cycle, energy, exergy.

1. INTRODUCTION
Energy consumption is a crucial factor in providing for fundamental human needs and raising the standard of living, making it one of the most closely studied indicators of a nation's capacity for both economic and social growth [1]. Climate change and global warming are caused by increased carbon dioxide emissions, health problems due to pollution, and other factors [2]. The rate of industrialization and population expansion have continued unabatedly, and as a result, the world's need for energy has been rising steadily. Because fossil fuels are so widely used, recent years have seen an increase in pressing issues including pollution and climate change. We require new, affordable energy sources that are trustworthy and sustainable to counteract these negative consequences and poverty [3]. Power suppliers nowadays must optimize production and embrace new operating modes for energy generation to meet economic and environmental demands. Conventional fossil fuel power plants have so far provided more than half of the world's electrical needs, although they are much less efficient than combined cycle generators. The CCPP technology incorporates two or more thermodynamic cycles to ensure a high level of efficiency (up to 60%) and to drastically minimize pollutant emissions [4]. Combined cycle power plants offer low operating and maintenance costs, high availability, minimal emissions, and reduced global warming impact [5].

2. MATERIAL AND METHODS
This study develops and analyzes an improved power cycle model based on a simple steam turbine cycle (Al-Musaib thermal power station in Iraq) in order to compare the best performance of these models in terms of fuel consumption, electric power production, and CO2 production. These models are (i) a simple cycle steam turbine in the first model, and (ii) a gas turbine added to the first model to create a combined cycle power generator in the second model.

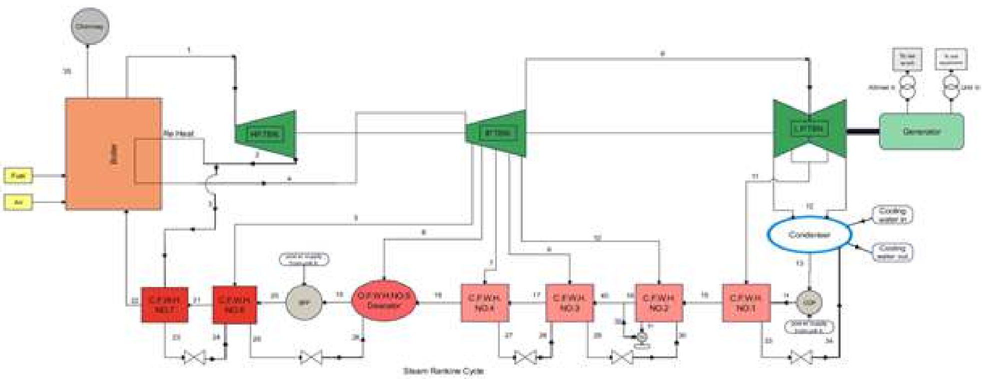

Fig.1. model 1 simple cycle steam turbine

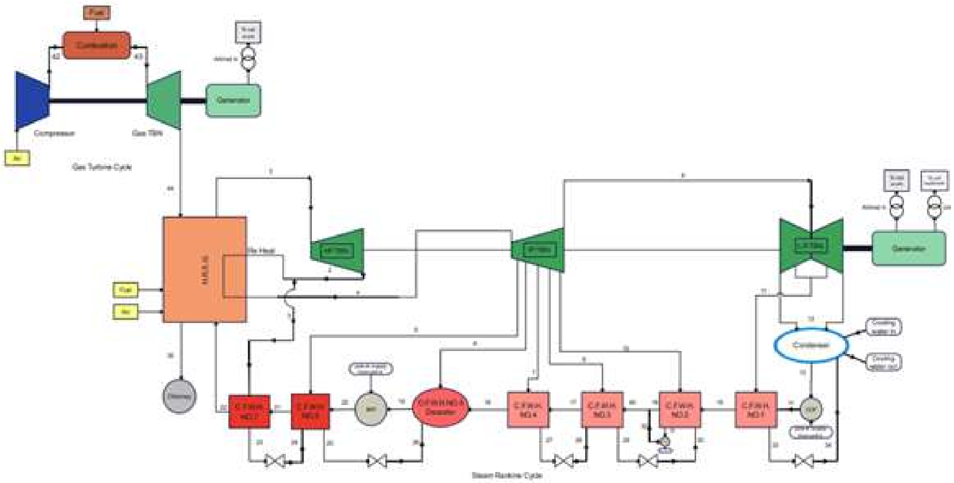

Fig.2. model 2 combined cycle power generation.

2.1 general assumptions

The general assumptions for the analyses [6]:
•heat losses and pressure drop in all system components are negligible.
•All equipment is well insulated and hence is taken as adiabatic.
•Steady-state, steady-flow, and processes conditions exist.
•Potential and kinetic energy changes can be negligible.
•The air and combustion gas flows in the cycle are supposed to behave ideally.
•3 kg of CO2 is almost produced from the combustion of 1 kg of CH4 [7].

2.3 Thermodynamic analysis

Exergetic Sustainability and global warming effect equations.
A.Exergetic Sustainability indicators [6].

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B. Global Warming Effect (GWE) per power generation [8].

$$\mathrm{GWE} = \mathrm{GWP}_{\mathrm{CO_2}} * \frac{\dot{m}_{CO_2}}{\dot{W}_{net}} * 3600 \quad (\mathrm{TonCO_2e/MWh}) \quad (4)$$

3. RESULTS AND DISCUSSION

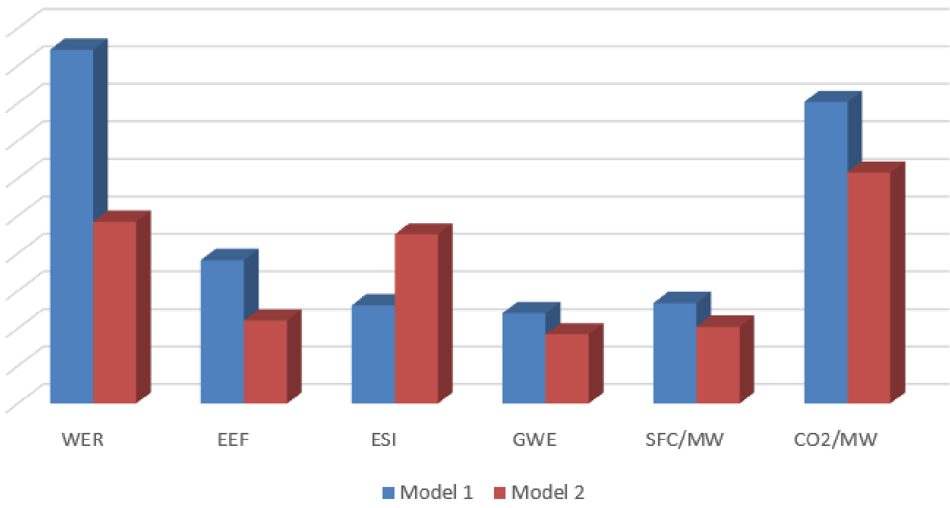

Fig.3. Qualitative illustration of global warming effect and exergetic sustainability comparison between model 1 and 2

4. CONCLUSIONS

The values for the CO2 production per power generation and global warming effect have been figured to be 616 kg CO2/MW year and 4.002 Ton CO2e/year, respectively. This implies that Model 2's high energy and energy efficiency and usage of thermal energy of exhaust gases result in a lesser global warming effect than the basic model. Model 2 is more energy-efficient than the others, as shown in fig. 3, according to the parameter for its exergetic sustainability index, which was calculated to be 0.451.

Acknowledgement

The authors would like to thank Yildiz Technical University and The State company Electricity Production Middle Euphrates- Al-Musaib thermal power plant for technical support.

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A Comparative Study for CO and NOx Emission Forecasting Using Random Forest and Decision Tree Methods

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ABSTRACT
In this study, CO and NOx (NO + NO2) gas emission forecast of a gas turbine located in Turkey's north western region is done with machine learning techniques. These techniques are decision tree (DT) and random forest techniques (RF). At first, the best performed architecture in each technique is determined for CO and NOx emission forecasting. Then, the technique which gives the best solution is determined among these techniques. Results show that, Random Forest gives the best result among these techniques.
Keywords: Machine learning techniques, prediction, decision tree, random forest

1. INTRODUCTION
CO and NOx gases which is emitted into the atmosphere, effects the amount of greenhouse gases, which are related to climate change and global warming. These gases play a key role in pollution, climate change and global warming. Forecasting of these emissions will provide optimizing the amount of these gas emissions. Recently, with the fast development of computer science and artificial intelligence, machine-learning technologies started to be used for forecasting.

Random forest method has not received much attention in load forecasting although it is easy to choose its parameters. On the other hand, it can give results as good as optimized ANN and Support Vector Machine (SVM). There is a few load forecasting with random forest studies. For instance, Lahouar and Slama (2015) used regression random forests for load forecasting model of one day ahead with resolution of one hour. In this study there were 24 random forest predictors. Input parameters are, season, temperature, type of the day and hourly load. The results feature has low prediction error especially when training is repeated every day. Johannesen et al. (2019) used regression methods for electrical energy demand forecasting. The regression techniques used in this study are; Random Forest Regressor, k-Nearest Neighbour (kNN) Regressor and Linear Regressor. Random Forest Regressor provides better performance in short-term load forecasting (30 min) while kNN gives relatively better performance in long-term load forecasting (24 hour).

In this study CO and NOx (NO + NO2) gas emission forecast of a gas turbine located in Turkey's north western region is predicted by using random forest and decision tree techniques.

2. MATERIAL AND METHODS
2.1 Data Collection
In this study, data was taken from UCI Machine Learning Repository website. Data is collected in range (01.01.2011 - 31.12.2015), includes gas turbine parameters (such as Turbine Inlet Temperature and Compressor Discharge pressure) in addition to the ambient variables.

2.2 Training of Macine Learning Techniques
This section presents the training stage of the RF. In random forest architecture, there is a collection of randomized decision trees (Breiman 2001). Each decision tree in the forest is learned from a random subset of training examples and a random subset of features. The outputs from each decision tree are averaged to determine the overall output. Each tree is traversed until reaching a leaf node (Ellis et al., 2014).

The training process of RF algorithm will be conducted based on following order:
●Setting a predefined variables for RF and DT training,
●Identifying the number of estimators among table 1 for RF.
●Identifying maximum depth using the best number of estimators among Table 2 and Table 5.
●Identifying the best maximum features among Table 3 and Table 7.
●Identifying the minimum samples leaf among Table 4 and Table 8.
Number of estimator is the number of trees built. Higher number of trees provides better performance but makes the RF code slower.

3. RESULTS AND DISCUSSION

3.1 Parameter Tuning in Random Forest and Decision Tree

●Number of Trees

This parameter belongs to only random forest technique. The higher number of trees provide the more accuracy. But sometimes higher number of trees causes overfitting. It is clearly seen in Table 1 that overfitting starts when trees are higher than 10000 trees.

●Number of Features

Table 2 and Table 5 shows the effect of number of features on MSE. Auto, places no restrictions on the number of features; sqrt, square root of the total number of features; log2, base two logarithm of the total number of features.

●Maximum Depth of Each Tree

Maximum depth means the depth of each tree in the forest. The deeper the tree, the more splits it has and it provides more information about the data. Table 6 shows the effect of maximum depth on MSE. It is clearly seen in Table 6 that after 100 depth of each tree, overfitting has start and MSE is getting higher.

●Minimum Samples at a Leaf Node

Increasing minimum samples at a leaf node leads to decrease variance and increase bias. Table 5 and Table 8 shows the effect of minimum samples at a leaf node on MSE.

3.2 Results of Random Forest Technique

Table.1 Effect of the change of number of tree of random forest

Number of Trees	Mean Squared Error (MSE)
1000	0.0039
5000	0.0034
10000	**0.00253**

Table.2 Effect of the change of number of features of random forest

Number of Features	Mean Squared Error (MSE)
auto	0.00261
log2	0.00257
sqrt	**0.00253**

Table.3 Effect of the change of maximum depth of random forest

Maximum Depth	Mean Squared Error (MSE)
5	0.0032
100	**0.00253**
1000	0.00292

Table.4 Effect of the change of minimum samples of a leaf node of random forest

Minimum Samples at a Leaf Node	Mean Squared Error (MSE)
1	**0.00253**
2	0.00271
3	0.003

3.3 Results of Decision Tree Technique

Table.5 Effect of the change of number of features of decision tree

Number of Features	Mean Squared Error (MSE)
auto	0.0059
log2	0.0052
sqrt	**0.0039**

Table.6 Effect of the change of maximum depth of decision tree

Maximum Depth	Mean Squared Error (MSE)
5	0.0048
100	**0.0039**
1000	**0.0039**

Table.7 Effect of the change of minimum samples of a leaf nodes of decision tree

Minimum Samples at a Leaf Node	Mean Squared Error (MSE)
1	**0.0039**
2	0.0044
3	0.005

Fig. Decision tree technique prediction results

4. CONCLUSIONS

Random forest gives the best results in predicting this gas emission data in comparison with decision tree. But selecting best parameters and creating an architecture which gives best solution is also important. Because random forest gives better results when it has best parameters like number of estimation or maximum leaf nodes.
In further studies, relationship between type of the data and the machine learning techniques will be studied on.

NOMENCLATURE

RF Random Forest
DC Decision Tree

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SYSTEM DESIGN FOR GREEN POWER GENERATION WITH PIEZOELECTRIC MATERIALS

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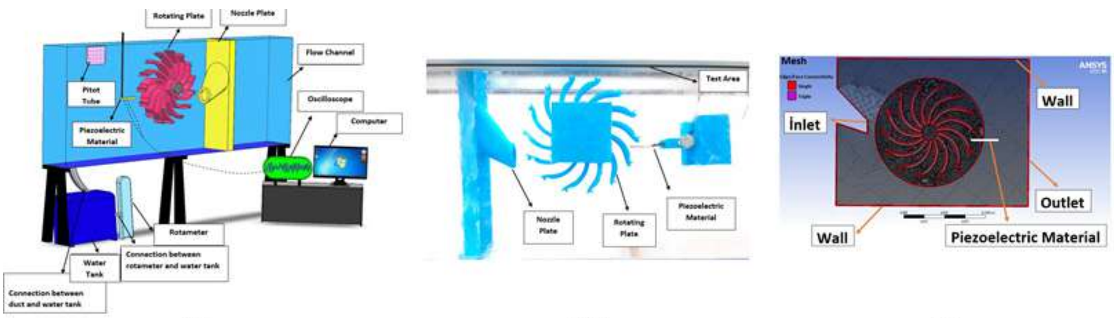
ABSTRACT
In this study; piezoelectric material is used to generate electrical energy within the scope of hydraulic energy, one of the renewable energy sources. In order to increase the electricity generation efficiency of the piezoelectric material used for energy conversion, turbulence intensity was tried to be increased in the existing closed system flow channel and vortex generating plates were designed. In order to establish the boundary conditions, experimental studies were carried out with the first vortex generator plates and then the data obtained with the numerical studies were compared. The number of blades and blade angle of the designed plate were modeled and numerical studies were carried out in ANSYS Fluent program to find the optimum values of the parameters considered. In addition, the optimum distances between the plates, nozzle plate and rotating plate were tried to be found experimentally. The final values obtained as a result of numerical and experimental studies were recorded as 0.019 TKE, 0.28 Volt. Considering the measured results, it was seen that approximately 1.6 times more efficiency TKE and 2.3 times more Volt were obtained than the previous studies.
Keywords: Energy conversion, Vortex generator, Piezoelectric material, Renewable energy.

1. INTRODUCTION
In the developing world, the need for energy is constantly increasing and the tendency towards alternative energy sources to meet this increasing energy need is increasing day by day. With the information age, energy-related developments in technology are progressing in a positive direction (Gross vd, 2003). Progress in technological developments positively affects access to renewable energy sources (Yayla vd, 2020). In addition, clean and renewable energy sources are recognized as the key to life for the future of our world. When the potential of renewable energy sources such as wind, solar, hydraulic (hydroelectric) and hydrogen is examined, it is seen that they are sufficient to meet the required energy demand. In order to generate electrical energy from hydraulic energy, which is a renewable energy source, vortex-based electrical energy generation methods are used. In recent years, the use of piezoelectric materials as generator materials in alternative methods used for electrical energy generation has become widespread. In this study, a series of experimental and numerical studies were carried out within the scope of piezoelectric energy harvesting method (PEH) in order to obtain electrical energy from hydraulic energy, which is a renewable energy source. In the related study, firstly, different plates were designed to increase the vibration on the piezoelectric material. The designed plates were studied numerically and experimentally and optimum values were selected.



(a) (b) (c)
Fig. 1. (a) Schematic illustration and (b) Test area (c) Mesh structure applied in CFD software.

2. SYSTEM DESCRIPTION AND ANALYSIS

The schematic representation of the designed system and the test area are given in Figures 1(a) and 1(b). As shown in Figure 1, piezoelectric materials are used to generate electrical energy and generator plates are used to generate vortices in a recirculating closed system flow channel. ANSSY Fluent program was used for numerical studies and Oscilloscope was used for voltage measurement in experimental studies. In the results obtained, TKE values in numerical studies and Voltage values in experimental studies were compared. Since the length of the nozzle plate was determined as 55mm in the previous study, the length of the nozzle plate was taken constant. In previous studies, the optimum Reynolds Number, and velocity and pressure values of the water flowing in the flow channel were studied and these values were taken as 30825 Re, 1.172 ms-1 and 686 Pa, respectively. In this study, the optimum values of the number of blades and blade angle of the rotating plate were tried to be found by taking the parameters in the previous studies constant. In the ANSYS Fluent program used in numerical studies, k-E model is selected. The number of elements is taken constant as 71702 in this part of the study by making it independent of the mesh in previous studies.

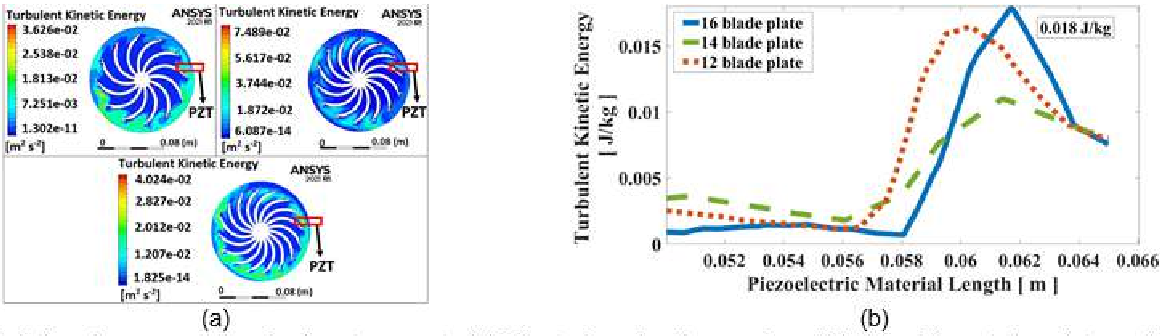


Fig. 2. Variations in exergy rates of subsystems as to (a) Effect of varying the number of blades of the rotating plate on the TKE contour plot, plate with 12, 14 and 16 blades respectively (b) plot of the effect of varying number of blades on Turbulence Kinetic Energy value.

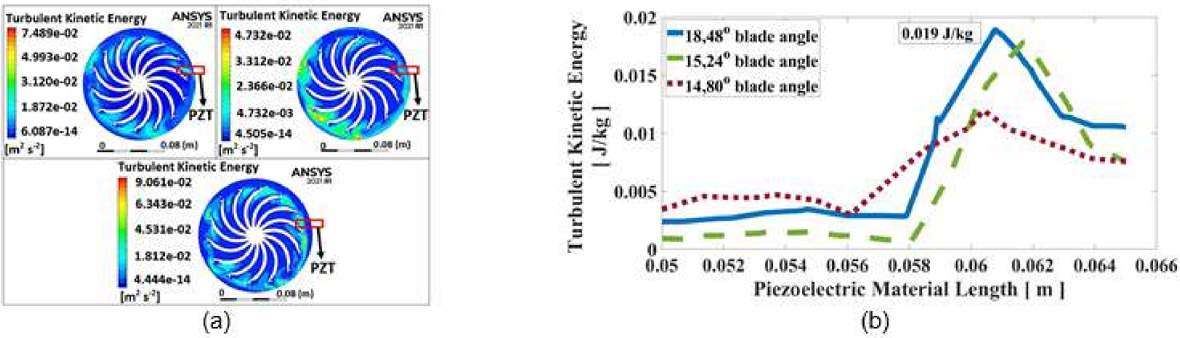


Fig. 3. (a) Effect of changing the wing angle of the rotating plate on the TKE contour plot, 14.80°, 15.24° and 18.48° degrees respectively (b) Plot of the effect of changing wing angle on the Turbulence Kinetic Energy value.

The solid modeling of the varying blade angles is shown in Figure 3 and the number of blades of the rotating plate in the system is fixed in all cases and is considered as 16. The wing angle given in Figure 3 is determined as 14.80°.

4. CONCLUSIONS

A series of experimental and numerical studies have been carried out to increase the efficiency of electricity generated using piezoelectric material. The optimum number of blades of the turbine modeled rotating plate was determined as 16 and the optimum blade angle as 18.48°. The final values obtained as a result of numerical and experimental studies were recorded as 0.019 TKE and 0.28 Volt. Considering the measured results, it was seen that approximately 1.6 times more efficient TKE and 2.3 times more efficient Volt were obtained compared to the previous studies.

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SOLAR RADIATION AND ENERGY EFFICIENCY: ANALYZING THE IMPACT ON COOLING AND HEATING IN DIFFERENT CLIMATIC REGIONS

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ABSTRACT
Energy conservation has become a critical concern due to the escalating environmental degradation resulting from power generation. This study specifically investigates the energy demands in the residential and commercial sectors, with a particular focus on regions characterized by extremely hot and cold climates. By analyzing factors such as latitude, altitude, and surrounding environmental conditions, this research highlights their significant influence on the cooling and heating requirements. The study places notable emphasis on the importance of solar radiation in building design and the determination of the optimal insulation thickness to achieve energy efficiency. Istanbul and Khartoum were selected as case studies due to their diverse climatic conditions, and the degree-day method was employed for analysis and found that the highest annual solar radiation values on the exterior walls of houses in Istanbul and Khartoum are in the western and northwest directions. Findings revealed substantial disparities in heating and cooling requirements when solar radiation and wall direction were considered. The results emphasize the critical role of incorporating solar radiation in building design and insulation strategies to attain optimal energy efficiency. These findings provide valuable insights for policymakers, architects, and engineers in their endeavors to create sustainable and energy-efficient buildings across diverse climatic regions.
Keywords: Solar Radiation Impact, Climatic Regions, Heating-Cooling Demands, Building Design.

1. INTRODUCTION
Energy conservation has emerged as a critical global concern due to the increasing environmental degradation caused by conventional power generation methods. Among the sectors contributing significantly to energy consumption, residential and commercial buildings hold a prominent position, particularly in regions with extremely cold or hot climates. The energy demands for cooling and heating purposes in these areas are significantly influenced by various factors, including latitude, altitude, and surrounding environmental conditions (Chung, 2017).
This research aims to examine the substantial impact of solar radiation on energy demands for cooling and heating, focusing on the significance of solar radiation in building design and the determination of optimum insulation thickness for achieving energy efficiency. By considering the diverse climatic conditions of Istanbul and Khartoum, two case study cities, this study sheds light on the interplay between solar radiation, building design, and insulation strategies (Li et al., 2023).
To investigate this interrelation, the degree-day method, a widely accepted approach for estimating energy requirements, was employed. Additionally. The study findings revealed significant disparities in heating and cooling requirements when solar radiation and wall direction were taken into account, compared to scenarios that ignored solar radiation. These disparities demonstrate the vital role of considering solar radiation in building design and insulation strategies to achieve optimal energy efficiency (Taleb, 2014).
The outcomes of this research provide valuable insights for policymakers, architects, and engineers who are dedicated to creating sustainable and energy-efficient buildings in diverse climatic regions. By recognizing the impact of solar radiation and incorporating appropriate design and insulation techniques, stakeholders can make informed decisions and contribute to global energy conservation efforts.

2. MATERIAL AND METHODS
The Degree-Day (DD) method serves as a crucial tool for planning the timing of crop cultivation, pest management, and building energy consumption. It entails the computation of accumulated degree days from a selected base date. Degree days are typically determined by integrating a temperature-based function that accounts for variations in temperature. The function is often constrained by upper and lower thresholds or appropriate limits. Multiple approaches exist for estimating or measuring degree days, such as continuous temperature monitoring, sinusoidal approximation, or modified formulas (U.S. Department of Energy, 2015). By employing the Degree-Day method, valuable insights into energy consumption can be gained, enabling effective energy monitoring, targeting, and the ability to predict heating and cooling costs in buildings. This method proves instrumental in optimizing energy efficiency and facilitating informed decision-making in the realm of building energy management (Day et al., 2004).

$$DD(HDD) = \sum_{i=1}^{n} (T_b - T_{o,i}) \quad , \quad \text{if } (T_O < T_b) \tag{1}$$

$$DD(CDD) = \sum_{i=1}^{n} (T_b - T_{o,i}) \quad , \quad \text{if } (T_b < T_o) \tag{2}$$

Without the influence of solar radiation:

$$T_{o,i} = \frac{T_{o,max} + T_{o,min}}{2} \tag{3}$$

With the influence of solar radiation:

$$T_{o,i} = T_{sun-air} = T_O + \frac{\alpha_s q_s}{h_o} - \frac{\varepsilon \sigma (T_O^4 - T_{surround}^4)}{h_o} \tag{4}$$

In the Degree-Day method, the indoor temperature (baseline temperature) is denoted as Tb, while To represents the daily average outdoor temperature. The total number of days requiring heating or cooling is represented by the variable n. To calculate the daily average temperature, the maximum and minimum temperatures measured per day are averaged. By utilizing these parameters and computations, the Degree-Day method provides a quantitative measure of energy requirements for heating or cooling in buildings based on the temperature differentials between indoor and outdoor environments.

3. RESULTS AND DISCUSSION

The primary objective of this study is to evaluate the impact of solar radiation on the outer walls of Istanbul and Khartoum. Specifically, the investigation aims to analyze the amount of solar radiation received and its subsequent influence on the heating and cooling loads experienced within buildings. The study findings, comprising solar radiation levels and the corresponding heating and cooling loads, are succinctly summarized in the tables and figures presented below:

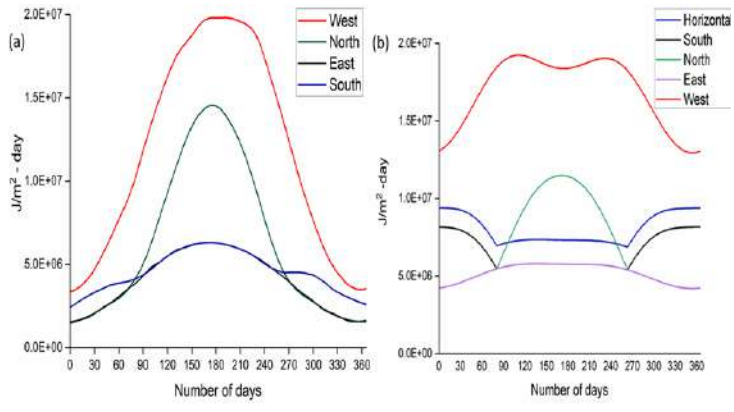

Fig. 1: (a) and (b) Variation of the daily total solar radiation (qs) falling on the vertical surface in the main directions in Istanbul and Khartoum.

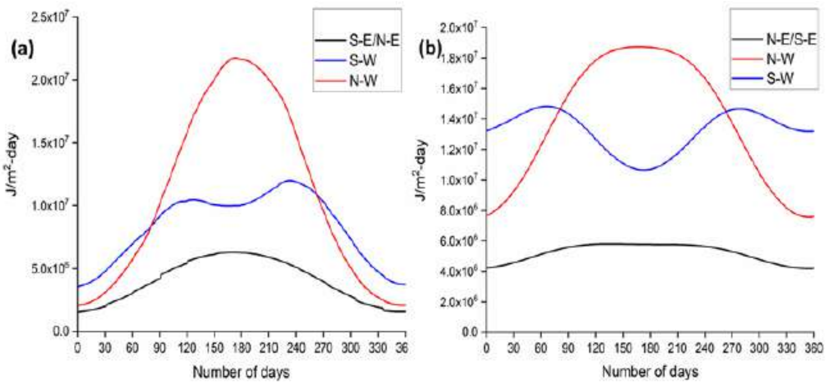

Fig. 2: (a) and (b) Variation of the daily total solar radiation (qs) falling on the vertical surface in the intermediate directions in Istanbul and Khartoum.

Fig. 2: (a) and (b) Variation of the daily total solar radiation (qs) falling on the vertical surface in the intermediate directions in Istanbul and Khartoum.Considering solar radiation, the degree-day values for heating and cooling in Istanbul were found to be 1568.7 and 163.4, respectively, while in Khartoum they were 36.8 and 4727. However, when solar radiation was taken into account, the degree-day values for heating on different orientations of vertical walls in Istanbul, including horizontal, south, west, north, and east, ranged from 1179 to 1440, while for cooling, they ranged from 535 to 240. Similarly, in Khartoum, the degree-day values for heating and cooling varied depending on the orientation of the primary and intermediate walls, ranging from 2.5 to 19.80 and from 6207 to 5134, respectively. Tables 1 and 2 show it clearly.

Table 1: The values of Heating- cooling requirements (HDD/CDD) in Istanbul.

Main	Horizontal	South	West	North	East
HDD	1179.3	1396.4	1232.5	1425.5	1439.8
CDD	537.5	240.2	472.3	330.5	240.2
Intermediate	**-**	**S – W (45˚)**	**N– W (45˚)**	**N – E (45˚)**	**S – E (45˚)**
HDD	-	1272	1313.1	1439.8	1439.8
CDD	-	312	480	240	240

Table 2: The values of Heating- cooling requirements (HDD/CDD) in Khartoum.

Main	Horizontal	South	West	North	East
HDD	2.5	13.2	3.5	19.8	19.8
CDD	6207	5242.5	6052.2	5277.8	5134.3
Intermediate	**-**	**S – W (45˚)**	**N– W (45˚)**	**N – E (45˚)**	**S – E (45˚)**
HDD	-	4.5	8.9	19.8	19.8
CDD	-	5761.3	5811.2	5134.3	5134.3

The study's findings indicate that Khartoum requires more energy for cooling compared to Istanbul's heating needs, attributed to its proximity to the equator, extended summer season, and high external temperatures. Furthermore, the research reveals that the western and northwest directions exhibit the highest annual solar radiation ratios on the exterior walls of houses in both cities, suggesting abundant heating energy availability in Istanbul and limited cooling energy availability in Khartoum. Economic factors, including energy costs, also influence the optimal insulation type and thickness for exterior walls in buildings in both regions.

4. CONCLUSIONS

In conclusion, this article examined the impact of solar radiation and energy efficiency on cooling and heating in different climatic regions, focusing on the case studies of Istanbul and Khartoum. The findings of the study highlighted the significant role of solar radiation in building design and insulation strategies for achieving optimal energy efficiency. Without considering solar radiation, the study revealed substantial heating and cooling requirements in both Istanbul and Khartoum. However, when solar radiation and wall direction were taken into account, variations in heating and cooling requirements were observed, emphasizing the importance of considering these factors in building design. This study underscores the critical need for incorporating solar radiation in building design and insulation practices to achieve significant energy savings. By implementing these findings, we can move towards a more sustainable future while meeting the energy demands of residential and commercial sectors in various climatic regions.

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USE OF THE TECHNIQUES OF CAESIUM-137 AND LEAD-210 IN EXCESS FOR SOIL EROSION ASSESSMENT IN NORTHWEST MOROCCO AND WESTERN TURKIYE: COMPARATIVE STUDY

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ABSTRACT
The western extremity of Anatolia and the Northwest of Morocco are two areas with typical Mediterranean climate and close to the European side. The combination of climatic factors and topography submitted the two areas to severe soil erosion. The fallout radionuclides approach was used in both areas to obtain reliable datasets on the magnitude of the phenomenon in some agricultural fields located within Nakhla and El Hachef watersheds in Northwest Morocco and in the Yatagan and Gediz basins in Western Türkiye.
Based on the Caesium-137 measurements and the MBM2, soil erosion rates of the sampled points ranged from 6.2 and 91.2 t ha-1 yr-1 within the Nakhla field and the mean erosion rate was 29 t ha-1 yr-1. In El Hachef sites, erosion rates of the sampled points ranged from 2.2 t ha-1 yr-1 and 78.9 t ha-1 yr-1 over the period (1954-2017) and the mean erosion rates within El Hachef sites was 31.45 t ha-1 yr-1. Comparing the obtained mean soil erosion rates with those obtained in previous studies in the same sites, the intensity of soil erosion significantly decreased due the implemented soil erosion control strategy in the Nakhla watershed and due to some beneficial changes in land use consisting of more frequent fallow periods and crop rotation practice in both the Nakhla and El Hachef study sites.
At Kayışalan within the Yatagan basin where there are intensive agricultural activities and based on the PM and the SMBM, the mean annual erosion rates were obtained to be 65 and 116 t ha−1 yr−1, respectively. The obtained high erosion rates pointed out the significant tillage contribution to soil loss. The Gediz basin is also one of the regions where intense agricultural activities take place in Western Türkiye. Erosion rates varied from 15 to 28 t ha−1 yr−1 with the PM, and from 16 to 33 t ha−1 yr−1 with the SMBM.
The excess Lead-210 (210Pbex) technique was used to generate data on soil redistribution rates over a longer time window of 100 years. In the Nakhla site, the mean erosion rates obtained by this technique was 27 t ha−1 yr−1, whereas in the Yatagan basin, the technique was found to be not suitable for erosion determination, due to the coal-fired power plants operating in the region.
Keywords: Soil erosion, Caesium-137, Lead-210 in excess, Northwest Morocco, Western Türkiye.

1. INTRODUCTION
Northwest Morocco and Western Türkiye are both submitted to Mediterranean climate which is from the main factors giving them similar geomorphology. The climate conditions and steep slopes characteristic of the two regions make soil erosion severe. This agro-environmental threat which aggravates under the impact of unsustainable agricultural practices, urbanization, deforestation, overgrazing threatens the sustainability of soil resource which is non-renewable at the human time-scale. Moreover, it is recognized that cultivation on hillslopes, as is the case in Northwest Morocco, and successive and intensive cultivation activity make the soil more vulnerable to erosion (Poesen et al., 2001). Indeed, the Gediz and Yatagan basins are regions in Western Türkiye where intense agricultural activities take place. Soil erosion is the most significant agricultural problem for soil conservation throughout this region (Saç et al., 2008). Soil erosion causes not only on-site degradation namely, the loss of topsoil, the decrease of soil fertility and the release of soil carbon into the atmosphere, but also off-site problems such as downstream sediment deposition in water bodies.
Classical techniques such as erosion plots and surveying methods for monitoring soil erosion have some limitations like expensive and time-consuming. The use of the fallout radionuclides approach overcomes these limitations. Indeed, it requires one sampling campaign, provides results promptly and allows retrospective assessment of soil erosion rates. 137Cs is an artificial radionuclide with a half-life of 30.2 years. It was introduced to the environment by nuclear weapon tests which started in 1950s. Additional inputs of 137Cs were received in 1986 as a result of the Chernobyl nuclear accident. The northern soils of Türkiye have been highly effected by this accident. According to reports of TAEK (Turkish Atomic Energy Agency) (2006), the 137Cs levels in soils of Karadeniz, Marmara and Ege-Akdeniz regions were determined to be 16−2225 Bq kg−1, 4−200 Bq kg−1 and 3−40 Bq kg−1, respectively (Saç et al., 2008). Inputs also arrived to Northwest Morocco. Indeed, the 137Cs was released into the atmosphere and distributed by wet and dry fallouts. It is rapidly and strongly adsorbed by fine soil particles so that in most agricultural environments, its redistribution is a direct reflection of the erosion, transport and depositions processes. The unsupported 210Pb (T1/2 = 22.2 y) was also used in some studies of soil erosion in Morocco and Türkiye but it is more used for dating sediment deposits due its natural geogenic origin.

It permits estimation of long term erosion rates extending over ca. 100 years.
Application of nuclear techniques in erosion studies in Türkiye has started by Ugur et al. (2003) in Gokova region in Western Anatolia who investigated the availability of the Cs-137 and Pb-210 techniques for estimation of soil loss in Yatagan basin in the region. In Morocco, soil erosion studies based on the fallout radionuclides approach started by the end of the 90s and the beginning of 2000s (Ibrahimi, 2005). In recent years, there has been increasing interest in the potential for using the fallout radionuclides techniques in soil erosion investigations in Morocco and Türkiye due its potential. The aim of this study is to compare soil erosion estimates obtained in Gediz and Gokova Region where Yatagan basin is located at Western Türkiye with those obtained by the last soil erosion studies based on Cs-137 and Pb-210 in excess techniques in Northwest Morocco (Moustakim et al., 2019; 2022).

2. MATERIAL AND METHODS

The Gediz Basin is characterised by slopes varying from 5 to 35% and by rainfall regime varying from 450 mm to 1,060 mm (Saç et al., 2008). In the Gediz basin, soil samples were collected from five distinct cultivated regions (Ulukent, Kestelli, Yartepe, Karkınkoy and Kırtepe) subject to soil erosion. In the study sites of the Yatagan basin, the climate is typically Mediterranean with a mean annual rainfall of 630 mm. Different grid sizes were applied at different fields depending on the soil structure, geological formation and the topographic futures, whereas in Northwest Morocco, the sampling grid was mainly applied in the reference sites and one field in Nakhla watershed and the general samplings in the other fields of the other basins were generally along transects from the topsoil to the bottom of the field.
The reference sites are stable, have the same annual precipitation of the concerned agricultural fields and were chosen close to the study fields.
In Gediz and Yatagan, an 8.5 cm diameter steel core tube was used for bulk core sampling and corer of 15.5 cm diameter was used for sliced soil profiles. Sectioned soil cores were collected in 5 cm intervals up to 40 cm soil depth for vertical distribution of 137Cs along soil profiles. In Northwest Morocco, soil samples were collected using a soil column cylinder auger of 9 cm in diameter and 90 cm in length driven into the ground by a motorized percussion. Core increments of the sampled sites in the three watersheds Raouz, El Hachef and Nakhla were between 4 and 5 cm. The bulk cores were collected to measure the inventories of radionuclides whilst the incremental samples allowed to establish the depth profiles associated with reference and agricultural fields.

Generally, soil samples are submitted to the same procedure of physical preparation. They were oven dried, disaggregated, sieved at 2 mm, weighed (< 2 mm) and homogenized. Sub-samples were put in specific pots for subsequent analysis. In Türkiye, the samples were analyzed for 137Cs by direct gamma assay, using Tennelec/Nucleus HPGe (184 cc) planar type coaxial intrinsic germanium detector. In Morocco, samples were analyzed using coaxial HPGE detector of 30% efficiency for Cs-137 and 50% for Pb-210 in excess and Cs-137. Detectors were calibrated in efficacity and energy.
The measurement of 226Ra, through its daughter 214Bi, requires sealing soil samples for 21 days to stop the emanation of 222Rn and achieve equilibrium between 226Ra and 214Bi. In Türkiye, the Alpha-activities for Pb-210 in excess measurements were measured by silicon surface-barrier detector with 29% in efficiency whereas Pb-210 in excess was measured by gamma spectrometry in Morocco based on a low-energy HPGe detector with 50% efficiency. In the two studies conducted in Türkiye, samples were counted for a period between 20 000 and 40 000 seconds. In Morocco, counting times were between 21 600 and 100 000 s.
After calculation of activities, erosion rates were calculated based on specific models. In Türkiye, for cultivated sites, erosion rates were estimated using two models, namely the Proportional Model (PM) (Walling and He 1999) and Simplified Mass Balance Model (SMBM). The PM is expressed as follows :

$$Y = 10\ BdX/100T \qquad (1)$$

Where d is the depth of the plough or cultivation layer (m), B the bulk density of the soil (kg m−3), T the time elapsed since the initiation of 137Cs accumulation (year).

According to SMBM, the mean annual soil loss rate (t ha−1 yr−1), Y is expressed as follows: (Nouira et al. 2003).

$$Y = 10Bd\left[1 - \left(1 - \frac{X}{100}\right)^{\frac{1}{t-1963}}\right] \qquad (2)$$

Where t is the ellapsed time since 1963.

The proportional model does not take into account the dilution of 137Cs concentrations in the plough layer. It assumes that 137Cs is uniformly distributed throughout the tillage layer and soil loss is directly proportional to the amount of 137Cs removed from the soil by erosion processes. So, the results obtained by PM could underestimate the actual rates of soil loss. For uncultivated soils, the profile distribution model (PDM) was used. In the study conducted in Northwest Morocco (Moustakim et al., 2019; 2022), the MBM2 (Walling et al., 2002) was used. The MBM2 is more difficult to use but it takes into account the temporal variation of the inputs of Cs-137 fallout and their initial distribution in the soil surface before their incorporation into the plough layer. It can be expressed as follows:

$$d(A)/dt=(1-\Gamma)I(t)-(\lambda+PR/d)A(t) \qquad (3)$$

A(t) is the 137Cs inventories (Bq m−2); t is the time since the onset of 137Cs fallout (yr) considered in 1954; R is the soil erosion rate (kg m−2 yr−1) which can be converted to t ha−1 yr−1; d is the cumulative mass depth representing the average plough depth (kg m−2); λ is the decay constant for 137Cs (yr−1); I(t) is the annual 137Cs deposition flux at time t (Bq m−2 yr−1); Γ is the proportion of the recently deposited 137Cs removed by erosion before being incorporated into the plough layer; P is the particle size factor.

3. RESULTS AND DISCUSSION

In the Gediz basin, the reference inventories varied between 770 and 1238 Bq m−2 with an average of 1001 Bq m−2. In the Yatagan basin, the mean 137Cs reference inventory is 12487 Bq m−2 in the Ürnez Hill and 36564 Bq m−2 in the Yatagan Hill. It should be mentioned that the Gokova region where the Yatagan basin is located, in Western Anatolia, was subject to the first study of soil erosion based on the nuclear approach in Türkiye (Ugur et al., 2003). The study conducted by Saç et al., (2008) studied the other three hills in the Yatagan basin. The reference inventories obtained in the Yatagan basin are higher than those recorded in Northwest Morocco even by radioactive decay to the year of sampling (2017 and 2018) of the Moroccan sites. Indeed, the reference inventories that were obtained in the Nakhla and El Hachef watersheds in 2017 are 1517 Bq m−2 and 1685 Bq m−2 respectively and 1710 Bq m−2 in the Raouz watershed in 2018. The forms of the reference profiles in both countries show that they are typical of reference sites. In both studies conducted namely in Türkiye and in Northwest Morocco, the highest 137Cs activity in the reference sites was generally found within the surface layers especially of the undisturbed soils. Moreover, in depositional areas found in Türkiye and in El Hachef watershed in Northwest Morocco, 137Cs inventories were found to be higher than those in reference areas.

In Gediz basin, erosion rates for the five agricultural sites, when PM was used, varied from 15 to 28 t ha−1 yr−1; and from 16 to 33 t ha−1 yr−1 using SMBM. The average erosion rates in this basin by PM and SMBM are 22 t ha−1 yr−1, 26 t ha−1 yr−1 respectively. Minimum erosion rates (15 and 16 t ha−1 year−1) were obtained by both models at Kırtepe site due to fact that the landscape does not have any significant slope inclination of more than 10% (Saç et al., 2008). The range of the erosion rates in this site are close to those recorded in one field within the Raouz watershed of about 16.1 t ha−1 yr−1 whereas in the other field, the mean erosion rate is even lower of about 5.7 t ha−1 yr−1. In the Yatagan basin, erosion rates were higher than the Gediz basin. Indeed, using the PM and SMBM in cultivated soils at Kayışalan, the mean annual erosion rates were obtained to be 65 and 116 t ha−1 yr−1, respectively. Increase in soil loss in these sites was attributed to the fact that these hills have bare landscape without any natural plant cover and also downhill cultivation processes are applied (Saç et al., 2008). Based on the PM, the average soil loss obtained in the Ürnez Hill was 47.44 t ha-1 yr-1. Within one field in El Hachef watershed, the mean soil erosion rate is 42.7 t ha-1 yr-1 in the same range of that found in the Ürnez Hill.

The mean erosion rate obtained in the study sites of El Hachef watershed is 31.45 t ha-1 yr-1. In the Nakhla site, the mean soil loss was 29 t ha-1 yr-1. It should be mentioned that the study sites in Morocco benefitted from some beneficial agricultural practices like fallows and crop rotation. Moreover, there was a soil erosion control strategy implemented in the Nakhla watershed based on more frequent fallow with natural vegetation and olive plantations (Moustakim et al., 2019). In Türkiye, the results also showed that the vegetation cover protects the soil from erosion. Indeed, the mean annual erosion rates found using PDM in undisturbed soils were 15 t ha−1 yr−1 at the Peynirli Hill where the vegetation cover is more uniform and 27 t ha−1 yr−1 at the Kırtas Hill.
In general, the study pointed out that the high erosion rates obtained in the cultivated sites of the studied basins in Türkiye are due to a significant tillage contribution to soil loss.
The study in Türkiye pointed out that the SMBM would be more suitable for water affected erosion studies in cultivated sites whereas, in the study conducted in Morocco, three models were used namely the PM, SMBM and MBM2 (Moustakim et al., 2021). The last one was found to be more suitable.
Regarding the application of the 210Pbex in Türkiye, namely in the Gokova region, the technique was found to be not suitable for erosion determination in the investigated area in the Yatagan basin, presumably due to the coal-fired power plants operating in the region (Ugur et al, 2004). It was concluded that there is an influence of the coal-fired power plants (CPPs) on 210Pb use for erosion rate applications. In the last study that was conducted in a study site within the Nakhla watershed based on the 210Pbex technique, soil erosion rates were found to be 27 t ha−1 yr−1 (Moustakim et al., 2019).

4. CONCLUSIONS

The Caesium-137 technique permitted to obtain results on soil erosion in Türkiye and Morocco whereas the 210Pbex technique did not permit to obtain results on soil erosion in the study site in Türkiye due to the influence of the coal-fired power plants. Some erosion rates recorded in both countries were in the same range whereas others recorded in Türkiye were higher due mainly to the effect of the tillage factor and steep slopes.
The Fallout Radionuclides approach has advantages over classical techniques such as erosion plots and surveying methods for monitoring soil erosion which have some important limitations in terms of the representativeness of the obtained data, involved time and costs, and potential to provide information on long-term rates of soil erosion. However, the fallout radionuclides technique still does not permit to identify the contribution of each factor in the erosion process.

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HYDROGEN PRODUCTION FROM GEOTHERMAL ENERGY

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ABSTRACT
As a renewable energy source, hydrogen energy emerges as the only energy carrier that corresponds to oil, and hydrogen is accepted as the energy of the future in the world. Technological studies on hydrogen energy have progressed slowly over time, but recently, the interest of countries in hydrogen energy has increased and the developments in this field have accelerated, at least technologically, by increasing their financial resources thanks to the hydrogen strategies they have developed. The situation is the same in Turkey and the Turkish Ministry of Energy and Natural Resources has prepared a hydrogen technologies strategy and roadmap. This article provides a brief overview of some hydrogen production systems using geothermal energy.
Keywords: Hydrogen production, Geothermal energy, Application.

1. INTRODUCTION
The crises in energy supply and climate are caused chaos in the world when we look at the last point of the events in the world. Due to the climate crisis, underlines the importance of the Paris Agreement target (IPCC 2018) supported by the Glasgow Climate Pact (UNFCCC, 2021) to strive to limit global climate change to below 2 ˚C of pre-industrial temperatures and limit it to 1.5 ˚C is drawn. Zero carbon studies are carried out in the target of 2050. The main targets for 2030 are to reduce greenhouse gas emissions by at least 40% (compared to 1990 levels), to have at least 32% share of renewable energy, and to improve energy efficiency by at least 32.5% (EC, 2022).
As a renewable energy source, hydrogen energy emerges as the only energy carrier that corresponds to fuel-oil. For this reason, hydrogen is considered as the energy of the future in the world. Technological studies on hydrogen energy have progressed slowly over time, but recently, countries' interest in hydrogen energy has increased and the developments in this field have accelerated, at least technologically, by increasing their financial resources due to the hydrogen strategies they have developed.

Hydrogen is produced using fossil fuels and renewable energies. Hydrogen production from renewable energies is called green hydrogen, and it is more efficient in terms of efficiency and cleaner energy from an environmental point of view. But unfortunately, today still demand for hydrogen is met almost entirely by hydrogen production from unabated fossil fuels. In 2021, total global production was 94 million tons of hydrogen (Mt H2) with associated emissions of more than 900 Mt CO2 (IEA, 2022).

In the literature, there are studies on hydrogen production from geothermal energy. These studies generally focused on hydrogen production rate, energy and exergy efficiency, modelling, suitable materials, and cost.

In this study, information about the methods of hydrogen production from geothermal energy is given and improvement suggestions about energy efficiency are presented. In addition, some of the latest developments about hydrogen production in the world are summarized.

2. HYDROGEN PRODUCTION USING GEOTHERMAL ENERGY
Geothermal energy is used for electricity generation and direct use (heat). The types of geothermal power plants as flash, binary, flash-dual, regenerative, regenerative, and organic Rankine flash cycles are counted, respectively. Electrolysis is used in hydrogen production and the electrical energy required for this electrolysis process is provided from geothermal power plants. Among various hydrogen production systems, water splitting through electrolysis is a widely acceptable and commercial approach for producing high-purity hydrogen (Karayel et all., 2022). The hydrogen production rate from geothermal power plants was found to vary from 5.439 kg/h to 13958 kg/h (Mahmoud, et all., 2021). High temperature electrolysis is an alternative method of electrolysis. Some of the required energy is provided by heat, thus reducing the production cost, and increasing the overall efficiency. Using a high temperature electrolysis system provides the possibility of 30-50% higher thermodynamic efficiency (Karayel et all., 2022). In another study on increasing the temperature in the electrolysis process, the effect of temperature on the electrolysis process was investigated in a geothermal sourced hydrogen production system based on an artificial neural network (Yilmaz et all., 2019). It was observed that if the temperature increased from 25 °C to 70 °C, the power required for hydrogen production would decrease from 43.51 kW/kg to 42.2 kW/kg, corresponding to a reduction of about 3%. Typically, a preheater is installed to increase the temperature of the water entering the electrolyzer (Yilmaz et all., 2014).

The hybrid use of solar energy increases efficiency. At the same time, it will benefit from solar energy support in low-temperature geothermal fields and will allow these fields to be used in hydrogen production. Geothermal systems powered by solar energy are widely used in hydrogen production. The reviewed solar-geothermal systems were able to produce volume ranges of hydrogen between 0.115 kg/h to 561.6 kg/h and 0.005 MW to 4.631 MW of electricity with energetic and exergetic efficiencies varying from 5.67% to 78.37% and 7.49% to 70.16%, respectively (Mahmoud, et all., 2021).

Recently, it has been stated in the literature that the use of thermoelectric modules in renewable energy systems is beneficial in increasing efficiency. Chavez-Urbiola et al. (2012) used concentrated solar energy to heat one side of a thermoelectric module to generate renewable electricity. With such a system, 4% efficiency was obtained in the operating conditions considered. Zare and Palideh (2018) integrated thermoelectric modules into a Kalina loop to increase its efficiency. They reported a 7.3% increase in energy and energy efficiency by integrating thermoelectric generators (TEGs). The economic evaluation revealed that the proposed system would be profitable if the added TEG cost was less than $6.4/W. According to Khanmohammadi et al. (2020) proposed the improvement of a geothermal system that generates electricity and hydrogen via electrolysis by recovering waste heat from condensers using thermoelectric modules. Based on the economic research, the authors found that the payback period is quite reasonable if the cost of TEGs is less than $6/W. The use of TEG for hydrogen production in low temperature geothermal fields was investigated and 0.5652 kg/m2/year hydrogen was produced (Hadjiat, 2021). Efficiency increase in Hydrogen Production can be achieved using electrical energy produced by TEGs from low temperature fields or without reinjection of the geothermal fluid.

3. HYDROGEN ENERGY IN THE WORLD AND IN TURKEY

Although hydrogen energy is a known energy, it has fallen behind in technological developments because it has not received the necessary attention. Due to the demands in energy supply and climate change, countries have had to develop their policies and strategies on hydrogen. Some of the studies in the world carried out for the production of hydrogen from renewable energies are presented below;

New Zealand : The first green hydrogen plant in New Zealand has officially started production. The facility uses renewable geothermal energy produced at the Tuaropaki Trust's geothermal power plant in Mokai, near Taupo. The plant, with a power of 1.25 MW and a production of 180 tons of hydrogen, became operational in early 2021. The facility's long-term goal is to contribute to a complete hydrogen supply chain that includes transportation, storage and refueling (Halcyon Power, 2023; Thinkgeoenergy, 2023).

Germany-REFYHNE: Rhineland electrolyzer: One of the world's largest hydrogen proton exchange membrane (PEM) electrolyzers was built in 2021 at the Shell Rhineland Refinery in Wesseling, Germany. Its peak capacity is 10 MW and produces 1,300 tons of hydrogen per year. The electrolyzer also helps stabilize the local electricity grid by enabling the refinery to produce and then store hydrogen when there is excess power from variable renewable sources such as wind (Shell, 2023).

China-M4 Electrolyzer: The 20 MW power to hydrogen electrolyzer and hydrogen refueling stations in Zhangjiakou became operational in January 2022. Leveraging solar and onshore wind power, the facility can produce eight tons of renewable-based hydrogen per day. In the second phase, plans are made to scale up to 60 MW in the next two years (Shell, 2023).

Netherlands-Netherlands Hydrogen I: Holland Hydrogen I, which will be Europe's largest renewable hydrogen plant, will be operational in 2025. The 200 MW electrolyzer will be built on Tweede Maasvlakte in the port of Rotterdam and will produce up to 60,000 kilograms of renewable hydrogen per day. Renewable power for the electrolyzer will come from the offshore wind farm Hollandse Kust (noord) (Shell, 2023).

The Turkish Ministry of Energy and Natural Resources has declared hydrogen as one of the priority areas due to its contribution to the sustainable energy future. Their aim is to create a carbon-zero economy model using hydrogen, in line with economic development and 2053 net zero carbon emission targets. To achieve this aim, "Turkey Hydrogen Technologies Strategy and Roadmap" has been prepared. According to this roadmap, the target is to reduce the cost of Green hydrogen production to below 2.4 US/kgH by 2035 and below 1.2 US/kgH by 2053 and It is to ensure that the installed power capacity of the electrolyzer reaches 2 GW in 2030, 5 GW in 2035 and 70 GW in 2053 (ETKB, 2023).

The total hydrogen production potential from geothermal energy of Turkey is estimated to be 559.76 kilotons, using alkaline and high-temperature solid-oxide electrolysers. Without using HTE system, hydrogen production from single, double, triple, and quadruple flash staged power plants are 428.61, 437.06, 479.18, and 485.42 kilotons, respectively (Karayel et all., 2022).

4. CONCLUSIONS

It has become imperative to use renewable energies for human beings who are faced with both the energy crisis and climate change. Like other renewable energies, Hydrogen has taken its place in this field. The importance of hydrogen energy is that it is the only energy source to replace Fuel-oil. In the world, breakthroughs in the development of hydrogen technologies have accelerated. The use of hydrogen energy is already very high around the world and at the same time the CO2 emissions from hydrogen production are high. Hydrogen produced from renewable energies is considered environmentally friendly. Hydrogen strategy has been established in our country as well as in the world. In our country, which has a high potential in geothermal energy, there are studies on hydrogen production from geothermal energy. The implementation of these studies as soon as possible is encouraged by the Turkish Ministry of Energy and Natural Resources. In addition, the use of other renewable energy sources together with geothermal energy will increase efficiency in our country, which is rich in renewable energy.

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EVALUATING THE IMPACT OF SOLAR ENERGY SYSTEMS ON EXERGY EFFICIENCY AND CARBON FOOTPRINT IN EXTRA VIRGIN ORGANIC OLIVE OIL PRODUCTION

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ABSTRACT
In this study, the impact of photovoltaic (PV) solar energy system on the exergy efficiency and carbon emissions of organic extra virgin olive oil production were investigated by using real operational data in a facility located in Urla, İzmir. With the life cycle approach, energy, exergy and sustainability analyzes were carried out and energy, water, raw materials and waste management were discussed.
Results showed that, 0.06 kWh of electricity is consumed at the factory stage for the production of 1 liter of olive oil (functional unit). The PV system have a performance ratio of 86% and generates 1483.6 kWh annually per 1 kWp. Exergy efficiency ranged from 6.36% to 14.61% for different olive varieties. The average carbon footprint was determined as 0.25 kg CO2eq for per liter of olive oil, with a water footprint of 0.98 m3 per liter.
Keywords: Sustainability, solar energy, organic olive oil, exergy analysis life cycle analysis.

1. INTRODUCTION
Olive trees have cultural significance in the Mediterranean and adopting sustainable practices in production is crucial. Sustainability means meeting present needs without compromising the future. As for the investigation of olive oil in terms of sustainability, important outputs are the less use of natural resources, high energy – exergy efficiency, minimizing and regaining of the waste.
Providing energy from natural sources in food production process is extremely important (Colak and Hepbasli, 2005). Climate change, global warming and desertification are some of the destructive consequences of carbon emissions, and hence fossil fuel consumption. For these reasons, It is very important to obtain energy from renewable sources with clean and efficient technologies instead of limited fossil resources. The olive oil sector should be supported by renewable energy where energy consumption exists and exergy destruction should be minimized as in all other industrial sectors. The studies about sustainability of the organic olive oil production are scarce in the literature. To have more sustainability studies is important for Turkey, aiming the higher positions in the World olive oil production list.
Exergy analysis, which is an indispensable part of the design, simulation and performance calculation of energy systems is directly related to sustainability (Hepbasli, 2008). The concept of exergy is crucial for assessing the quality of energy based on the second law. Exergy represents the maximum work potential of a system relative to a reference point, known as the dead state. It quantifies the usable work that could be extracted from a system interacting with its environment. Overall, exergy provides insights into the work potential and efficiency of a system while considering the irreversibility involved. It is very important to analyze the solar energy according to the second law of thermodynamics like all production and consumption systems. The energy efficiency of this system is calculated by the amount of radiation incident at the maximum power point (Biyik and Araz, 2018; Rawat et al., 2017).
In this study, the effects of photovoltaic (PV) solar energy system on the exergy efficiency and carbon emissions of organic extra virgin olive oil production were investigated by using real data in a plant located in Urla, İzmir.

2. MATERIAL AND METHODS
This study was carried out at the organic olive oil production line of the factory operated by TURLA TARIM Ltd. Co. in Urla, Izmir. The factory is equipped with a 52.5 kWp solar power plant. The annual maximum production capacity of the factory is 1100 tons of olive oil. Four different olive varieties, namely Domat, Ayvalık, Erkence, and Gemlik, were used in the organic olive oil production process. The resulting olive oil is organic, extra virgin, and cold-pressed, known for its high quality and multiple awards.
As can be seen from Figure 1 that shows the process flow chart of organic extra virgin olive oil production; the production process at the facility follows a two-phase continuous system, involving feeding, washing, crushing, pulp preparation, decantation, and separation units. Unsuitable olives are manually sorted at the conveyor belt. The olives go through various stages, including vibrating screening, crushing, malaxation (kneading), decantation, and separation. The pomace with seeds is separated from the mixture in the decanter, and the oil is further polished with warm water in the separator. The separated water is collected in the pomace tank, while the olive oil is transferred to chrome tanks and preserved with nitrogen gas. Olives unsuitable for oil production are used for soap production, and the leaves are utilized as feed for goats. The pomace with olive seeds is processed in the kernel separation machine, and the remaining seeds are stored for domestic usage.

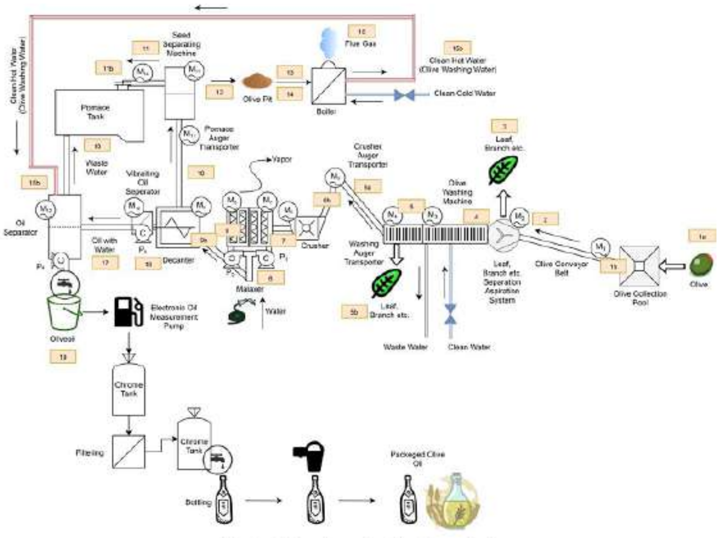

Fig 1. Olive oil production flow chart.

The solar energy generation system consists of PV panels and inverters. UP Solar UP-M250P, a 250 Wp polycrystalline PV panel, is used, and REFUsol 020K (19.2 kW grid-connected) and REFUsol 010K (10 kW grid-connected) inverters are employed. PV panels generate energy. An inverter is placed to alter the direct current (DC) to the alternating current (AC). The Inverter supports the electricity grid. Produced energy is sold to the grid and used energy is bought from grid. The difference between the two invoices is to be paid by the commercial sides.

At the outset, pumps and motors were listed with their powers. Then, the running times of each pump and motor were calculated for each variety. The amount of consumed energy was calculated by multiplying the powers by the usage time. Finally, the data was saved as a logical database.

Each component was modelled to determine the performance of the system. After modelling, analyses were done. CCalC2, PVSol, Excel, Matlab are the programs which have been used in this study.

While calculating the second law (exergy) efficiency, the general efficiency formula was adapted. Since olive and olive oil have calories as nutrients, this value was included in the exergy efficiency equation. Details of data and calculations can be found in Öner's MSc thesis (Öner, 2021).

In this study, the CO2eq emissions of 1 liter of organic extra virgin olive oil were calculated from the cradle to gate using the CCalC2 program. Carbon footprint in agricultural stage were calculated using the work of Notarnicola et al. (2004). The life cycle inventory was presented in Table 1.

Olive and olive oil production should not be considered only as carbon emissions. In olive production, carbon is also used due to photosynthesis. The amount of CO2 used; 2.74 t/(ha.year) in agricultural land consisting of young trees and 9.54 t/(ha.year) of mature trees (Sofo et al., 2005).

Table 1. Life cycle inventory

Raw Material Input	**Domat**	**Ayvalık**	**Erkence**	**Gemlik**	**for Soap**
Olive, branch, leaf etc [kg]	7.96	7.23	3.30	5.00	6.19
Water [l]	0.49	0.47	0.29	0.17	0.33
Energy Usage					
Electricity [kWh]	0.86	0.71	0.55	0.48	0.55
Olive Seed [kg]	0.001	0.001	0.001	0.01	0.001
Energy Generation					
Electricity from PV [kWh/l]	11.67	11.67	11.67	11.67	11.67
Wastes					
Waste Water [l]	0.49	0.47	0.29	0.17	0.33
Leaf, Branch [kg]	0.031	0.081	0.06	0.0001	-
Olive Seed [kg]	0.61	0.59	0.52	0.27	0.42
Pomace without Seed [kg]	6.40	5.64	1.80	3.81	4.85
Inconvenient Olive (for soap) [kg]	0.33	0.17	2.43	0.26	-

3. RESULTS AND DISCUSSION

In this study, an organic extra virgin olive oil production line was investigated in terms of energy, exergy and sustainability. The amount of electrical energy required to produce 1 liter of olive oil from each variety is given in Figure 2. While the highest energy consumption was realized in Domat olives, the least energy consumption was realized in soap purposed olive pressing. One-year actual electricity generation values of the factory from solar energy have been graphicated and given in Figure 3. While the highest production was in July; the lowest production was in January. Energy production is 77886.9 kWh/year. Annual energy production for 1 kWp is 1483.6 kWh/year. The performance ratio of the system is 86%.

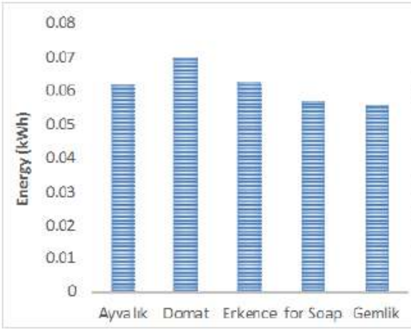

Fig. 2. Energy required to produce 1 liter of olive oil.

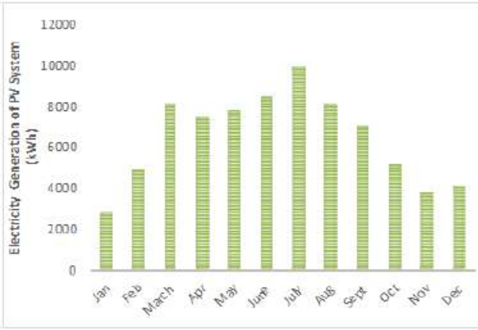

Fig. 3. Monthly real electricity generation of the PV plant (kWh).

Fig. 2. Energy required to produce 1 liter of olive oil. Fig. 3. Monthly real electricity generation of the PV plant (kWh).
In general, the exergy destruction of each variety at the same stages was found close to each other. The yield of each variety was also found close to each other, except for Erkence. Exergy efficiencies (without solar energy) for each variety is given in Table 3. The reason why the exergy efficiency of the Erkence is higher is related to the production of more oil with less olive.

Table 3. Percentage exergy efficiency for each variety.

	Domat	Ayvalık	Erkence	Gemlik	for Soap
Without Solar Energy	8.06%	6.81%	14.61%	7.89%	6.36%

Fig. 2. Energy required to produce 1 liter of olive oil. Fig. 3. Monthly real electricity generation of the PV plant (kWh).
In general, the exergy destruction of each variety at the same stages was found close to each other. The yield of each variety was also found close to each other, except for Erkence. Exergy efficiencies (without solar energy) for each variety is given in Table 3. The reason why the exergy efficiency of the Erkence is higher is related to the production of more oil with less olive.

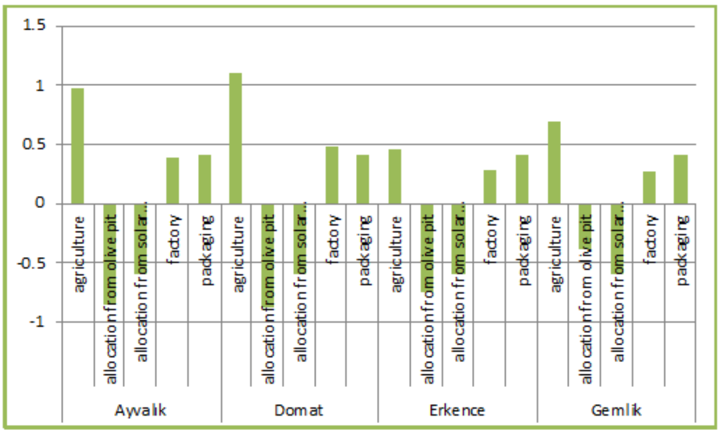

Fig. 4. CO_{2eq} emissions and allocation during process.

4. CONCLUSIONS

In this study, energy-exergy analyses and life cycle assessment (from cradle to gate) has been done within the scope of sustainability, with using real operation data got from an organic natural extra virgin olive oil production facility at Urla/İzmir. Exergy efficiency values for all system have been calculated as 10.73%. Carbon footprint has been determined as 0.25 kg CO2eq./l product, and average water footprint as 0.99 m3 water/l product.

This study concluded that it is possible to produce a sustainable natural extra virgin olive oil by using organic olives as raw materials, supported with solar energy and valorizing the wastes.

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ENHANCED EXERGETIC PERFORMANCE OF A GEOTHERMAL-BASED ORGANIC RANKINE CYCLE THROUGH EMPLOYING PARTIALLY EVAPORATED WORKING FLUID

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ABSTRACT
In the present day, the Organic Rankine Cycle (ORC) has emerged as a promising technology for addressing the escalating electricity demands and holds great potential in harnessing low-grade waste heat. ORC is being implemented in numerous heat recovery plants due to its advantages, such as lower initial costs, reduced maintenance requirements, and environmentally friendly characteristics. In this study, a thermodynamic exploration of the partially evaporated ORC (PEORC), a modified version of the ORC, is presented. The power generation performance of the PEORC is evaluated under different heat source conditions and compared to that of a traditional ORC. The results showed that, power output of sub-critical ORC and PEORC can be estimated to be 1.844 kW and 3.088 kW respectively. Moreover, both cycles have yielded approximately same energy efficiencies as 4% while exergy efficiency of sub-critical ORC and PEORC has been calculated to be 8.19% and 13.73%. Besides, findings of parametric study underscore the considerable influence of vapor quality selection on the attainable net power output.
Keywords: PEORC, ORC, Geothermal, Exergy.

1. INTRODUCTION
Energy serves as a vital element for achieving sustainable development in any nation. However, conventional energy resources are limited on our planet, and the gradual depletion of fossil fuels poses both environmental and sustainability challenges. Additionally, a significant portion of the world's energy is wasted as heat due to the inefficiencies of various components. Thus, waste heat can be utilized for power production using thermodynamic cycles, such as organic Rankine cycle (ORC), and trilateral flash cycles (Tchanche et al., 2011). The utilization of ORC technology allows for the conversion of low-temperature renewable heat sources, including geothermal, biomass, solar, or waste heat, into power generation. This technology has the capability to make a substantial impact in mitigating climate change. For instance, in Germany, the economic potential of hydrothermal geothermal sources was estimated to be 9.1 TWhel per year, considering sustainable exploitation (Eyerer et al., 2020). In contrast to the conventional Rankine Cycle, the ORC utilizes organic working fluids, such as refrigerants, instead of water as the working fluid. These organic fluids generally possess lower boiling points compared to water, allowing the ORC to effectively produce power from low-temperature heat sources, as mentioned earlier. Therefore, one can consider the ORC as an extension of the CRC, offering an additional degree of freedom through the selection of the working fluid. An Organic Rankine Cycle (ORC) is composed of four primary components: a working fluid pump, an evaporator, an expander, and a condenser. In large-scale ORC systems, turbines are commonly employed as expansion devices, while smaller-scale ORC units often utilize positive displacement expanders such as twin-screw, scroll, piston, or vane expanders (Lemort et al., 2017). In addition to the ORC, the literature frequently discusses the Trilateral Flash Cycle (TFC) as a potential alternative for generating power at low temperatures (Lecompte et al., 2015). By aiming to integrate the advantages of both the ORC and TFC, the concept of the Partially Evaporated Organic Rankine Cycle (PEORC) has been developed. The PEORC operates by utilizing a working fluid that is partially evaporated during the cycle. This characteristic allows the PEORC to harness the primary advantage of the TFC concept: enhanced utilization of the heat source. Dawo et al., 2023 presented an experimental study focusing on the PEORC and its comparison to the conventional low-temperature heat source power cycle, the ORC.

The main objectives of this study is to perform a thermodynamic modeling of a PEORC and sub critical ORC in order to compare the technical performances and highlight the superiority of PEORC from the exergy viewpoint. The sub-objectives can be classified as follows:

- To model a PEORC sub critical ORC based on the first law of thermodynamics.
- To determine the overall energy and exergy efficiency of the both cycles.
- To perform a parametric study to see the effects of major design parameters on the performance of the both cycles.

2. MATERIAL AND METHODS

2.1. System Description

In Fig. 1, the ORC layout and temperature-entropy diagram of the PEORC and subcritical ORC is presented. As shown in the figure. In the case of subcritical ORC, the process begins with the pressurized working fluid (1) being preheated, evaporated, and slightly superheated in the evaporator, utilizing heat transferred from the geothermal source. The superheated working fluid (2) is then directed to an expansion device, where it undergoes expansion to reach the condensation pressure level. The energy released during this expansion process is subsequently converted into electrical energy by a generator. In the case of the PEORC, all the processes are the same as subcritical ORC but just the working fluid undergoes preheating and partial evaporation before being flash-expanded to the condensation pressure. In this study, R1233zdE was considered as the working fluid for both cycle concepts.

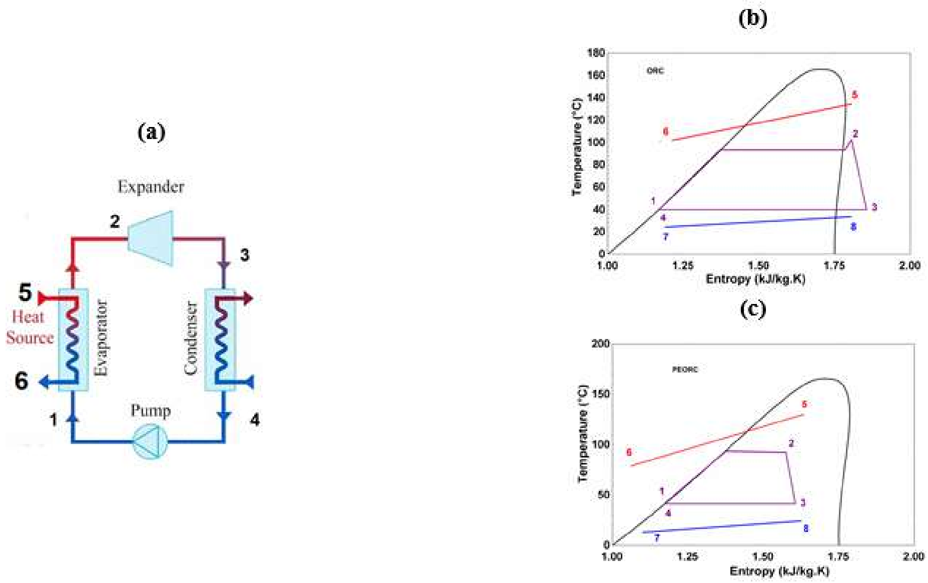

Fig. 1. Key components and diagrams illustrating the principles of ORC and PEORC. a) Configuration of the cycle with labeled components. b) T-s diagram showcasing an ORC with a heat source and cold source. c) T-s diagram specifically showcasing PEORC with HS and CS. The fluid states labeled 1−4 in a correspond to the corresponding states in b and c.

2.2. Analysis

In order to analyze a steady-state, steady-flow process, three balance equations are typically employed: mass balance, energy balance, and exergy balance equations. These equations are utilized to determine various parameters such as heat input, power output, exergy flows, rate of irreversibility, as well as energy and exergy efficiencies. The mass balance equation can be expressed in rate form as follows:

here $\dot{m}$ is the mass flow rate and the subscript *in* stands for inlet and *out* for outlet. The general energy balance then becomes

$$\dot{Q}+\sum \dot{m}_{in}h_{in}=\dot{W}+\sum \dot{m}_{out}h_{out} \quad (2)$$

The general exergy balance equation can be expressed in the form of rates, taking into account the flow and exchange of exergy within the system.

$$\sum_{in}\dot{m}_{in}ex_{in}-\sum_{out}\dot{m}_{out}ex_{out}+\sum_{r}\dot{E}x^{Q}-\dot{E}x^{W}-\dot{E}x_{d}=0 \quad (3)$$

where, ex refers the specific exergy. Ex^{Q} and $\dot{E}x^{W}$ denote the exergy transfer as a result of $,\dot{Q}_r$ and $\dot{W}$.
The term $\dot{E}x_d$ refers to the exergy destruction rate that occurs within the system.
The heat source utilization (HSU) is defined as follows:

$$HSU = \frac{h_5 - h_6}{h_5 - h_0}$$

where h_0 is the enthalpy of dead state. The exergy efficiency is calculated as

$$\eta_{ex} = \frac{\dot{W}_{net}}{\dot{m}_c ex_c}$$

3. RESULTS AND DISCUSSION

The following section provides a detailed description of the results and their discussion. Firstly, the obtained results showed that, power output of sub-critical ORC and PEORC can be estimated to be 1.844 kW and 3.088 kW respectively. Moreover, both cycles have yielded approximately same energy efficiencies as 4% while exergy efficiency of sub-critical ORC and PEORC has been calculated to be 8.19% and 13.73%. In the second step, the role of the vapor quality (x2) and degree of superheating (DSH) in the exergy efficiency, produced power and heat source utilization (HSU) of sub-critical ORC and PEORC are presented in order to assess the performances of these two studied cycles. Afterwards, the impact of the geothermal temperature (T5) on the exergetic efficiencies and heat source utilization of both cycles are evaluated and compared.

Fig. 2 presents the impact of vapor quality on the exergy efficiency and heat source utilization of PEORC. The results highlight that the choice of the vapor quality can have a significant impact on the achievable net power output. By increasing vapor quality, both mass flow rate and enthalpy difference of the expander decrease and produced power decreases as a result. Moreover, when the vapor quality varies between 0.1 and 0.8, the HSU decreases as about 72% which means less capability of a power cycle to extract heat from a heat source in relation to a reference state.

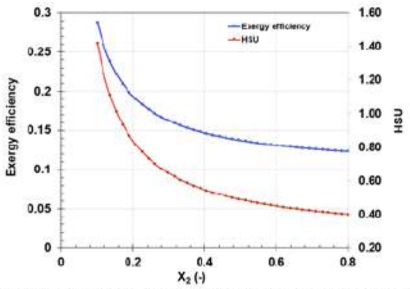

Fig. 2. The effect of vapor quality on the exergy efficiency and HSU.

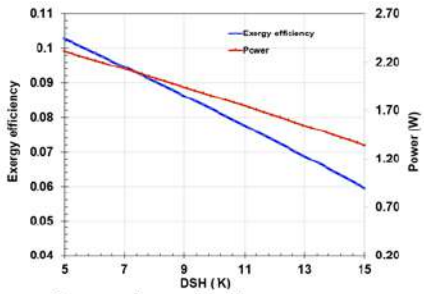

Fig. 3. The effect of degree of superheating on the exergy efficiency and HSU.

Fig 4 provides a clear comparison of performances of the PEORC and sub-critical ORC in terms of exergy efficiency and HSU through the variation of geothermal temperature. it is obvious that, for both cycles exergy efficiency and HSU improves with boosting the geothermal temperature from 110 C to 140 C. Also, the HSU of PEORC is about 1.93 times more than sub-critical ORC which reveals the superiority of PEORC in being capable to extract heat from a geothermal source.

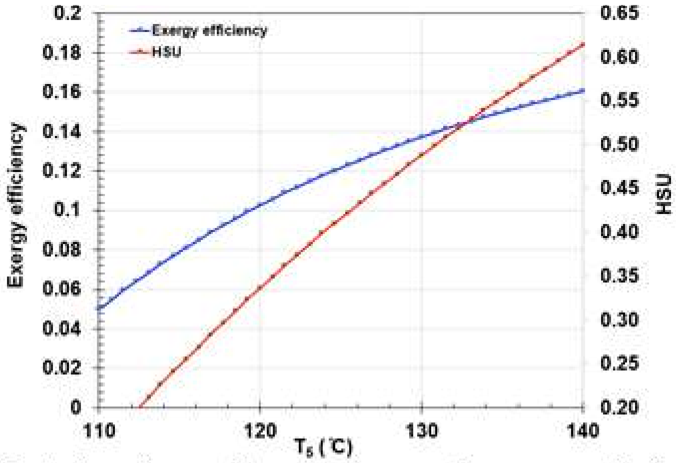

Fig. 4. The effect of geothermal temperature on the exergy efficiency and HSU.

4. CONCLUSIONS

Given the prevailing energy crisis, the significant issue of renewable energy sources, particularly low-grade heat resources, requires attention. The PEORC system emerges as a promising technology for the recovery and generation of power from such sources. Through analytical analysis conducted in this study, it is demonstrated that replacing an ORC system with a PEORC-based system yields greater power output and higher exergetic performance. In summary, the findings of this research can be summarized as follows:

•Vapor quality selection has the great impact on the attainable net power output as well as exergy efficiency of the system.

•Increasing the geothermal temperature from 110°C to 140°C enhances both the exergy efficiency and HSU for both cycles.

•Increasing the degree of superheating has a significant decrease in both the generated power and the exergy efficiency of the sub-critical ORC .

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EVALUATION OF INVERTER TYPES USED IN SOLAR ENERGY SYSTEMS WITH MULTI-CRITERIA DECISION MAKING (MCDM)

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ABSTRACT
In this study focuses on the evaluation of the types of inverters used in solar energy systems using the KEMIRA-M method, one of the Multi-Criteria Decision Making (MCDM) methods. 50kW inverters from seven different brands were evaluated under eight different criteria, four internal and four externals. These criteria cover the factors that play an important role in the inverter selection process and affect the effectiveness and efficiency of the selection. As a result of the evaluation made by the KEMIRA-M method, the most suitable inverter for solar energy systems was determined. The results obtained provide guidance to decision makers and provide a valuable basis for achieving goals in the solar sector. This study provides a framework for how this type of inverter selection process can be implemented in the event that inverter capacity or criteria are changed in the future. The KEMIRA-M method has proven to be an effective tool in the evaluation of the types of inverters used in solar energy systems.
Keywords: Multi-Criteria Decision Making (CCTV), KEMIRA-M Method, MATLAB, Solar Energy, Inverter

1. INTRODUCTION
While solar energy is at the forefront of renewable energy sources, technological advances towards its effective and economical use are underway (Chowdhury et al., 2022). As an important component of solar systems, inverters play a decisive role in the energy efficiency and performance of these systems (Nguyen & Le, 2022). However, the choice of the most suitable inverter often requires a complex decision-making process in which various factors are considered.

These factors include a wide range of criteria such as energy efficiency, reliability, cost, ease of installation, maintenance requirements, and operating life (Kou et al., 2023). This makes it both appropriate and necessary to apply Multi-Criteria Decision Making (MCDM) methods in such a selection process (Deshmukh & Cai, 2022). MCDM methods stand out as a valuable tool in choosing among alternatives, taking into account multiple criteria. These methods are particularly suitable for situations where conflicting criteria must be considered when selecting and evaluating inverters (Kou et al., 2023).

This study focuses on the evaluation of the types of inverters used in solar energy systems with Multi-Criteria Decision Making (MCDM) methods. First, it will provide an overview of the current MCDM methods in the literature and the types of inverters used in solar energy systems, then provide an approach to how these methods can be applied to the inverter selection process (Deshmukh & Cai, 2022). The aim of this study is to emphasize the importance of the right inverter selection in increasing the efficiency and efficiency of solar energy systems and to present a method to facilitate this selection process.

2. MATERIAL AND METHODS
In this study, alternatives for the selection of inverters to be used in solar energy systems were evaluated by KEMIRA-M method and the most suitable inverter was determined for the system. Alternatives consisting of 50kW Inverter types belonging to seven different brands for use in solar energy systems are evaluated under eight criteria, four internal and four externals, as in Table 2 and Table 3.

Table 1. Alternative Types

Brand A
Brand B
Brand C
Brand D
Brand E
Brand F
Brand G

Table 2. Internal Criteria

Usefulness of Interface
Maximum Efficiency
Dimensions
Number of MPPTs

Table 3. External Criteria

Unit Price
Brand Reliability
Lead Time
Service Support

From the internal criteria, the usefulness of the interface; that the interface of the inverter brand is understandable and easy to use by users, maximum efficiency; what percentage efficiency the brand of inverter works at, dimensions; to understand the usefulness of the dimensions of the inverter brand, the number of MPPTs; refers to how many MPPT numbers the inverter brand has. Unit price from external criteria; the value of the inverter brand in euros, brand reliability; how reliable the inverter brand is by customers, the lead time; how many days the seller's inverter brand can deliver to customers, service support; refers to how the inverter brand provides service support to customers.

In cases where the number of criteria is high, the criteria are divided into two groups as internal criteria and external criteria in order to make the transactions easier. The internal criteria are the technical and performance characteristics of the inverter brand, while the rest are the external criteria.

After the criteria are determined in the selection of the inverter, the experts in the field are listed according to the order of importance of the criteria, including internal and external criteria separately. After the ranking process, the alternatives were scored separately by the experts for interface usefulness from internal criteria and brand reliability and service support from external criteria. The data received by the experts and other data obtained were analyzed by the KEMIRA-M method on the MATLAB program.

3. RESULTS AND DISCUSSION

In our study, alternative inverter brands were asked to score between 1-7 from experts in the field of interface usability, which is one of the internal criteria, brand reliability from external criteria and service support. 7; highest score, 1; indicates a low score. Unit price; May 2023 inverter prices have been taken by the relevant companies. Lead time; It has been learned from the seller company how long it takes to deliver to the customer on a daily basis. Other criteria were obtained through the brands' datasheets. Brand names are not provided for privacy reasons. The results obtained are indicated in Table 4.

Table 4. Criteria Data of Alternatives

	Usefulness of Interface	Maximum Efficiency	Dimensions	Number of MPPTs	Unit Price	Brand Reliability	Lead Time	Service Support
Brand A	5	98.0	82	12	2300	4	10	3
Brand B	3	98.7	74	12	2600	3	60	4
Brand C	7	98.3	95	12	2270	7	10	6
Brand D	6	98.5	92	9	1900	6	180	7
Brand E	4	98.7	59	10	2050	5	120	5
Brand F	1	98.5	71	10	2400	1	10	2
Brand G	2	98.7	50	10	2100	2	75	1

Table 5. Criteria Rankings of Experts

Number of Expert	Usefulness of Interface	Maximum Efficiency	Dimensions	Number of MPPTs	Unit Price	Brand Reliability	Lead Time	Service Support
Expert 1	3	1	4	2	1	2	4	3
Expert 2	3	2	4	1	3	4	2	1
Expert 3	4	1	2	3	1	3	2	4
Expert 4	1	4	2	3	2	3	1	4
Expert 5	3	1	4	2	3	1	2	4
Expert 6	1	2	4	3	3	4	2	1
Expert 7	3	1	4	2	3	1	4	2
Expert 8	3	1	4	2	1	2	4	3

4. CONCLUSIONS

Table 6 shows the results we obtained from the MATLAB program using the KEMIRA-M method. According to the results obtained, Brand C was selected as the best alternative among the alternative inverter types. The last alternative inverter type among the alternatives was chosen Brand F.

Table 6. Rankings by Results

	Result of KEMIRA-M	Ranking
Brand A	1.1267	2
Brand B	0.6448	6
Brand C	1.4017	1
Brand D	0.9978	4
Brand E	1.0318	3
Brand F	0.6014	7
Brand G	0.8019	5

After all; The Kemira-M method contributes to the evaluation of solar energy-based green hydrogen production technologies in line with different criteria. The results obtained by this method provide an important basis for guiding decision-makers in the energy sector and achieving the goals of a sustainable energy transformation.

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EVALUATION OF SOLAR BASED GREEN HYDROGEN PRODUCTION TECHNOLOGIES WITH MULTI-CRITERIA DECISION MAKING (MCDM)

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ABSTRACT
Solar-based green hydrogen is one of the keys to a clean and sustainable future in the energy sector. The environmentally friendly production of hydrogen can contribute to reducing greenhouse gas emissions and reducing dependence on fossil fuels. However, there are different technologies and methods for producing hydrogen with solar energy and deciding between these options can be a complex process. Multi-Criteria Decision Making (MCDM) is an effective approach to decision processes where multiple criteria are considered. In the evaluation of solar-based green hydrogen production technologies, MCDM provides decision-makers with an objective evaluation and decision-making process. In this article, the role and importance of solar energy-based green hydrogen production technologies using Kemeny Median Indicator Rank Accordance Modified (KEMIRA-M) method, one of the MCDM methods, is discussed. To make this method even easier to use, code was written on the MATLAB program and the result of the analysis was revealed.
Keywords: Multi-Criteria Decision Making (MCDM), KEMIRA-M Method, MATLAB, Solar Based Green Hydrogen Production

1. INTRODUCTION
Hydrogen is now produced in large quantities from natural gas, a fossil fuel, causing greenhouse gases and other climate-changing emissions into the environment. Hydrogen energy can be obtained mainly through water electrolysis, in which water molecules are decomposed into hydrogen and oxygen gases using electric current. With the increasing importance of renewable energy sources, hydrogen is now attracting attention as an environmentally friendly and sustainable energy carrier. The depletion of fossil fuels and their environmental impact make the development of alternatives based on renewable energy inevitable. At this point, hydrogen energy plays an important role due to the fact that it is a zero-emission fuel and has a high energy density (Midilli et al., 2021). The electricity generated from solar energy is used in electrolysis to decompose into water, hydrogen, and oxygen. This method can obtain clean and environmentally friendly hydrogen gas and use it in energy storage, fuel cells and industrial applications. Hydrogen production powered by solar energy, especially through water electrolysis, is recognized as part of sustainable energy solutions (Dincer & Acar, 2022). However, this type of energy conversion process presents both technical and economic challenges. Moreover, when choosing between various hydrogen production technologies, various factors need to be considered (Dincer & Zamfirescu, 2020). In this study, he uses the Kemira-M method, one of the multi-criteria decisions making (MCDM) methods for solar-assisted hydrogen production. This approach provides a balance between the criteria and makes it easier to select the most appropriate technology (Granovskii et al., 2006). Nevertheless, the evaluation of hydrogen production technologies requires that the criteria be correctly defined and carefully evaluated. In this study, KEMIRA-M method, which is one of the MCDM methods, is used to determine the criterion weights of solar energy-based green hydrogen production technologies and to evaluate alternatives. KEMIRA-M method; In cases where the criteria are divided into internal and external criteria groups, it is a method used to determine the criterion weights and to choose between the alternatives we have determined by using these weights. In the first stage of this method, The alternatives from which we want to choose the most appropriate one are determined. Internal and external criteria are established for us to learn how the determined alternatives will be selected. The established criteria are sorted by experts in order of importance. Criteria ranking is done separately for internal and external criteria groups, The reason why we separate the criteria groups is that experts can sort a small number of criteria more easily. The KEMIRA-M method requires much less initial knowledge compared to other MCDM methods. The method does not require much initial knowledge of the criteria. It is used in areas where it is difficult and expensive to gather information from specialists. For the implementation of this method, it is enough for a few specialists to list the established criteria. Associating this method with MATLAB provides an effective tool for processing the decision matrix, applying weighting methods, and analyzing the results. MATLAB uses the Kemira-M method to help make objective and scientifically based decisions in the evaluation of solar-based green hydrogen production technologies. This study aims to make a scientific and technical contribution in this field by evaluating hydrogen production technologies supported by solar energy in terms of various criteria. This process could be an important tool in the development of a sustainable hydrogen economy and support wider adoption of these technologies.

2. MATERIAL AND METHODS

In this study, it is aimed to find the most appropriate type of electrolysis for the system during the installation phase of the solar energy-based green hydrogen production facility. The study was evaluated by KEMIRA-M method and the most appropriate type of electrolysis was analyzed. Alternatives to be used in the plant, consisting of five different types of electrolysis as shown in Table 1, were evaluated under eight criteria, four internal and four externals, as in Table 2 and Table 3.

Table 1. Alternative Types

Alkaline Electrolysis
Proton Exchange Membrane (PEM) Electrolysis
Oxide (SOEC) Electrolysis
Photoelectrochemical (PEC) Hydrogen Production
Biological Hydrogen Production

Table 2. Internal Criteria

Efficiency
Cost
Scalability
Technology Readiness Level

Table 3. External Criteria

Environmental Impact
Economic Impact
Social Acceptance
Energy Security

From these criteria, efficiency; the technology's capacity to produce hydrogen and its effectiveness in energy use, cost; the cost required to purchase, operate and maintain the technology, scalability; whether the technology is suitable for large-scale applications, technological readiness level; the stage of development of the technology and whether it is commercially available, environmental impact; the impact of technology on the environment, e.g. greenhouse gas emissions or water use, economic impact; the impact of technology on the economy, e.g. its potential to create jobs or its contribution to economic growth, social acceptance; whether technology is accepted by society, e.g. public views or policies, energy security; It addresses the safe, sustainable and uninterrupted nature of energy resources.

In cases where the number of criteria is high, the criteria are divided into two groups as internal criteria and external criteria in order to make the transactions easier. Internal criteria are directly related to the technical and performance characteristics of the plant to be installed. External criteria evaluate the relationship and interaction of the facility to be established with the environment.

After the criteria are determined in the selection of electrolysis, the experts in the field are listed according to the order of importance of the criteria, including internal and external criteria separately. After the ranking process, the alternatives were scored separately by the experts according to internal and external criteria. The data received by the experts were analyzed by the KEMIRA-M method on the MATLAB program.

3. RESULTS AND DISCUSSION

Alternative types of electrolysis in our study were asked to be scored between 0-100 from experts in the field. The averages of the results obtained are indicated in Table 4.

Table 4. Scoring Alternatives by Criteria

	Efficiency	Cost	Scalability	Technology Readiness Level	Environmental Impact	Economic Impact	Social Acceptance	Energy Security
Alkaline Electrolysis	79.6	98.6	91.4	98.6	92	95	92	91
PEM Electrolysis	98	56	93	86.4	93	83	100	95
SOEC Electrolysis	56.4	42	33.4	43.4	86	56	68	82
PEC Electrolysis	29	36	37	53.8	94.4	49	57	73
Biological Electrolysis	51	71.4	32	50	96	68.6	62	68.6

In Table 5, the internal and external criteria of the experts are listed among themselves. The incoming data were analyzed with the file prepared in MATLAB program with KEMIRA-M method and finalized.

Table 5. Criteria Rankings of Experts

Number of Expert	Efficiency	Cost	Scalability	Technology Readiness Level	Environmental Impact	Economic Impact	Social Acceptance	Energy Security
Expert 1	1	2	4	3	2	1	4	3
Expert 2	1	2	3	4	3	1	4	2
Expert 3	1	2	3	4	4	1	3	2
Expert 4	2	1	3	4	3	1	4	2
Expert 5	2	1	4	3	3	1	4	2

4. CONCLUSIONS

Table 6 shows the results we obtained from the MATLAB program using the KEMIRA-M method. According to the results obtained, PEM Electrolysis was selected as the best alternative among the alternative electrolysis types. The last type of alternative electrolysis among the alternatives was PEC Electrolysis.

Table 6. Rankings by Results

Alternative Type	KEMIRA-M Result	Ranking
Alkaline Electrolysis	1.4888	2
PEM Electrolysis	1.8616	1
SOEC Electrolysis	0.6128	3
PEC Electrolysis	0.3284	5
Biological Electrolysis	0.5268	4

After all; The Kemira-M method contributes to the evaluation of solar energy-based green hydrogen production technologies in line with different criteria. The results obtained by this method provide an important basis for guiding decision-makers in the energy sector and achieving the goals of a sustainable energy transformation.

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INVESTIGATING THE IMPACT OF GREEN CERTIFICATE CAMPUS IMPLEMENTATION ON GREENMETRIC IN UNIVERSITY CAMPUSES

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ABSTRACT
Universities yielding knowledge and technology are considered as micro-cities due to their size, population and activities which lead to environmental issues such as pollution and energy consumption. Having a pioneering role in the region and society, universities are of key importance in implementing sustainability activities. Today, the formation of sustainable and green campuses can be examined as per the university, city and community scales with the help of tools such as the Green League, Environmental and Social Responsibility Index, GreenMetric, LEED, BREEAM and Green Certification. In this study, widely used GreenMetric implemented by universities worldwide and the Green Certification Campus assessment tool developed in our country were compared. This study has objective to achieve the level and score range in GreenMetric when a university campus gets a certificate scoring the campus as 'pass,' 'good,' 'very good,' and 'national excellence'.
Keywords: University Campuses, Sustainable Campus, Green Campus, Green Certification, GreenMetric.

1. INTRODUCTION

Including educational, research, housing, health, and social units, with green spaces and circulation systems, universities play guiding and innovative roles. After the Stockholm Declaration, green campus initiatives were initiated to achieve sustainable development goals and are becoming increasingly common (Nurcahyo et al., 2019; Pandya et al., 2022). Today, various factors have been developed to evaluate the green and sustainable nature of universities such as the Green League, Environmental and Social Responsibility Index and GreenMetric. Within these systems, GreenMetric is the most common method and it has six categories to create global awareness and sub-themes with corresponding references (Lourrinx and Budihardjo, 2019).

There are also assessment tools which have been developed to achieve sustainability. LEED (Leadership in Energy and Environmental Design) and BREEAM (Building Research Establishment Environmental Assessment Method) are one of the most commonly implemented tools worldwide. Turkey also has Green Certification system which supports the sustainable development with a systematic and holistic approach, involves national and international standard procedures, and provides benefits to the economy, ecology and society in the long term (Koçak and Topay, 2022). This system is eligible to grant the "green" designation to a campus in Turkey and improves the innovative and guiding role of universities. The green certification includes six themes, 23 categories and 75 criteria with respect to buildings, while the green certification for campuses involves six themes, 21 categories and 77 criteria. The assessment tool includes four categories, namely "pass," "good," "very good," and "national excellence" (Ministry of Environment, Urbanization, and Climate Change, 2022).

In general, embracing sustainability and development from an ecological, economic, and social perspective, GreenMetric and Green Certification systems share common principles with respect to creating resilient campuses improving sustainable development factors and they are direct relation with the requirements and goals of universities.

Within the scope of this study, there is an obligation to have at least one green building in the existing residential areas category. The approximate score of a university, which received a certificate in the categories of "pass", "good", "very good", "national superiority" from the Green Certificate Building evaluation tools, in the GreenMetric system has been examined. Afterwards, the expected rankings within the framework of the current score table were examined.

Table 1. GreenMetric and Green Certificate comparison chart

GreenMetric			Green Certificate Site			
Categories and Sub-Themes	Weight	Range of Achievable Points	Pass	Good	Very Good	National Excellence
Building and Infrastructure	%15					
⋮		⋮	⋮	⋮	⋮	⋮
Energy and Climate Change	%21					
⋮		⋮	⋮	⋮	⋮	⋮
Waste	%18					
⋮		⋮	⋮	⋮	⋮	⋮
Water	%10					
⋮		⋮	⋮	⋮	⋮	⋮
Transportation	%18					
⋮		⋮	⋮	⋮	⋮	⋮
Education and Research	%18					
⋮		⋮	⋮	⋮	⋮	⋮
Total		2500-10000				

3. RESULTS AND DISCUSSION

3.1. Building and Infrastructure

With respect to the GreenMetric structure and infrastructure category, achieving the criteria to create budget, operation, and maintenance plans, evaluating the building's life cycle, planning the operational lifespan, and generating monthly and annual measurement reports are scored ranging from 75 to 300 in GreenMetric.

Concerning the Pass level in the Green Certificate Site, the fulfilment of criteria like calculating the building density of the region, evaluating demographic characteristics, determining and making conservation decisions regarding existing ecological values, identifying and mapping areas and species covered by vegetation, creating agricultural/forest areas and water resource maps and establishing equal/accessiible/safe public spaces meeting the needs are scored ranging from 50 to 1200.

Since all criteria in the structure and infrastructure category achieved the Pass level, other categories were not further examined; however, more detailed projects such as calculating, increasing and defining the percentage of open green spaces will be prepared.

3.2. Energy and Climate Change

In the GreenMetric energy and climate change category, it is assumed that a score ranging from 15 to 300 is obtained in the GreenMetric Building due to the assumption of receiving points from the innovation category and having an advanced monitoring/evaluation system. This is based on the criteria of smart building application. Achieving this score is possible by conducting energy-related analyses, developing potential energy strategies, performing periodic energy consumption checks, using energy-efficient devices, opting for local and/or recycled materials, determining steps to be taken after the building's lifespan, improving building energy performance, and installing renewable energy sources within the area or purchasing them from outside the area. A score between 145 and 1300 can be achieved by meeting these criteria.

In the GreenMetric Passing level for Sustainable Campus, the criteria to meet renewable energy sources to meet the energy needs of the area, providing education and training for increased skills, and enhancing innovative programs to support social development and employment opportunities can be met. A score between 125 and 500 can be obtained. Since all the criteria in the energy and climate change category meet the Passing level, other categories were not further examined. However, further detailed studies have been conducted to meet the criteria required by the good, very good and national excellence categories as well as reducing carbon emissions by at least 20%.

3.3. Waste

In the GreenMetric waste category, the preparation of waste management plans is a mandatory criterion in the GreenMetric Building. In line with the goal of zero waste management, there are criteria for the treatment of organic and inorganic waste, the collection of recyclable waste, the separate accumulation and treatment of hazardous waste. Additionally, the separate accumulation and promotion of reuse of waste generated from renovation and construction activities are encouraged. It is possible to score between 375 and 1500 in the waste category of the GreenMetric Building.

In the Passing, Good and Very Good levels of the GreenMetric Sustainable Campus, there are no corresponding criteria in the waste category. At the National Excellence level, there are criteria related to the non-mixing of rainwater with sewage and conditions for sewage disposal, and these can get score from 75 to 300.

3.4. Water

In the GreenMetric water category, achieving water efficiency and effectiveness through the selection of efficient fixtures, preventing water loss and leaks, and ensuring the recycling of greywater and rainwater are criteria to get a score ranging from 200 to 800 in the GreenMetric Building.

At the Passing, Good, and Very Good levels of the GreenMetric Sustainable Campus, there are no direct criteria in the water category. However, at the National Excellence level, there are criteria for the recycling of wastewater and its utilization in recreational areas, as well as the detailed planning of rainwater harvesting systems, which can result in a score between 50 and 200.

3.5. Transportation

In the GreenMetric transportation category, the detailed criteria found in the GreenMetric Sustainable Campus were not addressed at the building scale. At the Passing level of the GreenMetric Sustainable Campus, criteria including reducing car dependency, diversifying transportation alternatives, prioritizing pedestrian and bicycle use, creating a five-year recommended transportation plan and ensuring easy access to open spaces can get result ranging from 175 to 700.

At the Good level of the GreenMetric Sustainable Campus, although there is no additional score obtained beyond the Passing level, the criteria emphasized at the Passing level were further detailed, and specific guidance on bicycle use was provided in addition to the GreenMetric themes.

At the Very Good level of the GreenMetric Sustainable Campus, the transportation criteria addressed at the Passing and Good levels were detailed at the design scale to promote a more sustainable approach, although no additional GreenMetric theme was fulfilled.

At the National Excellence level of the GreenMetric Sustainable Campus, criteria including evaluating parking areas and making future projections, providing transportation services within the project area, promoting the use of electric vehicles can get score ranging from 410 to 1800.

3.6. Education and Research

The themes such as increase in the number of sustainability-related events in the GreenMetric education and research category, the elaboration of the sustainability report with the data obtained during the certification process, the increase in the number of programs aimed at improving teaching and learning, the number of sustainability community services projects organized and/or involving students and the number of initiatives related to sustainability corresponds to the Green Certificate Settlement criteria and it is possible to obtain a score in the range of 150-600.

4. CONCLUSIONS

In this study comparing GreenMetric and Green Certificate evaluation systems, it is expected that GreenMetric receives a score between 1320-7200 if the certificate is at the 'pass', 'good', 'very good' level in the Green Certificate Settlement, but considering that the sustainability studies are detailed with the increase in the certificate level, it is predicted that the GreenMetric ranking increases. If a certificate at the "national superiority" level is obtained in the Green Certificate, it is expected to achieve score from 1682 to 8800.

GreenMetric themes, which are not directly included in the Green Certificate criteria but indirectly promoted, it seems possible to rank 26th when 2022 World ranking scores are taken as reference. In our country, it is possible to achieve a success higher than Istanbul Technical University, which ranks 47th with 8585 points (UI GreenMetric, 2023).

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A CASE STUDY OF CARBON FOOTPRINT MEASUREMENT IN THE UNIVERSITY CAMPUS

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ABSTRACT
The rapid increase in carbon emissions and unwillingness to interfere by the policy makers towards this situation have affected both profit and non-profit organizations. United Nations has declared 17 sustainable development goals in 2015 which are aims to provide clear information about environmental challenges. The 13th SDG addresses and focuses on climate change. At this point, educational institutions act as a catalyst to educate and implement in this regard. In the current literature, it is observed that there is an effort to measure the carbon footprint in higher education institutions and to reduce it. Universities around the world, including Turkey, measure their own carbon emissions and try to develop tools to reduce carbon emissions. This research has the same aim as well. In this study, the carbon footprint of Haliç University was measured for the first time. Carbon emissions of the university are presented in the article within the framework of greenhouse gas emission (GHG) scopes.
Keywords: greenhouse gas emission, carbon footprint, higher education institution, GHG protocol

1. INTRODUCTION
Sustainable development is defined as ensuring harmonious institutional change based on resources, investment, technology, and the ability of current and future potential development to meet human needs in the report (Brundtland, 1985). "Our Common Future" which has published by the United Nations, has mentioned the effort of integrity of sustainable development. Higher education institutions have the task of educating the younger generations and guiding the next generation by applying them in their own institutions. Li, Chen, Yang et al. (2021) has been revealed in their bibliometric analysis research which is covering the years 2010-2019, that there is a continuous increase in carbon footprint studies. However, universities have the opportunity to progress and develop with new technologies and applications, apart from legal obligations. Learning tools are developed with case studies. At the same time, it leads the way for improvement by showing the limits at the organizational level for researchers. The purpose of this study is to quantify and reveal the current situation the Carbon Footprint at Haliç University. Besides, Haliç University never used Carbon Footprint measurement since it has established. This study will include the first carbon footprint measurement of Haliç University. This is another differential feature of this research.

2.Methods
Although the carbon footprint issue is a mainstream agenda, measurements should be made according to the characteristics of the institutions and road maps should be developed accordingly. The International Organization for Standardization (ISO), the World Business Council for Sustainable Development (WBCSD), the World Resources Institute (WRI) and the British Standards Institution (BSI) has developed different carbon footprint assessment standards which refers to ISO14064, GHG Protocol, PAS2050 (Gao, Liu, Wang, 2014). Yañez et al. (2019) examined carbon footprint research done on university campuses and, they stated the most widely used methods in their article. Among these methods, two most used methods stand out: ISO 14064 and the Greenhouse Gas (GHG) Protocol. In the same study, the authors emphasized that there is no unique study to show results and are usually expressed in terms of tCO2e per student/employee/person (Yañez et al., 2019). In the report published by the IPCC, the effect of all greenhouse gases on global warming is measured in CO2 equivalent carbon footprint (IPCC, 2014). Wiedmann and Minx (2008) define a carbon footprint as a measure of the total carbon dioxide emissions that a product or activity produces directly or indirectly throughout its life stages. Limits and boundaries are differed in carbon footprint measurement of people, organizations, cities, countries. The bottom line is to make the measurement correctly within the framework of need and area. This section will be discussed the following topics: i) Reviewing of the historical and current physical condition of the university, ii) Explanation of the methodology choice with justifications, iii) Calculation of direct and indirect emissions produced by the university.

2.1.Description of the carbon footprint measured land: Haliç University
Haliç University has founded in 1998 and it continues its activities for more than 25 years. The University has a single main campus which is in İstanbul. This campus consists of 7 Faculties, 3 Vocational Schools, a Conservatory, and a Postgraduate Education Institute. The campus, which is located on an area of 1959794 m2, has 18 buildings. Haliç University had around 15346 registered students and 746 staff members in 2023. The university does not yet have a policy regarding sustainability and green campus practices. As mentioned before, this will be the first carbon footprint measurement of the University.

2.2.CF Measurement Methods and GHG Protocol

The most common approach to calculating greenhouse gas emissions is the application of documented emission factors. These factors are calculation rates that correlate GHG emissions with a representative measure of activity at an emission source. The IPCC guidelines refer to a hierarchy of computational approaches and techniques for the application and direct monitoring of generic emission factors (GHG Protocol, 2004).

Scope 1 GHG emissions refer to the purchased quantities of commercial fuels such as natural gas and heating oil. Scope 1 GHG emissions are calculated based on the using published emission factors. Scope 2 GHG emissions are calculated with the sources of electricity consumption and supplier-specific, local grid, or other published emission factors. Scope 3 GHG emissions include primarily fuel use or passenger miles and are calculated by published or third-party emission factors (GHG Protocol, 2004: 42). As a result of these measurements, while no net decrease is observed in emissions, the carbon footprint can be reduced with the participation of the university's stakeholders.
According to GHG Protocol Corporate Standards there are two approaches. The first one address cross sectoral tools which are include stationary combustion, mobile combustion, HFC use in refrigeration and air conditioning, and measurement and estimation uncertainty. The second one comprises the emission in specific sectors such as aluminum, iron and steel, cement, oil and gas, pulp, and paper (GHG Protocol, 2004: 42). This research will be carried out with the cross sectoral approach, which is in the first category.

2.3. Calculation of the Emissions and Results

While the GHG Protocol Corporate Standard (WRI and WBCSD, 2004) has indicated the scopes 1 and 2 emission requirement, scope 3 has unsolid framework and it stands optional. For this reason, it would be appropriate for universities to decide on the emission consumption items to be included in the carbon footprint calculation in line with their own experiences. Based on the characteristics of universities, consumption of fossil fuels is usually included in scope 1, while purchased electricity is included in scope 2 (Kiehle et al., 2023).

Scope 1

Scope 1 includes direct emissions which are refers to cars and other transportations owned by the school and fuel combustion. The following formula was used to calculate Scope 1 emissions:
$\boldsymbol{EtCO2}$ = [(FC × $\boldsymbol{d}$ × $\mathbf{101\ -3}$) × C$\boldsymbol{F}$ × $\mathbf{102\ -3}$] × $\boldsymbol{EF}$ × $\mathbf{103\ -3}$ × POC × GWP

Where;
FC: Fuel consumption (m3)
d: Density (kg/m3)
CF: Conversion Factor
EF: Emission Factor
POC: Percentage of oxidized carbon (1% for CO_2 according to IPCC 2006)
GWP: Global warming potential (1 for CO_2 according to IPCC 2006)
Since the fuel consumption amounts of the vehicles can be reached directly, there is no need to calculate over km.
$\boldsymbol{EtCO2}^{*}$ = [(FC × $\boldsymbol{d}$ × $\mathbf{101\ -3}$) × C$\boldsymbol{F}$ × $\mathbf{102\ -3}$] × $\boldsymbol{EF}$ × $\mathbf{103\ -3}$ × POC × GWP

Where;
FC: Fuel consumption (L)
d: Density (kg/L)
$\mathbf{101,3\ -3}$ = coefficient of conversion from kg to tons
CF: Conversion Factor (TJ/Gg)
$\mathbf{102\ -3}$ = coefficient of conversion from tons to gigagrams
EF: Emission Factor (kg/TJ)
POC: Percentage of oxidized carbon (1% for CO_2 according to IPCC 2006)
GWP: Global warming potential (1 for CO_2 according to IPCC 2006)

Scope 2

It contains all the electricity information that the university purchases and consumes from outside. All information was obtained from the administrative unit of the university. The following formula was used to calculate Electricity consumption:

$EtCO2$ = [(EC × EF × TDL%) + (ET × EF)] × 10-3

EC: Electricity Consumption

EF: Emission Factor

TDL: Transmission and Distribution Losses

$EtCO2$ = WC × EF × $10-3$

WC: Water Consumption

EF: Emission Factor (kg/L)

Scope 3

Scope 3 includes varying indirect couple of emissions. In this research, rental cars and school ring services were calculated.

$EtCO2^*$ same formula is used for fuel consumption.

Table 1: Scopes and amounts of CO_2 emission of Haliç University

Scope	Emission Source	CO_2 emission (tone/year)	Emission per person
Scope 1	Natural gases	1330.9587	0.082709
	Owned cars gasoline consumption	11.9872	0.000745
	Owned cars diesel consumption	24.1961	0.001504
Scope 2	Purchased electricity	2457.76973	0.152732
	Water consumption	0.0214942	0.000001
Scope 3	Rented cars gasoline consumption	37.4866	0.002330
	Rented cars diesel consumption	25.6038	0.001591
	School buses & ring services	339,2534	210.821153

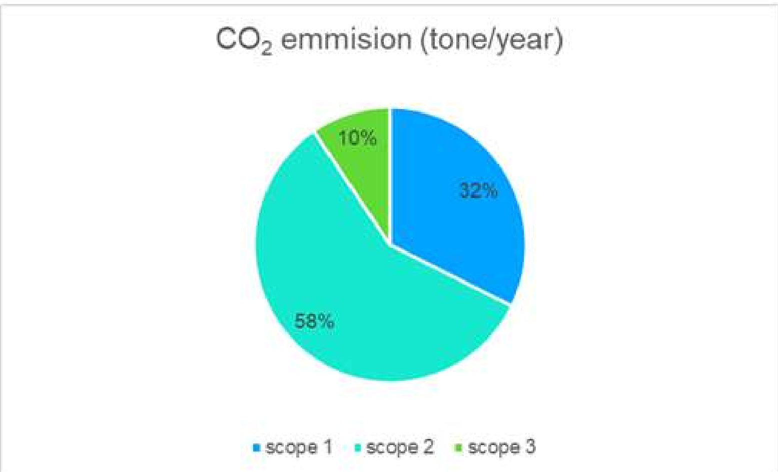

Figure 1: Total CO_2 emission consumption percentages

2.4. Limitations of the Study

Data from 2022 were used in the measurement. Since it is the first measurement of the university, a comparison with previous years could not be made. As it is also a new approach for corporate culture, only basic data could be obtained. Another limitation concerns the issue of scope. The scope of water consumption in terms of higher education institutions is controversial in the literature. While the water consumption in the calculations of the production facilities was examined within the scope 3, as a result of the literature review, it was observed that the water consumption was considered in the scope 2 in the carbon footprint measurement of the higher education institutions (Üreden, Özden, 2018). In this study, the scope of water consumption was taken as scope 2.

3. Conclusion

Sustainability and green campuses are still an emerging and developing issue for universities. The fact that this development is only in the education part and that there is no pressure and sanctions on universities like other production facilities causes the subject to progress slowly.

A similar issue can be mentioned in the case of Haliç University. This is the first carbon footprint report of Haliç University. As a result, Haliç University 4227.277024 tons of CO2-e in total of 2022 year. There is 0.26269 tons of CO2-e per person.

The university needs to include sustainability and the environment in its strategic plans. The activation of waste management and smart electricity systems within the school will be meaningful steps to manage carbon emissions. Most fundamentally, it is essential for the university to replace its electricity consumption with renewable energy.

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BLENDED FINANCE FOR THE JUST TRANSITION MECHANISM: BIBLIOMETRIC ANALYSIS FOR GREEN DEAL IN THE SCOPE OF FINANCIAL SOLUTIONS

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ABSTRACT
The European Union aims to reduce carbon emissions to 55% by 2030 and to be carbon neutral by 2050. To achieve this goal he document that explains the transition to achieve this goal is The Fit for 55 package. This package is a set of proposals that EU legislation could revised to ensure that EU policies are in line with the climate targets adopted by the Council and the European Parliament. At the same time, The Fit for 55 package aims to provide a coherent and balanced framework for achieving climate targets. While the European Parliament has announced that 100 billion euros will be available in the market for the fair and balanced transition to carbon neutral, the issue of investment financing the just transition is still being discussed by public and private sectors. This study will first give information about the financial research of green deal with the bibliometric analysis method. Then, the blended financing technique will be discussed in the consideration of current discussions and the information published by the European Parliament and will be presented as a proposal to the just transition mechanism.
Keywords: BLENDED FINANCE, FIT FOT 55 PACKAGE, JUST TRANSITION MECHANISM, GREEN DEAL

1. INTRODUCTION
The European Green Deal presented in December 2019 can be summarized as reducing net greenhouse gas emissions to zero by 2050 and creating an economic and industrial opportunity by ensuring the transition to a green economy for Europe. The green deal is not limited to only European countries. Carbon neutral goal largely affects developing countries and connects the commercial and economic relations between Europe and other third-party countries. This radical goal has raised concerns, particularly in developing countries, and has led to debates about its just transition and financing. The Fit For 55 was announced to eliminate these concerns and ensure that the just transition takes place with certain programs and financial resources. The "Fit for 55" package is a set of proposals that propose changes and revisions to EU legislation to ensure that EU policies are in line with climate targets. While grounding the EU's pioneering position against climate change, it creates a framework that strengthens the EU industry by maintaining just transition and maintaining its innovative and competitive power. However, funding sources are still a matter of concern, particularly for developing countries.

This study will address the debates on the financing of the carbon neutral goals of the European Union and propose a blended finance technique. The first section will introduce and give brief information about The Fit For 55 package. Afterwards, the blended finance method and its use will be explained. Due to the investment costs of sustainable energy technologies are high blended finance method will be presented as a proposal for this investment. In the light of the information given in these two sections, the financing model will be discussed within the framework of the "fit for 55" package.

2. LITERATURE REVIEW
2.1. The Fit For 55: The Just Transition Mechanism
The Fit for 55 package is a set of proposals to revise and update EU legislation and implement new initiatives to ensure that EU policies are in line with the climate targets adopted by the Council and the European Parliament. As European Commission dedicated The Just Transition Mechanism (JTM) is a fair tool for the transition to a climate-neutral economy by leaving no one behind (commission.europa.eu, 2020). JTM will mobilize at least 100 billion Euros in the market, ensuring that social and economic impacts are made through a just transition. 100 billion Euros includes direct investment, mobilization of investments and public credit supported by the EU budget (European Commission, 2020). The JTM consists threefold pillars: i) The Just Transition Fund -which will be mobilized directly-, ii) A dedicated scheme under the InvestEU program -that is special program- iii) A public sector loan facility provided by the European Investment Bank to mobilise additional investments in the regions concerned is the -which constitutes the main research subject of this study-.

2.2. Blended Finance
OECD (2018) defines blended finance as "The strategic use of development finance for the mobilization of additional finance towards sustainable development in developing countries." (OECD report, 2021).

Table 1. Definition of blended finance (Source: Spratt, Lawlor, Coppens (2021))

Definition type	Inputs	Outputs	Institutional Source
1	Development finance or non-financial resources from public/philanthropic or private sources	Additional market-rate investment for SDGs from public or private sources	OECD
2	Concessional finance from public/philanthropic or private sources	Additional market-rate investment from DFIs and/or private sources for private sector development and SDGs.	DFI Working Group
3	Catalytic capital from public/philanthropic sources	Additional private investment for SDGs in emerging or frontier markets	Convergence
4	Grant finance from public sources (EU)	Additional investment from IFIs and/or private investors	EU

In the light of these definitions, there are currently 4 different finance models used: i) In business terms, all development-oriented finance (and non-financial inputs) leading to additional public or private investment supporting the SDGs, ii) Concessional development financing (excluding grants) that supports SDGs, leading to additional public or private investment on commercial terms, iii) Concessional development financing (including grants) leading to additional private investment in support of the SDGs, iv) Development finance grant leading to additional public investment on commercial or near-commercial terms supporting SDGs (Spratt, Lawlor, Coppens, 2021).

3. METHODOLOGY

In line with the claim of the research, bibliometric analysis method has been used to understand where the current literature is standing on the financial aspect of just transition. Before mentioning the findings of the research, it is useful to explain the subject of constraints.

The search was limited to Web of Science database and to show visualizing patterns of the previous studies on selected keywords we used VOSwiever software. The keywords used for data collection include “green deal”, “just transition”, and some of the keywords, that related with finance. The search field is limited to “topic” (which includes searches in “titles,” “abstracts,” and “keywords”), and there is no chronological filter.
The search was conducted using the following keyword strings to determine any research trend on financial aspects of green deal or specifically just transition.
1. “green deal”
2. “just transition”
3. (TITLE-ABS-KEY (“just transition”)) AND (TITLE-ABS-KEY (“Financial” OR “finance” OR “funding” OR “economic*” OR “invest*”))

A summary of the results of search attempts is shown in the table.

Table 1. Summary of the search results

Keyword string	Document
"green deal”	1310
"just transition”	559
(TITLE-ABS-KEY ("just transition")) AND (TITLE-ABS-KEY ("Financial" OR "finance" OR "funding" OR "economic*" OR "invest*"))	272

Co-occurrence analysis is used to study potential relationships within this data. This method focuses on analyzing counts of co-occurring entities within a collection of units (Zhou, Zhou, Huang, 2022). We choose fifteen as the minimum number of occurrences of a keyword to meet the threshold.

To begin to understand relationships and occurrence in a general sense we analyze “green deal” string first. There are 28 keywords within that limitation and none of them is related with a financial method.

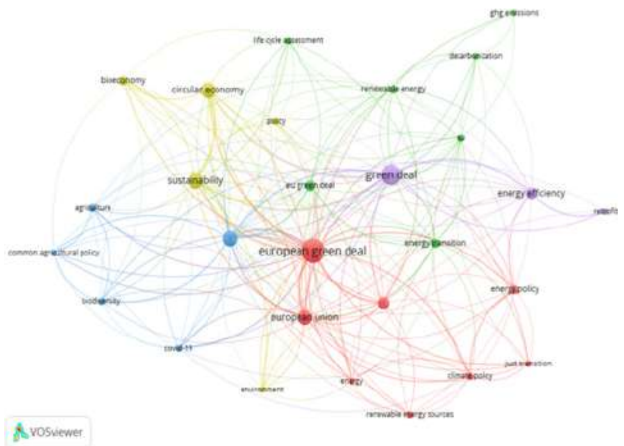

Fig.1. Network visualization of "green deal" search on WOS

To narrow the scope interested area, second search was conducted on "just transition" keyword string. There are 14 keywords within that limitation and none of them is related with a financial method

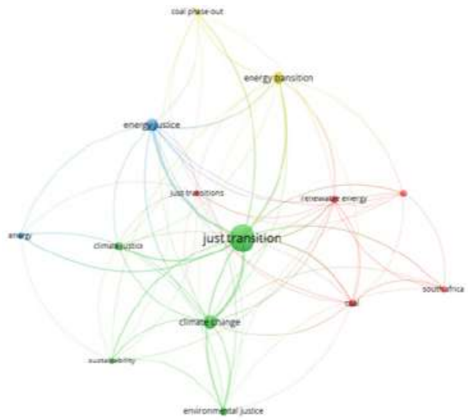

Fig.2. Network visualization of "just transition" search on WOS

Even with a keyword string that include possible financial words we did not find any keyword related with a financial method.

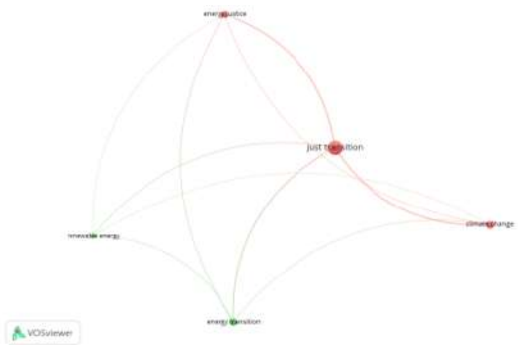

Fig.3. Network visualization of (TITLE-ABS-KEY ("just transition")) AND (TITLE-ABS-KEY("Financial" OR "finance" OR "funding" OR "economic*" OR "invest*")) search on WOS

4. CONCLUSIONS

As can be seen from the analysis results, there is no finance model determined and used for green transformation. In line with this information, the financial distribution of the just transition mechanism needs to be discussed separately. The importance of this position is obvious among the development plans of the developed and developing countries, particularly for the 100 billion Euros and beyond.

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TURKEY'S CHANGING ROLES IN THE GEOPOLITICS OF ENERGY TRANSPORT: A DISCURSIVE APPROACH

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ABSTRACT
After the end of the Cold War the issue of energy transportation emerged as a new pillar and critical dimension of Turkey's geopolitical importance and made an irreversible entrance into the agenda of Turkish governments. Turkey adapted its traditional geopolitical language to the energy field by developing many metaphors and concepts such as energy bridge, energy terminal, energy corridor, energy hub or energy trade center that identify Turkey's strategic position in potential oil and gas transportation projects in Eurasia region. What has been worth to consider has been the changing prominence of these concepts and metaphors depending on certain time periods. This paper draws attention to this change in the usage of these concepts and metaphors by highlighting the breaking points in the official discourse on Turkey's geopolitical role in energy transport in post-1990 process. Inspired by the views of critical geopolitics approach, it seeks to understand the relation between the context, discourse and Turkey's foreign energy policy within historical process of energy relations with specifically US, EU and Russia. The paper also touches upon the effect of the war in Ukraine, energy transition, Turkey's new position as a small-scale hydrocarbon owner, its policies on renewable energy and hydrogen in the process of recreating its geopolitical roles.
Keywords: Turkish foreign policy; energy geopolitics; discourse

1. INTRODUCTION
Turkey has engaged with the issue of energy in a way of balancing its internal energy needs-i.e. its own energy security with its very advantageous geopolitical position for energy transport projects since the end of the Cold War. This engagement reflected itself in the official discourse that had a special focus on the roles that Turkey would play in the transport of energy while securing the supply for growing energy demand has been the other important pillar.
This paper attempts to illustrate Turkey's "evolving" roles in geopolitics of energy transportation after the end of the Cold War and to explain the post-1990 process of Turkey's discourse of energy transport as a historical narrative, which is derived from the highlights and breaking points in the official discourse/ practical geopolitics (Tuathail, 2002). Leaving the importance of Turkey's geopolitical position out of the discussion, the primary focus is given to the change of the dominant metaphors that represent Turkey's geopolitical role and timing of the change with a concern on the related context. It is argued that slight or significant changes in the expressed roles attributed to Turkey in regional energy projects prove the context-related nature of the used concepts .
By giving the historical flow and hence the evolution of discursive practices, the study tries to explain how Turkey's geography is redefined in terms of pipeline politics.
The metaphors that are used in the discourse of Turkey's geographical role in energy transportation, i.e. energy bridge, energy terminal, energy center, energy corridor, energy hub, energy trade center, are hence evaluated as tools of justifying and preparing certain policy choices. So that these metaphors are presented as expressions of breaking points of policy according to the way/intensity they are used, while the simultaneous use of the metaphors is seen as an effort to enlarge the space of balancing between seemingly contradicting policies.

2. MATERIAL AND METHODS
The analysis of the discourse is inspired by Lene Hansen's research model (2006). Through the aim of tracing the evolving discourses of political leadership, speech text material of leaders (heads of state (president, prime minister) and ministers of energy and foreign affairs of the Republic of Turkey.) analyzed in a way of finding the most frequently and consistently articulated signs, i.e representations of geography through metaphors and specifically developed concepts and they are evaluated in the context they are developed.
The analysis is made for 1991-2020 period in a historical/chronological way. "The breaking point" is accepted as the adoption of a new metaphor and maintenance of its use more saliently /frequently compared to previous others in a specific period. The search is conducted through pdf / soft text search /manual search of printed texts/text books.

3. RESULTS AND DISCUSSION

The years between 1991-1994, 1994-1998, 1998-2006 (with two sub-periods: 1998-2002, 2002-2006), 2006-2020 have been identified as the periods that one representation is preferred, while other representations become weaker although not totally abandoned. Following the assumption that discourse is followed by policy, it is assumed that a specific metaphor has become the tool of a specific policy. That is, changes in the use of metaphors have been the expressions of breaking points of policy, while the simultaneous use of the metaphors is seen as an effort to enlarge the space of policy for balancing between seemingly different policies.

3.1. Bridging for energy: initial discourses on Turkey's new geographical roles (1991-1994)

1991-1994 has been a period of meeting with the geopolitics of energy for Turkey. The first role of Turkey would play in transporting the energy resources in the newly emerged political context of Post-Cold War era emerged as to be a “bridge” for energy. While bridge is one of the most used metaphors to express Turkey’s exceptional geopolitical position (Yanık, 2009), the new context that created new “Turkic” neighbors in Central Asia and the Caucasus with rich energy resources made Turkish leaders to adapt the metaphoric usage of the term into the field of energy through the mid-1990s. Energy and pipelines started to appear in the official speeches within the early euphoria towards region. “Bridge” as an existing and handy concept has been applied to a possible role in energy transportation, almost without a mention of Turkey’s lack of energy sources. Here the function of the bridge of energy is mainly characterized by serving to West/Europe: Turkey would serve as a bridge, from East to West, to close the energy gap of Europe by transporting rich energy sources of the East, thus be indispensable for Europe and prevent exclusion from the EC-EU. During this period, the first steps were taken for the Baku-Tblisi-Ceyhan (BTC) oil pipeline project and some initial negotiations for Turkmen gas.

3.2. Constructing a geography of energy: Turkey as an energy terminal/ energy center (1994-1998)

1994-1998 period is the exact beginning of constructing a geography of energy in which Turkey aimed to be an actor. In these years, the language of the political leadership focused around the metaphor of “terminal”, i.e. “energy terminal” and later “energy center”. While energy started to appear more clearly as a foreign policy area rather than a separate area of relations, the awareness of domestic energy demand increased and brought cooperation with Russia and Iran as energy providers and non-Western partners.

The usage of the “energy terminal”, which is innovatively developed for the first time in Turkey, was representing the effort of attracting the potential parties engaged in the possible energy transportation projects to cooperate with Turkey in a way that Turkey’s geography would physically be the arrival point of the transported oil and gas. The use of the term has represented a change of policy towards Caucasus and Central Asia, from a culture based policy to a policy with economic concerns (Erşen, 2013).

In this period, Turkey started to ideationally construct an energy (first and foremost oil and later gas) geography on its territory to enable the projects in the agenda. Though the term was evoking a more powerful and active function than bridge, and a more multi-directional position that is not limited to East-to-West, it can be said that the difference between the two –bridge and terminal-has seemed ambiguous. Because, “energy terminal” concept finally went hand in hand with the BTC oil transportation project which is the essential part of the East-West energy corridor concept and the official version of US policy on diverting energy routes from Russia to other geographies. Turkey’s invention of itself as an “energy terminal” has been quite practical that it enables energy cooperation with West by the matching of BTC project-Ceyhan as terminal of East to West energy transportation, “proves” geographical importance, foresees partnership not only with West but also with Russia since new oil and gas projects were started to be negotiated. In addition to BTC, the Blue Stream Gas Pipeline agreement (and its possible extension), negotiations on Samsun-Ceyhan Oil Pipeline project and energy relations with Iran have been the practices of this discourse. The accompanying use of “energy center” term since mid-1990s has reinforced the multifaceted foreign policy of Turkey in engagement to possible routes of energy transportation.

3.3. Turkey between energy corridor and energy terminal/center (1998-2006)

Years between 1998-2006 presents a mixed discourse in which simultaneity of the usage of corridor and terminal/center metaphors was becoming clearer. "Energy corridor" as a role to be played by Turkey has made an entrance to the discourse of leaders starting from 1998, inspired by the declaration of the idea of East-West energy corridor by US. To be a corridor quite resembled the bridge function in terms of the direction East-to-West and the transit role but it had a different character. Corridor, beside the meaning of being a passage way/bridge for oil and gas, has also implied technic-political dimensions. Actually a corridor would be possible with the final agreement of many partners starting from Turkmenistan and Azerbaijan as suppliers, Europe at the user side and Turkey as both user and transit. The corridor metaphor hence is a whole. However, Turkey by presenting itself as "the corridor" tried to attract the attention on its own inclusion to possible agreements and stay involved in the transportation projects, thus focused on "being the essential part" of projects. Thus it redefined and used the corridor with a closer meaning to "bridge", but by speaking with the Western energy terminology.

In early 2000s energy agenda of Europe and Turkey's Europe agenda was reciprocally intensified and created a European context both for foreign and energy policy of Turkey. In practice, the number of the projects negotiated have increased both with the effect of EU's new concerns of energy security and Turkey's increased activity in foreign policy with special focus to EU. So that till 2006, Turkey promoted itself as an "energy corridor" more than ever, while "terminal" concept has also been used without a change. So that, remarkably Turkey's relations with the EU and the intensity of the use of corridor metaphor went very parallel. While the discourse of "energy corridor" was strongly adopted in terms of the East-West directed projects, a North-South dimension of corridor has been added, resembling much the 1990s starting with a West-dominant policy and turns to a Russian and Eurasian one especially through the end of 1990s. Moreover, the projects on the agenda have been the renewed versions of the previous ones: Blue Stream 2 and Samsun-Ceyhan Oil Pipeline projects have again added the North-South directions to Turkey's role.

3.4. Redefining the existing geopolitical roles for energy transportation: upgrading from corridor to terminal/hub/energy trade center (2006- 2020)

2006 is another breaking point to redefine the existing geographic roles for energy transportation in a way differentiating energy corridor and energy terminal, moreover "upgrading" from a passive corridor to an active terminal that turns Turkey into an energy market in which Turkey controls energy trade and have the right to re-exporting energy, mirroring the transformation of Turkey's geopolitical imagination and self-perception from bridge to "center state". So while the roles are differentiated they are redefined and constructed differently than their previous versions.

With the realization of BTC, Baku-Tblisi-Erzurum (BTE) and Italy-Turkey-Greece (ITG) projects which have said been said to make Turkey an energy corridor, it has now become a secondary role with regard to terminal that now means to be an energy "trade" center. Similarly while "energy terminal" previously meant a physical distribution point more to imply a physical-directional center including North-South not only East-West, now the type of function has gained a different meaning which has been completed with the emergence of the discourse of "energy hub". Ceyhan and oil has been the starting point in the adoption of the role, regarding especially the Samsun-Ceyhan Oil Pipeline project.

In the post-2006 period, it is seen that Turkey started to involve in various gas projects routing to Europe, in addition to efforts on making Ceyhan an energy trade center. In terms of the abundance of possible pipelines from multiple energy regions, which can be the minimum physical requirement of an energy hub-terminal-trade center, it can be suggested that Turkey was to pursue the new discourse with its practice. So that, in the context of the increase of the role of gas and the intense agenda of competing gas pipeline projects through 2010s, such as Nabucco, Blue Stream 2, Samsun-Ceyhan Oil Pipeline, South Stream, TANAP and Turk Stream, "hub" concept-as being not limited to oil and Ceyhan- became more visible in the discourse of Turkish leaders. "Hub" has become a suitable metaphor for Turkey's geopolitical role, regarding that the EU was also describing Turkey as a future energy (gas) hub. Having in mind that it is a question whether the perception of the EU about Turkey's role has matched the one adopted by Turkey, it can be suggested that EU's discourse has reinforced that of Turkey. On the other hand, energy relations with Russia has also been effective in Turkey's adoption of the hub discourse, especially in terms of giving Turkey a geopolitical leverage and card, and credibility as the transit partner for Russia.

3.5. Gas exploration, energy transition: 2020 and beyond

With the natural gas exploration in 2020, 2021 and 2023 which reaches to 710 bcm, Turkey's role conception in energy issues has gained a new momentum. The gas exploration has created a new context in which Turkey can use a more powerful discourse of "energy actor", a role offering more than "geography". While being a "net exporter" was set as a future target, Russia's war on Ukraine has been a game changer and seems to have retransformed the upper-context resembling very much the regional energy security issues of the immediate post-Cold War period. With the reintroduction of geopolitics of energy in the region, Turkey's strategic role in possible energy deals that are alternative to Russian hydrocarbons, especially for the EU, started to be re-discussed. However, after discursively rejecting the corridor or bridge metaphors to define Turkey's role in regional energy geopolitics, it is more expectable that Turkey would form a new discourse or reinterpret its existing discourse to play a strengthened leading role in drawing the energy lines and emphasize its "actorness" in its region especially after its own gas exploration. On the other hand current energy and climate trends pose numerous challenges as well as new opportunities for key actors, such as Turkey, in critical regions such as Eurasia (Yılmaz, 2023). In the context of energy transition, the shift from a geopolitical world structured by oil and gas dependency will also have a crucial impact on traditional understanding of energy geopolitics and may transform the discourses. In the new context, the subject material of the geopolitics of energy likely to be renewables, hydrogen energy and renewable hydrogen.

In the case of renewable hydrogen, if adopted at scale, the dynamics of future markets would be similar to today's natural gas markets creating new importers, export champions and dependencies; but Turkey can be in an advantageous position again for being a renewable resource/high infrastructure potential (Pflugmann&De Blasio, 2000).

4. CONCLUSION

Turkey's geopolitical role in energy transportation whether it is expressed as energy corridor, terminal, hub, base, energy trade center, energy actor etc. became a major component of the discourse in the post-Cold War context. This discourse has gave Turkey a new "energy identity" adopted by almost all leaders since 1990s. The validity of Turkey's strategic role in the energy geography has been quite related to the upper-context where the majority of the energy demand is in the West. It is important to note again that since the emergence of the energy discourse in Turkey, none of the metaphors and concepts are totally abandoned. The given periods are showing the dominant metaphor among others which now represent weaker ties with the related context. However, simultaneous use of metaphors (for example corridor and terminal) with nearly equal visibility in some periods has created a conceptional chaos. This can be evaluated as a way of keeping multiple policy choices, with concerns of both EU and Russia, at hand.

On the other hand the choices and preferences on these roles and the way they were used has been connected to the sub-context: Turkey's general foreign policy direction, its international relations and relations specifically with Western partners and Russia, and its energy demand. Turkey in a way of enlarging the space of movement by the use of language in a geopolitically attractive way, tried to balance all these relations. Geopolitical roles and discourse on them are contextually bounded, rather than being natural and stable. Discursive changes in Turkey's practical geopolitics of energy occurred as a response to mentioned contextual changes. So, these changes will likely to transform discourse and practical geopolitics as it did before.

To have the clues of birth of new policies for the coming period, it will be important to observe how the transformation of Turkey's discourse of energy will unfold and whether there will be a new discourse to be presented by new metaphors that is in accordance with the new dynamics of regional geopolitics and Turkey's energy security together.

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THE EFFECTS OF GLOBAL WARMING AND CLIMATE CHANGE ON HUMAN HEALTH

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ABSTRACT
Global warming and the resulting natural events due to climate change are the most important environmental problems encountered in recent years, especially today. The excessive consumption of resources after the developments in the field of industry has led to the release of harmful gases into the atmosphere, which causes the depletion of the ozone layer. In addition, the unconscious use of natural areas, forests and cultivated areas due to the rapid increase in population has led to the reduction or destruction of agricultural areas. Changes in precipitation have led to drought in some places and pollution of sea and drinking water resources caused by flood waters in others. Due to the use of polluted sea and drinking water, it has created serious problems for living things, especially human health, and revealed infectious diseases and skin diseases. In addition, polluted air has caused cardiovascular and respiratory diseases. Increases in the number of premature infants and infant deaths have been observed with the increase of greenhouse gases. In addition, an increase in deaths due to tick bites has been observed as a result of the proliferation of ticks due to the lack of snow and warm weather in the winter months due to climate change.
Keywords: Health, Global warming, disease, climate

1. INTRODUCTION
Greenhouse gases causing global warming; It is a gas consisting of water vapor, small water molecules in the atmosphere and carbon dioxide, many of which are formed by excessive fossil fuel consumption, Hydrofluorocarbon chlorofluorocarbon, methane, nitrogen oxides and ozone. These act as a cover on the earth, keeping the environment at normal temperature for the continuation of the life of living things. Due to the increase in the concentration of these gases, which hold excess heat and have a high effect, in the last century, there is a change in the climate as a result of the warming of the earth more than it should be. This change has caused negative consequences on health due to the effect it has caused by drought, flood, fire and desertification.(Reyhan, A.S; Reyhan H, 2016).
Living things need a healthy natural environment to survive. Climate, which is a part of life; weather events, atmospheric processes, average values of climate variability have led to changes due to human-induced mistakes. The negative effects of global warming, which occurs as a result of mistakes made, on human health are seen in different ways (Kantarlı, S, 2020).

2. MATERIAL AND METHODS
Climate change has become a hot issue lately. 21st century has to face a new crisis that could have long term effects on the world as well as on human health. Climate change becomes a hot topic now because of things that human have been doing for the last 100 years have been increasing and can change the Earth climate. If there is no preventions, climate change could happen very fast than any in the last 1000 years. Climate change in many ways. Climate changes dramatic and rapid, some the result of the impacts from comets or asteroids (New England Aquarium, 2012). But today, human activities have become the main force causing climate to change rapidly. Climate change is not only about change to the weather. It could affects the environment that people, plants, and animals depend on. This means that climate change is not affect human only but it is about plants, animal, and all the other living and non-living things such as soil, rocks, oceans, and lakes. The melting of polar ice caps shows that human being needs to be concerned about climate change. The rising of sea level could damage the land and if it is occurs without any attention to stop it, human could lose their homes. The effects of climate change that have occurred could wake the people up about the importance to preserve the Earth. Scientists believe that climate change could increase the spreading of disease. Dissemination of diseases could lead to heat-related illnesses and even death. Extreme weather such as storms, could increase the risk of high winds, dangerous flooding, and direct threats to human being and property (United State Environmental Protection Agency, 2012). The number of people facing health problems caused by climate change will rise. Climate change not only causes damage to the Earth, it could also affect human health. Climate change can lead to mental health problems and stress-related disorders, asthma, respiratory allergies and airway diseases, and foodborne diseases and malnutrition.

3. RESULTS AND DISCUSSION

Climate change could bring mental health problems and stress-related disorders. Mental health is a point of well-being in individual when he or she realizes his or her abilities, can work productively, can cope with the normal stresses of life, and is able to make a contribution to his or her community. In certain cases, many mental health disorders can also lead to other chronic diseases and even death. Stress- related disorders comes from abnormal responses to acute or prolonged anxiety, and included diseases such as obsessive-compulsive disorder and post-traumatic stress disorder. It is been reported that 26.2 per cent of Americans over the age of 18 suffer from a diagnosable mental health disorder in a given year, 9.5 per cent suffer from mood disorders, and 6 per cent undergo serious mental illness (Environmental Health Perspectives and the National Institute of Environmental Health Sciences, 2010). In 2008, a boy is depressed and is admitted to the psychiatric unit at the Royal Children's Hospital in Melbourne as he refusing to drink water because worrying about millions of people would die if he drink the water. This situation shows that even climate change could lead to mental health problems and stress-related disorders. Some children also having terrible nightmares about global-warming-related natural disasters. Responsible persons should know their roles to prevent mental health problem on children before it is too late as they are too young to face climate change. Family members loss is also one of the cause that lead to mental health problems and stress-related disorders. Tornadoes and wildfires, floods, and droughts have caused mental suffering to people since time eternal. Extreme events cause damage or loss of property, death or injury of loved ones, and last but not least the recovery efforts could also lead to stress.
Besides, climate change also could cause asthma, respiratory allergies, and airway diseases. Asthma is a chronic disease in which the airways of the lungs become inflamed or narrowed resulting in disruptions to normal breathing pattern. Asthma has become the second main cause of other chronic diseases affecting children. Asthma affects mostly five years old children. However, the frequency of asthma is highest among adults. This disease is dangerous as it could block the airways and end in death if action is not taken fast. Climate change threatens asthma in many ways. Higher temperatures caused by climate change increase certain greenhouse gases such as ozone, sulphur dioxide, and nitric oxide. Smog caused by minute particles from smoke stack emissions and diesel exhaust particles from vehicles create danger for people with respiratory illnesses such as chronic obstructive pulmonary disease and cystic fibrosis, as well as asthmatics. Ground level ozone which is a toxic component of smog causes asthma attacks and makes existing asthma become worse. Dust, soot, fly ash, and exhaust particles can become lodged in the lungs and also could trigger asthma attacks. Research have been made and shown that the number of hospitalisations for asthma has increases as the level of particulate matter rise (Natural Resources Defense Council, 2005). Air pollution also could lead to asthma, respiratory allergies, and airway diseases. Air pollution includes greenhouse gases that could cause global warming by trapping heat from the Sun in the Earth's atmosphere.

Climate change could cause foodborne diseases and malnutrition. Foodborne disease is a disease caused by consuming contaminated food or drink (MedicineNet.com, 2012). There are more than 250 known as foodborne diseases and most of them are caused by bacteria, parasites, and also viruses. Foodborne diseases spreading in many ways. First symptoms effect in gastrointestinal tract as all foodborne microbes and toxins enter the body (MedicineNet.com, 2012). High air temperature can boost cases of Salmonella and bacteria-related food poisoning as bacteria tends to grow rapidly in warm environments (United States Environmental Protection Agency, 2012). These kind of diseases are dangerous as it could cause gastrointestinal distress and death. Heavy rainfall also can spread foodborne diseases by the overflows from sewage treatment plants into fresh water sources and finally effect certain food crops with pathogen-containing feces. Other diseases related with foodborne are Campylobacter, E. Coli, and Calcivirus. Malnutrition is the insufficient, excessive or imbalanced consumption of nutrients (Medical News Today, 2010). Climate change causes insufficient in food all over the world. Depletion of nutritionals food causing many mineral deficiency among people and in certain cases it could lead to death. Poor diet could lead to a vitamin or mineral deficiency and sometimes causing in scurvy, a disease where an individual has a vitamin C deficiency (Medical News Today, 2012). Scurvy still occur although it is a very rare disease. It affects elderly people, alcoholics, or people who live on a diet devoid of fresh fruits and vegetables. Beriberi is caused by lack of vitamin B1. This disease affects the nervous system. Pellagra is also a disease related to malnutrition. It is caused by a deficiency of Vitamin B3. Rickets are caused by the deficiency of vitamin D, phosphorus, or calcium in body. People who are infected with this disease suffer from fragile bones, delayed growth, pain in bones, and muscle weakness.

Heavy rainfall also can spread foodborne diseases by the overflows from sewage treatment plants into fresh water sources and finally effect certain food crops with pathogen-containing feces. Other diseases related with foodborne are Campylobacter, E. Coli, and Calcivirus. Malnutrition is the insufficient, excessive or imbalanced consumption of nutrients (Medical News Today, 2010). Climate change causes insufficient in food all over the world. Depletion of nutritionals food causing many mineral deficiency among people and in certain cases it could lead to death. Poor diet could lead to a vitamin or mineral deficiency and sometimes causing in scurvy, a disease where an individual has a vitamin C deficiency (Medical News Today, 2012). Scurvy still occur although it is a very rare disease. It affects elderly people, alcoholics, or people who live on a diet devoid of fresh fruits and vegetables. Beriberi is caused by lack of vitamin B1. This disease affects the nervous system. Pellagra is also a disease related to malnutrition. It is caused by a deficiency of Vitamin B3. Rickets are caused by the deficiency of vitamin D, phosphorus, or calcium in body. People who are infected with this disease suffer from fragile bones, delayed growth, pain in bones, and muscle weakness.

Climate change has many consequences and effects to the Earth and to humans. Climate change can lead to mental health problems and stress-related disorders. mental health problems not only effect adult but also among children. They tend to have nightmares about global-warming-related natural disasters. Family loss also one of the causes of mental health problems and stress-related disorders. Climate change leads to asthma, respiratory allergies, and airway diseases. Asthma is dangerous as it could block the airways and will lead to death if action is not taken fast. Dust, soot, fly ash, and exhaust particles are dangerous as they become lodged in the lungs and also could trigger asthma attacks. Asthma could attack anytime and anywhere. Precautions are needed for people who already suffer from asthma. Climate change decreases the production of foods on Earth. This situation could lead to foodborne diseases and malnutrition. Foodborne disease is a disease caused by consuming contaminated food or drink while malnutrition is the insufficient, excessive of imbalanced consumption of nutrients. Foodborne diseases mostly caused by bacteria, parasites, and viruses. Diseases related to malnutrition are scurvy, Pellagra, and rickets. There are many ways to prevent climate change. Prevention is needed to save the Earth and secure a better place for human being. Human should walk, bike, take mass transit, or carpooling to reduce gas consumption that could lead to asthma. Recycle can saved up to 2,400 pounds of carbon dioxide each year if people recycle half of his or her household waste (Earth911.com, 2022). Replacing a compact fluorescent from a regular light bulb could saves 150 pounds of carbon dioxide each year. Turn off your television, computer, and other electronic devices when are not in use as it could save each household thousand of carbon dioxide every year. People can plant trees. Trees can absorb one tone of carbon dioxide over its lifetime. The most important way is by stay informed about the environmental issues (Earth911.com, 2022).

4. CONCLUSIONS

Measures to reduce the impact of global warming, which is one of the biggest problems in the world, should be taken as a priority. In order for present and future generations to continue their existence, it is necessary to prevent the pollution of drinking and utility waters of flood waters caused by climate change-induced temperature increase and abnormal precipitation, and accordingly, measures should be taken to prevent the emergence and spread of infectious diseases. threatens the existence of living things. In regions with high population growth, relevant organizations should increase controls and inspections in order not to destroy the biodiversity in cultivated agricultural areas and wetlands. In order to prevent the increase in greenhouse gases, the society should be made aware of the use of solid fuels and some products.

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FORECASTING WIND POWER GENERATION USING MACHINE LEARNING ALGORITHMS

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ABSTRACT
The increasing concern over the harmful impacts of greenhouse gas emissions on the Earth's climate system has led to an urgent call for sustainable and renewable energy sources. Among the various alternatives, wind energy has emerged as a viable solution for reducing global warming effects while meeting the ever-growing energy demands. Wind energy generation is of paramount importance as a renewable energy source due to its abundance, environmental benefits, cost competitiveness, job creation, and energy security advantages. To optimize wind energy generation, accurate prediction of wind resources and output is essential. Forecasting models, based on historical data, meteorological conditions, and advanced analytics, are used to predict wind patterns and optimize turbine performance. Accurate predictions help utilities and grid operators manage the intermittent nature of wind power and integrate it into the electricity grid effectively. In this study wind power generation is predicted with machine learning methods involves using historical weather data and corresponding wind power generation data to train a model that can forecast future power generation based on weather conditions. The dataset used in machine learning algorithms is taken from the real-time scada data of the wind turbine. Each weather data is for the relevant time period only and is matched with data on wind power generation.
Keywords: WIND ENERGY, TURBINE PERFORMANCE, FORECAST, MACHINE LEARNING

1. INTRODUCTION
Global warming, primarily caused by the release of greenhouse gases (GHGs) into the atmosphere, has profound implications for the Earth's climate system. The resultant climate change manifests in rising temperatures, altered precipitation patterns, and extreme weather events. The Intergovernmental Panel on Climate Change (IPCC) warns that urgent and significant action is required to limit global warming to well below 2 degrees Celsius above pre-industrial levels to avoid irreversible and catastrophic consequences (IPCC, 2023).
Reducing and controlling the effects of global warming is one of the biggest problems and working areas of today's world. It can be summarized as reducing carbon dioxide (CO_2) emissions, developing capture and storage technologies, and also direct carbon dioxide removal from the atmosphere (Richter, Ming, Caillol, & Lie, 2016). But the most urgent and necessary thing for our world is the reduction of emissions. Gases such as CO_2 move into the upper atmosphere (troposphere) which acts as a screen against sunlight. They let the sun's rays in, but stop the re-emergence of heat radiation, as in the glass in the greenhouse (Lee, 2002). As a result, in this case the whole world warms up (Field et al., 2004). The use of Renewable energy technologies (RETs) such as wind, solar, geothermal, ocean thermal and kinetic, hydrokinetic, biomass and hydroelectric energy are the most important elements to combat global warming (Caldeira et al., 2003). Wind energy is a resource that can be used all over the world and can reduce the burden of global warming as a relatively sustainable clean energy source. Unlike other renewable energy sources, wind energy is also adversely affected by the consequences of global warming. In other words, as this energy source will shrink as our climate warms up, we must make use of wind energy quickly (Ren, 2010).

Wind energy has gained significant attention due to its abundant availability, scalability, and environmental benefits. Wind energy is derived from the kinetic energy of moving air masses and represents an abundant and inexhaustible resource. It does not produce direct emissions of GHGs or other harmful pollutants during power generation, thus contributing to improved air quality and public health. By displacing fossil fuel-based electricity generation, wind energy plays a vital role in reducing GHG emissions. A study by the International Renewable Energy Agency (IRENA) estimates that the deployment of wind energy has the potential to mitigate approximately 3.3 billion tons of carbon dioxide (CO_2) annually by 2030. Diversification of energy sources through wind energy reduces dependency on fossil fuel imports, enhancing energy independence and security for countries. While wind energy presents immense potential, several challenges need to be addressed for its effective integration into the energy mix. These challenges include intermittency, grid integration, land and wildlife considerations, and social acceptance. However, advancements in technology, policy frameworks, and international collaboration provide opportunities to overcome these barriers and unlock the full potential of wind energy (IRENA, 2023).

Wind power generation prediction is crucial for grid stability, renewable energy integration, energy market operations, infrastructure planning, and environmental sustainability. Accurate predictions enable efficient utilization of wind resources, optimize energy systems, and facilitate the successful integration of wind power into the electricity grid. Wind power generation prediction is of significant importance for several reasons:

Grid stability and reliability: Wind power is an intermittent and variable energy source, as wind speed fluctuates throughout the day and across seasons. Accurate prediction of wind power generation helps grid operators and utilities anticipate and plan for these fluctuations, ensuring a stable and reliable electricity supply. It allows them to balance the supply and demand of electricity, optimize power dispatch, and prevent blackouts or grid instability due to sudden changes in wind power output.

Integration of renewable energy: Wind power is a key component of the transition to renewable energy sources. Accurate prediction of wind power generation enables better integration of wind farms into the existing power grid. It helps grid operators manage the variability of wind power and coordinate its generation with other renewable sources, such as solar power or hydroelectricity. By understanding the expected wind power output, utilities can optimize the dispatch of different energy sources and reduce reliance on fossil fuel-based generation.

Infrastructure planning and investment: Wind power generation predictions are vital for planning and optimizing the deployment of wind farms. By analyzing historical wind data and making accurate predictions, developers and policymakers can identify suitable locations for wind projects, estimate the potential energy yield, and optimize the design and capacity of wind turbines. Reliable predictions also aid in assessing the economic viability of wind energy investments and securing financing for new projects (Foley et al., 2012).

Wind power generation prediction using machine learning algorithms is a popular application in the renewable energy sector. Several machine learning algorithms can be used to predict wind power generation based on historical data and meteorological features (Malakouti, 2023). Linear regression, XGBoost, Gradient Boosting, Random Forest, Decision Tree, KNeighbors are some of the algorithms used in this area.

Linear Regression: Linear regression is a simple and widely used algorithm for prediction tasks. It can be used to establish a linear relationship between the input features (such as wind speed, temperature, etc.) and the target variable (wind power generation). Linear regression assumes a linear relationship between the input features and the target variable.Gradient Boosting: Gradient boosting is a collective learning technique that combines multiple weakly predictive models (typically decision trees) to create a strong predictive model. It trains models iteratively, where each new model focuses on correcting mistakes made by previous models (Friedman, 2001).

2. MATERIAL AND METHODS

In this study, it is aimed to make estimations of power generation from the wind turbine and to determine the high-performing algorithm by taking the current weather conditions as input in Python application with Linear Regression, Decision Tree, Random Forest, KNeighbors, XGBoost algorithms. The implementation part was carried out by following the Cross-Industry Standard Process for Data Mining (CRISP-DM) steps (Raschka, 2018).

2.1.Data Understanding

In order to evaluate the performance of the algorithms, two separate datasets consisting of wind power generation dataset and historical weather data such as wind speed, wind direction, temperature, humidity, atmospheric pressure and other related variables were used on Kaggle (Kaggle, 2023). In the shared dataset, the real-time power generation amount (Power(kW)) of a wind turbine between 01.01.2019 and 14.08.2021 is given on a 10-minute basis.

When the data set was loaded via Python, it was seen that there were a total of 154262 observations and 77 attributes in the data set.

2.2.Data Preparation

During the data preparation phase, the number of features, which was 77 at the beginning, was reduced to 10 by making feature selection in line with the purpose of the study. The data set was checked for missing and repetitive data. Observations with missing values were removed from the data set. The number of observations, which was initially 154262, decreased to 136730 after the analysis.

2.3.Modeling and Evaluation

At this stage, their performance on the data set was evaluated by using Linear Regression, Decision Tree, Random Forest, KNeighbors, XGBoost algorithms. "Hold-out" was used as a model performance evaluation method. According to this method to be used, the performance of the model was evaluated by creating a training data set and a test data set with a data set of 80%-20%.

While evaluating the model performance, R-squared, Adjusted R-squared, Mean Absolute Error (MAE), Mean Squared Error (MSE), Root Mean Squared Error (RMSE) criteria were used.

3. RESULTS AND DISCUSSION

Model performance evaluation results are summarized in Table 1.

Table 1. *Performance evaluation criteria*

Performance Evaluation Criteria	Algorithms				
	Linear Regression	**Decision Tree**	**Random Forest**	**KNeighbors**	**XGBoost**
R-squared	-0.00	0.99	0.99	0.99	0.99
MAE	981.64	12.48	9.66	23.85	12.01
MSE	1165677.75	3789.48	2209.57	10572.79	1954.09
RMSE	1079.66	61.55	47.00	102.82	44.20

Rsquare, which shows the extent to which the independent variables explain the variability in the dependent variable, is high in every model except the Linear Regression model. However, this evaluation criterion alone is not sufficient in performance evaluation.
The Mean Absolute Error shows how much the model's predictions deviate from the true values on average. From this point of view, the Random Forest model showed a deviation of 9.66 units from the real values in its estimations.
When examined over the MSE value, it is seen that the XGBoost model is quite low compared to other values. In this case, the predictions of the model are very close to the true values and have good performance.
In the RMSE criterion, which shows the closeness of the model to the predicted values, the predictions of the XGBoost model gave the closest result to the truth.

4. CONCLUSIONS

The success of your wind power prediction model depends on the quality and relevance of the collected data, as well as the appropriate selection and tuning of the machine learning algorithm. These are just a few examples of machine learning algorithms that can be used for wind power generation prediction. The choice of algorithm depends on the specific requirements of the problem, the available data, and the desired level of accuracy. It is often a good practice to compare and evaluate different algorithms using appropriate performance metrics to select the best model for wind power generation prediction. In the study, model performance evaluation was made using Linear Regression, Decision Tree, Random Forest, KNeighbors, XGBoost algorithms. As a result of the analysis, it was found that the XGBoost model gave the highest performance.

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HOLISTIC CHAIN MANAGEMENT OF ENVIRONMENT, MATTER, ENERGY AND PROCESSES WITH ARTIFICIAL INTELLIGENCE FOR SUSTAINABLE TOURISM INDUSTRY

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ABSTRACT
In today's world, global environmental pollution and climate change due to the rapidly increasing world population cause the industry to turn towards clean and renewable energy day by day. Pollution and energy use are major threats in our world and in Turkey as well, as a result of the material-oriented regional and local initiatives of states. Globally, the world is facing the problem of resource depletion. Nowadays, it is very important that Turkey's touristic centers and natural resources are open to the whole world and that this is made sustainable both economically and by protecting the environment. But the biggest challenge is to ensure that the interaction of environment, matter and energy is managed in a beneficial way. In order to achieve this, it is necessary to develop a model that will include a holistic approach. In this study, a solution model is presented to this negative situation in the world by providing this holistic approach in a beneficial way with artificial intelligence.
Keywords: Holistic Approach, Artificial Intelligence, Environment and Matter Interaction, Renewable Energy

1. INTRODUCTION
Over time, there has been a rising trend in sustainability, renewable resources, decreasing environmental pollution due to the increasing world population, human&nature activities and their effect on the environment. As a result of this, there are many researches to find best solutions for saving the World with natural sources and supplying sustainability. The irresponsible use of natural resources is the root cause of significant ecological problems like water scarcity, climate change, and deforestation (Dong et. al., 2017). Environmental damage results from the use of petroleum in transportation, energy generation, home and industrial usage, and other economic activities (Zhang et. al., 2022). Tourism is a vital economic source in the World. However, the rapid and unchecked growth of this sector could harm these sensitive natural areas (Mejjad et. al., 2022). Most studies on the topic of sustainability have mostly analyzed the relationship between tourism and sustainability through descriptive analysis. Additionally, existing research are willingly disregarded because it is still unclear how tourism and the environment are truly connected over the long term. The studies seek to provide a way to think about tourism's role in environmental deterioration based on empirical estimation because they have failed to offer sufficient implications to reach the targeted level of sustainable tourism (Lorente et. al. ,2023). Traditional business processes and energy resources are used for the services and products produced in the Traditional Tourism Economy around the world. This situation brings with it major problems. First of all, a consumption environment is created without considering the Resource Inventory of the environment and without considering the harmony of the Tourist Profile and Tendency in terms of planning. As a result, unplanned urbanization, environmental pollution and climate changes occur, leading to a decrease in the quality of tourism and making it unsustainable. Today, artificial intelligence and digitalization are doing a great job of promoting environmental sustainability (Lorente et. al. ,2023).
The problem presented in this article is to determine from which of the Renewable Energy Sources and at what scale, within the scope of the Sustainable Tourism Economy, the energy consumed from traditional energy sources to finalize a region serving in the Traditional Tourism Economy, a product located and offered within the region, and the product. In order to support the processes used in the tourism industry with energy from renewable sources for a sustainable tourism economy, this article focuses on a software algorithm that assesses all environmental resources with artificial intelligence. As a result, it recommends the location, renewable energy sources, scale, location, and transmission structures that are best for the environment and tourist profile.

2. MATERIAL AND METHODS
Traditional business processes and energy resources are used for the services and products produced in the Traditional Tourism Economy around the world. This situation brings with it major problems. First of all, a consumption environment is created without considering the Resource Inventory of the environment and without considering the harmony of the Tourist Profile and Tendency in terms of planning. As a result, unplanned urbanization, environmental pollution and climate changes occur, leading to a decrease in the quality of tourism and making it unsustainable.

The problem addressed in this article is to determine which of the Renewable Energy Sources and at which scale to obtain the energy consumed from traditional energy sources in order to finalize a region serving in the Traditional Tourism Economy in Turkey, a product within the region and a product offered, within the scope of Sustainable Tourism Economy. It performs instant query and data update by connecting via API to the databases of the relevant government agencies that produce statistics of tourist profiles, orientations and trends of profiles, produce economic and sectoral statistics of tourism, and where all data related to geographical, administrative, financial, natural resources, plant and animal resources of regions (environment) are kept and statistics are produced. It then uses machine learning methods to classify the data it queries, updates and saves as region (environment) and tourist profiles. In addition, it makes a large internet-based and data storage to learn the business processes of services and products in traditional tourism. Finally, in order to calculate alternative renewable energy sources and the transfer units of these energy sources, it stores the data by scanning over the internet. In this way, the learning process is completed. While the learning process continues continuously, when it reaches the stage where it will provide service, it makes comparisons between classes and outputs recommendations and results.
In this paper, the system structure on which the algorithm will work consists of four layers.

1.Cloud Data Center Layer: The exchange layer of the system infrastructure between data centers.
2.Virtualization Layer: Abstraction layer where the Application/Data layer resides
3.Application/Data Layer: The algorithm's application servers are the database file group layer.
4.Business Continuity Layer: It is the layer that will ensure that the algorithm runs continuously.
The algorithm developed in accordance with the solution of the problem is shown in Figure 1. The algorithm given in Figure 1 is explained in 3 parts.

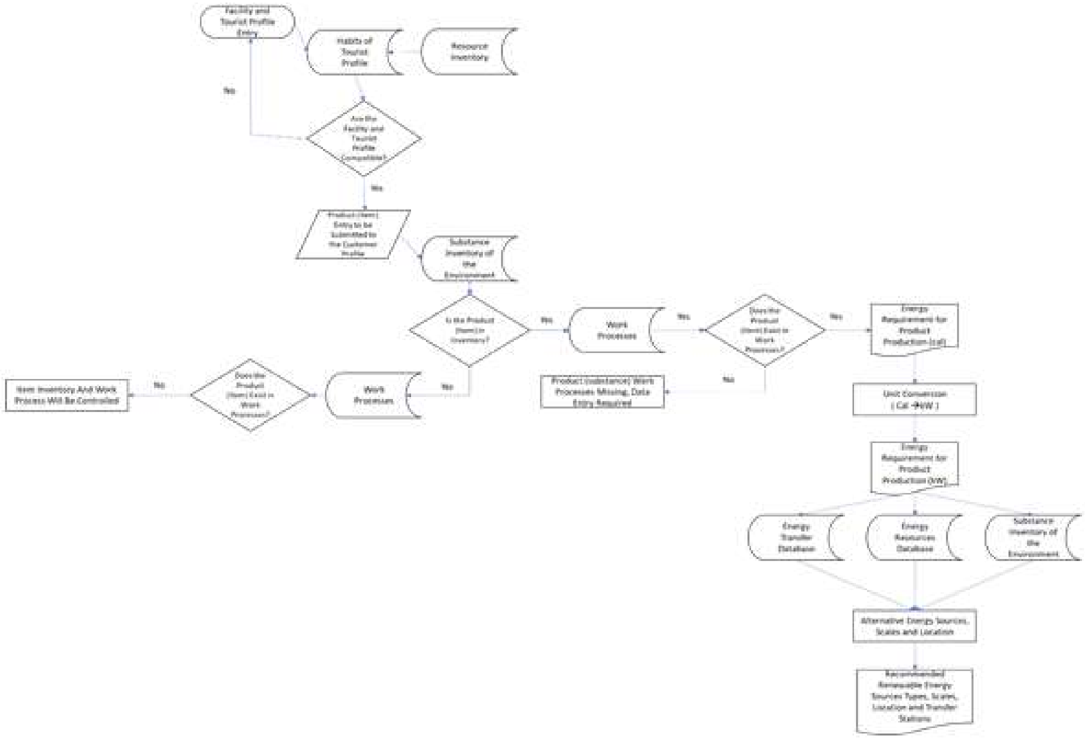


Fig.1. General algorithm presented for sustainable tourism

First of all, the region where tourism will be served and the tourist profile that will come to the region are entered into the system. Artificial intelligence compares the habits of the tourist profile that it has previously taken into its database with the resource inventory of the relevant region (environment) and makes a positive or negative decision according to whether the region has resources that can respond to the habits of the tourist profile or provide a suitable environment, or whether it has resources in percentage terms. In case of a negative decision, re-entry is required to match the right region (environment) with the right tourist profile. With a small enhancement, if the AI is told what the prioritized invariant input is, the AI can recommend the appropriate tourist profile or the appropriate region (environment) according to this invariant priority.

If the inputs are appropriate, the AI asks the tourist profile for the product (item) to be offered for the next step after matching.

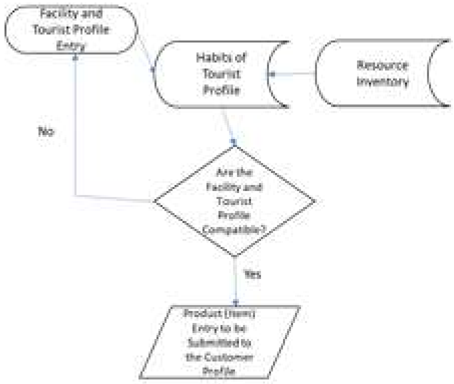


Fig.2. Environmental profile compliance

For the product to be presented to the tourist profile, artificial intelligence makes a comparison with the resource inventory that it has previously received in the database. If it is not in the resource inventory, it looks at business processes. If it cannot find a match there either, it outputs that the resource inventory is not suitable for this product and that business processes need to be entered. If the product is suitable for production in the matching made with the resource inventory, business processes are looked at. If a suitable match is not found in business processes, it outputs that business processes should be entered. If the product and business processes are found to be suitable in the matching, this time artificial intelligence detects the energy consumed for the production of the product from the business processes and outputs the product as energy requirement

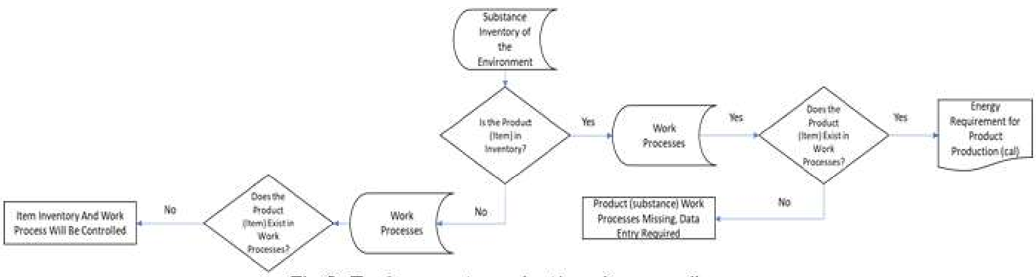
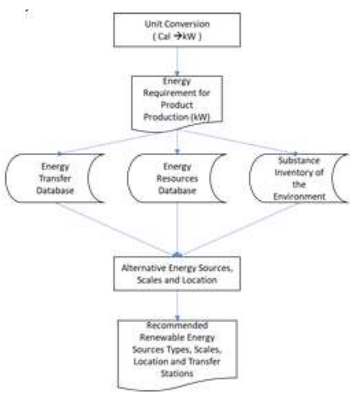


Fig.3. Environment, product/service compliance

Then artificial intelligence then determines the energy consumed for the production of the product from the business processes, and after the product outputs as energy requirement, it outputs the energy required for the production of the product in kilowatt (kw) by subjecting the energy unit consumed to unit conversion.
Afterwards it compares this energy need with renewable energy sources and scales in the resource inventory, energy resources database, and energy transmission lines and scales in the energy transmission database, and outputs the most appropriate renewable energy source, scale and transmission units that can be obtained in that region (environment).



3. RESULTS AND DISCUSSION

In this paper, the algorithm is the result of end-users comparing and interpreting the data in the statistics created by the state over the years with the ability of artificial intelligence to respond with great accurate probabilities without the need for laboratory and soil surveys. What allows artificial intelligence to compare and interpret many of the data in these statistics is based on machine learning, which classifies and indexes a very high number of data according to their similarities, differences and relationships in its research on the internet and statistical data. As a result, comparing the high number of data with the inputs that are interpreted by establishing a relational link and interpretation will give a high accuracy rate, which is a factor that will help decision-making in rapid decision-making, reducing decision-making costs and decision-making. This will help the relevant tourism business to reveal its mistakes and risks from the very beginning of planning and lead it to make the right decision. This high level of classification and relational interpretation can be applied to sustainable agriculture and sustainable livestock breeding based on a very similar logic as it is for sustainable tourism decisions. It can also be used in the food takeaway sector by further enhancing data classification.

4. CONCLUSIONS

In the Traditional Tourism Economy in Turkey, the IT infrastructure and artificial intelligence required to ensure the compatibility of the products and products to be offered by matching the region (environment) and the tourist profile, and to ensure the compatibility of the products and products to be offered according to the resource inventory and business processes of the region, and to determine the energy need and to ensure the production with the most appropriate renewable energy determined according to the resource inventory of the region, are simply designed as the focus. In the short term, the implementation of this result of the algorithm will bring more local, regional and economic benefits, and visible quantifiable results can be recorded. However, in the medium term, it is obvious that the demand for renewable energy in Turkey will increase day by day, the economic pie in the renewable energy equipment market will increase, the fight against environmental pollution and climate change will naturally spread, and the demand for traditional energy sources will decrease. In the long term, by implementing this method worldwide, an economic measure will be taken in the fight against climate change and environmental pollution. This will both reduce the energy costs of the regions in economic terms and contribute to the benefit of the regions and the world in ecological terms. In terms of the tourism economy, it will ensure that the right investment is made in the tourism regions (surrounding areas) and the right tourist profile arrives, while at the same time providing easy access and fast production while providing services and products to the local people with the resources of the environment.

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THERMODYNAMIC ANALYSIS OF GEOTHERMAL POWER PLANT ASSISTED ORGANIC RANKINE CYCLE WITH ANN APPROACH

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ABSTRACT
The Organic Rankine Cycle (ORC) is a high-efficiency system used for heat-to-electricity conversion utilizing a variety of sources such as waste heat recovery, biomass, solar energy, and geothermal. The Organic Rankine cycle (ORC) is known to be a reliable technology with potential solutions that can be implemented effectively, which can efficiently convert these low to medium heat sources into useful power. In the study, the water vapor mixture pressed by the flash chamber from the geothermal source was determined as the energy source for the system. Two different paths were determined for the different phases of the water-steam mixture separated with the help of a separator. The vapor phase was used in the open steam rankine cycle to obtain energy with the help of turbine. The use of the water phase in the heat exchanger provided an energy source to the ORC system using different fluid types. For the ORC system, 4 different refrigerants were preferred R134a, R245fa, n-pentane, and isobutene. As the output values, the overall efficiency of the system, the efficiency of the ORC system, and the mass ratio leaving the separator calculated using by Engineering Equation Solver (EES) program were preferred. For this reason, the Artificial Neural Network (ANN) model is used to forecast different types of energy efficiency problems. An ANN method capable of identifying complex non-linear relationships between input and output data sets. This study proposes a new procedure to identify the structure and parameters of the hidden layer, which can apply the feedforward ANN model to the model and proves the potential of this type of model for thermodynamic values. We compare a model based on an artificial neural network (ANN) with a model based on the principles of thermodynamics as an audit and prediction tool to predict such as overall efficiency, ORC efficiency, and mash ratio of the Organic Rankine Cycle by applying different neural network architecture types. The results obtained from the method are also compared to the input-output model predictions of more than 0.95.
Keywords: ORC, Thermodynamic Analysis, Efficiency, ANN

1. INTRODUCTION
With increasing energy consumption, the use of renewable energy, including wind energy, solar energy and geothermal energy, is an alternative to fossil fuels. Geothermal energy source is recognized as one of the most reliable renewable energy source options. It is known as the energy stored under the earth's crust (BAO, 2013). Organic Rankine Cycle (ORC) are systems that meet the energy needs of resources such as geothermal, solar biomass, waste energy from the source. They are classical Rankine cycle systems with some differences. The fluid, which is an organic liquid, is preferred instead of the traditionally used steam/water (Hattiangadi, 2013).
(Mago et al., 2007) preferred R134a, R113, R245ca, R45fa, R123, isobutene, and propane organic fluids in their study. Some physical properties of these organic fluids are given in Table 1.
Considering the first and second laws of thermodynamics, (Mago et al. 2007) evaluated results such as thermal efficiency and irreversibility under the same conditions. As a result, it was observed that ORCs using R113 showed the best thermal efficiency, while those using propane showed the worst efficiency. However, considering that some organic fluids perform better in a certain temperature range, the importance of choosing the right fluid is emphasized.
(Doğan, 2019) used the organic rankine cycle produced by using the waste heat source obtained from the internal combustion engine working with natural gas. The effects of different parameters such as thermal and exergy efficiency, the net power output, mass flow rate of working fluids, the ratio of evaporator heat transfer rate to preheater heat transfer rate on the system performance were investigated. In their study, they preferred 5 different refrigerants in the Organic Rankin cycle: cyclopentane, benzene, R123, R141b, and R245fa.

Table 1. Properties of some organic fluids used in Organic Rankine Cycles (Mago et al., 2007)

References	Fluid	Critical Properteis		Range of Application		
		P(MPa)	T(°C)	Minimum Temperature (°C)	Maximum Temperature (°C)	Maximum Pressure (MPa)
Tilber-Roth et al. 1994	R134a	4.059	101.06	-103.3	180.0	70
Younglove et al. 1987	Propane	4.248	96.70	-187.3	326.9	733
Younglove et al. 1987	Isobutane	3.64	134.7	-159.6	326.9	35
Defibuagh et al 1997	R245fa	4.25	154.05	-73.2	226.9	60

(Boyaghchi and Heidarnejad, 2014) proposed a new micro solar Combined Cooling, Heating and Power (CCHP) cycle integrated with the Organic Rankine Cycle (ORC) to operate in summer and winter seasons. R134a is preferred as the refrigerant in the Organic Rankine Cycle. Genetic Algorithm (GA) was used to find the final solutions by determining three objective functions as thermal efficiency, exergy efficiency and total system cost ratio.

In this study, input values, well pressure, heat exchanger temperature difference, and turbine efficiency were determined. The pressure of the well-used as a geothermal resource was determined in the range of 200-2000 kPa. 5,10,15, and 20 K for the heat exchanger temperature difference providing energy to the ORC system, and 0.6, 0.7, 0.8, and 0.9 as turbine efficiencies were preferred. For the ORC system, 4 different refrigerants were preferred R134a, R245fa, n-pentane, and isobutene. We compare a model based on an artificial neural network (ANN) with a model based on the principles of thermodynamics as an audit and prediction tool to predict such as overall efficiency, ORC efficiency, and mash ratio of the Organic Rankine Cycle by applying different neural network architecture types.

2. MATERIAL AND METHODS

In this section, the Organic Rankine Cycle system and its elements will be explained in detail. The situations and approaches determined for each component in the system will be defined. In addition, the thermodynamic analysis equations required for the calculation of the output values corresponding to the input values and the types of ANN models to be used will be explained.

2.1. Organic Rankine Cycle Description

A geothermal well was preferred for the source to be used in the study. With the help of the flash chamber, the water-steam mixture is transmitted from the well to the separator. In the separator, this mixture is separated into water and vapor phase. Steam is transmitted to the steam turbine of the flash rankine cycle, and water to the heat exchanger to be used as a heat source in the organic rankine cycle. The schematic representation of the working system is shared in Fig. 1.

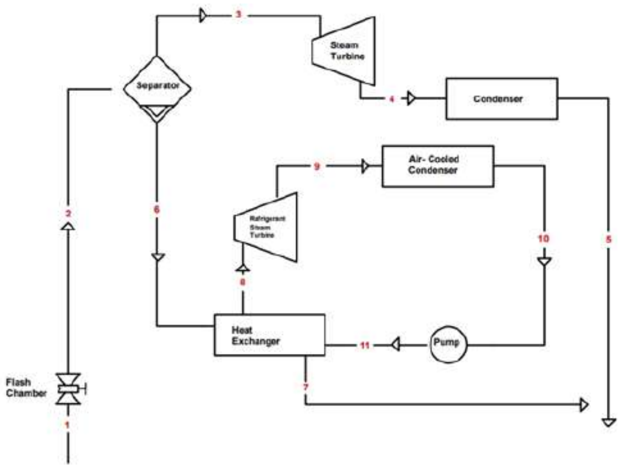

Figure 1. ORC system diagram

2.2 Conditions and Assumptions

In the study, various assumptions have to be made in the fluid and component values to calculate the total efficiency, orc cycle and mass ratio in the heat exchanger. Approaches realized within the scope of this study are shared in Table 2.

Table 2. Assumptions of fluid and component values

Condition	Unit	Value
Well Pressure Range	P_2 (kPa)	200-2000
Heat Exchanger Temperature Difference	ΔT_{HE} (K)	5, 10, 15 and 20
Turbine Efficiency	η_{tur}	0.6, 0.7, 0.8 and 0.9
Pump Efficiency	η_{pump}	0.65
Mass Flow	m_dot (kg/s)	200
Well Temperature	T_1 [K]	500
Heat Exchanger Pressure	P_8 (kPa)	3250

2.3 Thermodynamic Analysis

In this part of the study, various equations derived from the laws of thermodynamics will be used to calculate the output parameters of the system. The steam flow rate formed by separator separation of the water-steam mixture obtained from the geothermal source well is calculated with the help of equation 1 and the water flow rate is calculated with the help of equation 2.

$$\dot{m}_3 = \dot{m}_w \cdot x_2 \quad (1)$$

$$\dot{m}_6 = \dot{m}_w \cdot (1 - x_2) \quad (2)$$

The power produced by the turbine in the flash rankine cycle is calculated with the help of equation 3.

$$\dot{W}_{ST} = \dot{m}_3 \cdot (h_3 - h_4) \quad (3)$$

The power produced in the organic rankine cycle and the heat gained from the heat exchanger per unit time are calculated with the help of equations 4 and 5.

$$\dot{W}_{ORC} = \dot{m}_{ORC} \cdot (h_8 - h_9) \quad (4)$$

$$\dot{Q}_{ORC} = \dot{m}_{ORC} \cdot (h_8 - h_{11}) \quad (5)$$

The mass ratio (MR) to be obtained by the ratio of the mass flow rate in the organic rankine cycle to the total flow rate is obtained by equation 6.

$$MR = \frac{\dot{m}_{ORC}}{\dot{m}_w} \quad (6)$$

The energy equation in the heat exchanger is shared in equation 7.

$$\dot{m}_{ORC} \cdot (h_8 - h_{11}) = \dot{m}_6 \cdot (h_6 - h_7) \quad (7)$$

The total energy provided to the system from the geothermal well is calculated with the help of equation 8.

$$\dot{E}_{in} = \dot{m}_w \cdot (h_1 - h_0) \quad (8)$$

The overal efficiency of the system was calculated with the help of equation 9.

$$\eta_{overall} = \frac{\dot{W}_{ST} + \dot{W}_{ORCnet}}{\dot{E}_{in}} \quad (9)$$

Orc efficiency was calculated with the help of equation 10.

$$\eta_{ORC} = \frac{\dot{W}_{ORCnet}}{\dot{Q}_{ORC}} \quad (10)$$

2.4 Artificial Neural Network

Artificial intelligence (AI) systems are widely used for analysing and comparison of the energy behaviour of an organic rankine cycle. ANN is constructed in layers: the input layer, the output layer and some hidden layers. The number of hidden layers depends on the application and type of the problem. In this research, ANNs were implemented in Neural Net Fitting (MATLAB) with 2 hidden layers.

Here in, well pressure (P2), temperature difference in the heat exchanger (ΔTHE) and turbine efficiency (ηtur) are taken as inputs, and overall efficiency (ηtotal), ORC efficiency (ηORC) and mash ratio (MR) values from EES program is taken as output value for training. The 400 experimental data for every 4 different refrigerents (R245fa, R134a, n-pentane and isobutane) are compared with three different ANN algorithms; Levenberg- Marquardt (LM), Bayesian Regularization (BR) and Scaled Conjugate Gradient (SCG). The ANN performance of the data sets dealt with is based on some statistical criteria such as the coefficient of multiple determination (R2) and the coefficient of variation (r). R Squared formula is the following:

$$R^2 = 1 - \frac{\sum(y-\hat{y})^2}{\sum(y-\bar{y})^2} \tag{11}$$

where y is the actual value, $\hat{y}$ is predicted of y and $\bar{y}$ is the mean of the y values. The formula of the correlation coefficient is defined as follow:

$$r = \frac{n(\sum xy)-(\sum x)(\sum y)}{\sqrt{[n\sum x^2-(\sum x)^2][n\sum y^2-(\sum y)^2]}} \tag{12}$$

where n equals the number of patterns, x refers to the set of actual outputs and y refers to the predicted outputs.

3. RESULTS AND DISCUSSION

R134a, R245fa, n-pentane, and isobutene fluids were used in this study, which was carried out to investigate the exergy efficiency of different fluids in the organic Rankine cycle and to examine the ANN behavior.

In cases where the temperature difference in the heat exchanger is 5 and the turbine efficiency is 0.6, the variation of the power values produced by the turbines with pressure according to different fluid types is shared in Figure 2.

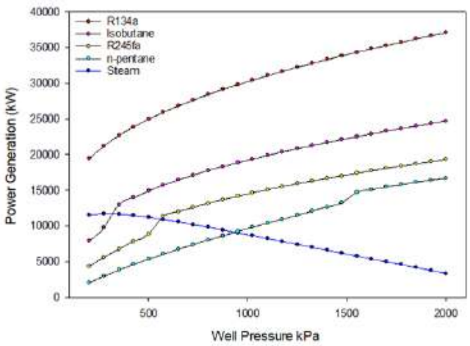

Figure 2. Turbine power generation using different fluids (ΔT_{HE}=5 and η_{tur}=0,6)

When the figure is examined, it is observed that as the pressure change increases, the power generation decreases in the turbine in the flash cycle using steam, while it increases in each fluid in the ORC system.

In this study, we examined R245, R134a, n-pentane, isobutane fluids by using ANN with Levenberg- Marquardt, Bayesian Regularization, and Scaled Conjugate Gradient algorithms. All the variants with R^2 values we studied are given in Table 3.

Table 3. Statistical values of predictions for Geothermal Power Plant Assisted ORC LM, BR, SCG algortihms

	R245fa	R134a	n-pentane	isobutane
LM	0.99955	0.99997	0.99901	0.9982
BR	0.99955	0.99997	0.99901	0.99259
SCG	0.99362	0.99965	0.99859	0.99652

4. CONCLUSIONS

In this study, power generation for R245, R134a, n-pentane, isobutane fluids in the ORC system was investigated. it has been observed that the highest power generation is obtained with R134a fluid and the lowest power generation is obtained with n-pentane fluid. It has been observed that the turbine power generation in the organic rankine cycle increases with increasing well pressure and the power generation in the flash steam turbine decreases.

Three different algorithms were applied. It has been seen that all algorithms can make good predictions of values above 0.95 for all 4 different fluids. In particular, it has been observed that the LM algorithm results in same sensitivity with BR algorithm for R245fa, R134a, n-pentane. In addition to this, overall and ORC efficiency values, turbine power generation values and thermodynamic properties of the system were also examined in the ANN approach. It has been concluded that the different type efficiencies and power generation of turbines for hybrid systems can be calculated well through artificial intelligence-based programs to be constructed using the relevant algorithms.

As a suggestion for future studies, ORC systems can be used instead of different kind energy soruce, more input parameters can be used in ANN, and alternative fluids can be researched instead of harmful fluids used in the industry. In addition, different heat exchanger temperature differences, mash ratios, turbine efficiencies values can be studied. In addition, cost analysis and the amount of carbon dioxide production can be examined with both thermodynamic and ANN approaches by choosing input parameters.

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TIN THE QUEST OF DECARBONIZATION; COMBINED HEAT AND POWER VERSUS HEAT PUMPS IN ELECTRIFICATION STRATEGIES

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ABSTRACT
This paper deals with the comparative role of combined heat and power (CHP) technology and heat pumps using green hydrogen. An exergy-based model has been developed, which assumes that green hydrogen is formed upstream by electrolyzing water in a closed circuit between the electrolysis stage and the fuel cell unit downstream, using an equal mix of solar photovoltaic (PV) panels and wind turbines. Green hydrogen is assumed to be utilized in CHP units or heat pumps, the latter of which is driven either by an onsite hydrogen motor or grid power. Normally, CHP units are not designed for upper calorific value. The exhaust is not condensed. But, in this case, where hydrogen is inputted to the CHP (with a possible mix of municipal-level biogas), exhaust vapor is condensed and fed back to the electrolysis stage on the premises with the make-up water to be minimized. It is expected that water vapor release to the atmosphere is eliminated. The additional equipment for the condensation pump and or fans uses electric power, and from the energy efficiency point of view, it is not rational unless a proper optimization is carried out. However, water is also an environmental issue and water reclaim is a plus at any rate. The oxygen gas is captured and stored. Electrolysis heat and the condensation heat from the CHP unit are reclaimed for maximum exergy efficiency. Results show that hydrogen trigeneration has the lowest carbon dioxide emission responsibility in the hydrogen chain and utilization for heat or cold, while hydrogen trigeneration generates electricity as heat pumps consume electricity for heat or cold.
Keywords: Hydrogen energy, trigeneration, cogeneration, heat pumps, exergy rationality, CO2 emission responsibility

1. INTRODUCTION
In an expanded view, Fig. 1 shows the history of green hydrogen in terms of CO2 emission responsibilities for a power plant and a photovoltaic (PV) plant. A power plant generates electrical exergy while irreversibly destroys the thermal exergy downstream. The situation is almost the same for a solar PV panel. Exergy destructions and corresponding nearly avoidable CO2 emissions, namely ΔCO2 are labeled in Fig. 1.

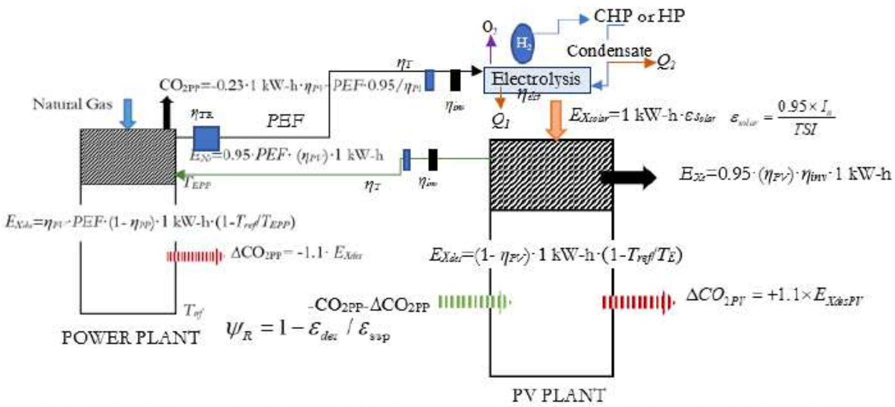

Fig. 1. History of Green Hydrogen and CO_2 Emission Responsibilities of a Power Plant and PV System

The net total ΣCO2 emission, which is a total of direct emissions, CO2 and ΔCO2 is given by Equation 1. ψR Is the rational exergy management efficiency and is an indicator of ΔCO2, as given in Equation 3. The factor (k) is a multiplier representing the direct relationship between the exergy destruction and carbon dioxide emission responsibility. It is 2.1 if the major exergy destruction takes place at the upstream of a process in a system or 1.1 if the major exergy destruction is at the downstream.

$$\sum CO_2 = \left(\Delta CO_{2PV} - CO_{2PP} - \Delta CO_{2PP}\right) > 0 \quad (1)$$

$$\psi_R = 1 - \varepsilon_{des} / \varepsilon_{sup} \quad (2)$$

$$\Delta CO_2 = k \times \varepsilon_{sup}\left(1 - \psi_R\right) \quad (3)$$

2. METHOD

The analysis involves a holistic account of major exergy destructions in a power plant and a solar PV plant. The PV panel generates electric power but destroys the thermal exergy downstream, and therefore it is responsible for $\Delta CO2PV$. It replaces grid power from a power plant and saves CO2PP and $\Delta CO2PP$. Assuming that PV panels are on the site of electrolysis, the primary energy factor, PEF is one, and there is not any need for an inverter. If the PV panels feed the grid first and the electrolysis uses grid power, then PEF is $1/[(\eta T \cdot \eta inv)2 \cdot \eta TR]$. For a fifty-to-fifty- mix of onsite PV panel contribution to the power with wind turbines feeding the grid, the following average PEF value is used.

$$PEF_{av} = 0.5 + \frac{0.5}{\left[\left(\eta_{inv} \cdot \eta_T\right)^2 \cdot \eta_{TR}\right]} \tag{4}$$

In an onsite CHP system, the power output is already in AC. Therefore, there is not any inverter loss. A CHP unit or a heat pump (HP) needs hydrogen production with an efficiency ηelct unit for their fuel feed. The heat pump unit does not need hydrogen unless it is directly driven with a hydrogen motor with an efficiency ηHM. This case is the common-base scenario with hydrogen base. Hydrogen production is preferable because it is easier to store renewable energy in the form of hydrogen. The renewable mix at the power plant is ignored because renewable energy systems feeding the grid also have their ΔCO2 components and they balance the emissions savings from the renewable mix.

From the wind turbine perspective, Fig. 1 applies, except ηPV is replaced by ηWT and εsolar is replaced by 0.95 kW-hex/kW-hen. In most cases, wind turbines feed the grid. Therefore, PEF is $1/(\eta T \cdot \eta inv)$. The land use effectiveness of solar panels and wind turbines must be also considered along with the heat island effect of PV panels and the use of agriculturally productive land unless PV panels are raised from the ground and plants with less solar light need farming.

During the electrolysis, shown in Fig. 1, electric power with, a unit exergy of 0.95 kW-hex/kW-hen, and an efficiency of ηelct is converted to hydrogen for CHP or HP units. The unit exergy of hydrogen is 0.89 kW-hex/kW-hen. Therefore, there is some exergy loss and subsequent ΔCO2 responsibility. Q2 is the reclaimed heat, which proportionately replaces the load on the heat pump or boiler. See Fig. 2 for the exergy flow bar graph for the electrolysis process. Assuming that oxygen is used in oxyacetylene torches in the industry, the unit exergy will be about 0.92 kW-hex/kW-hen corresponding to an adiabatic flame temperature of 3750 K is included. With the 2/1proportion of hydrogen and oxygen produced the overall unit exergy may be assumed to be about

0.9 kW-hex/kW-hen. If the reject heat, Q2 is utilized, it mitigates some emissions because it replaces an onsite boiler, using natural gas. Fig. 2 shows the CO2 emissions. The overall responsibility, when the second law of thermodynamics is considered with a direct link between emissions responsibility and exergy destruction, is usually negative. Therefore, electrolysis with a proper and optimized design and operation with green power mitigates some degree of CO2 emissions.

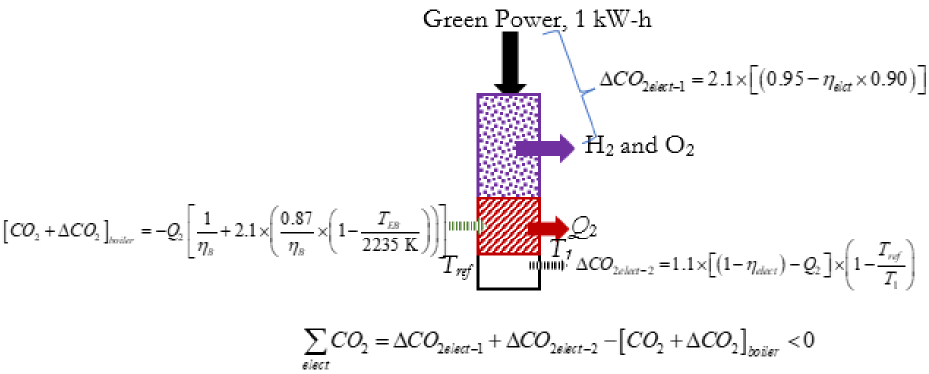

Fig. 2. Exergy Flow Bar Diagram and Emissions for Electrolysis

Fig. 3 compares a CHP unit and a heat pump (HP) on a common base of green hydrogen input. Green hydrogen (with a possible mix of municipal biogas) is the fuel input for CHP and the fuel input for a heat pump driven by a green hydrogen motor. Otherwise, the heat pump is driven by electricity.

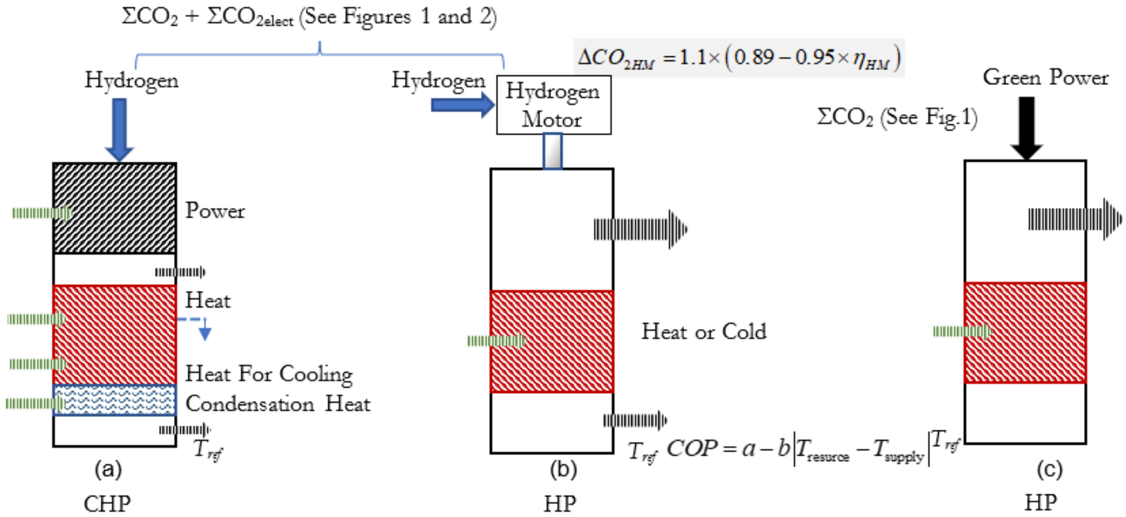

Fig. 3. Common-Base Comparison of Hydrogen Trigeneration and Heat Pump with Hydrogen

Trigeneration is the simultaneous delivery of power, heat, and cold. This is an advantage for CHP systems by delivering heat and cold through absorption or adsorption units by utilizing part of the heat generated. However, the emission responsibility increases a little in cooling. A heat pump may not deliver heat and cold at the same time. Heat pump COP must meet the following criteria (Kilkis, I. B., 2023):

$$COP > \frac{0.95}{\left(1-\frac{T_2}{T_1}\right)} \tag{5}$$

To minimize solar exergy destructions, solar photovoltaic-power-heat (PVT) systems and wind turbines capturing the nacelle equipment heat with heat pipes (Kilkis, B., Çağlar, M., Şengül, M., 2021.) and pressurized fluid transfer to the bottom of the turbine may be options for better performance.

3- RESULTS AND CONCLUSION

Fig. 4 is an illustrative example of the three cases. The CHP case (a) has the lowest CO2 emissions. A hydrogen motor-driven heat pump (Case b) has the highest. However, as the error margins indicate, results may switch order depending upon the special design cases and operating conditions on a case-by-case basis. Therefore, the most important takeaway from this research is that the second law, directly linked to exergy destructions-coupled ΔCO2 emissions makes it necessary to execute case-by-case analyses rather than arriving at generalized conclusions.

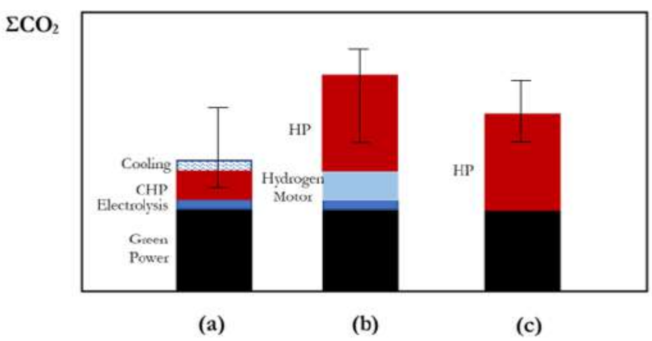

Fig. 4. Illustrative Comparison of the Total Emissions Responsibility of the Three Cases

EU countries are also heading for low-temperature district heating systems with solar prosumer buildings (Kilkis, I. B. 2022-a). However, this roadmap needs exergy-matching heating or cooling terminal units which are becoming available in the market using heat pipe technology (Kilkis, I. B. 2022-b). This analysis shows that the second law of thermodynamics is a strong tool to achieve optimal solutions for minimum overall emissions and emission responsibilities on a holistically vide platform in the built environment.

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THE ROLE OF HYDROGEN IN REDUCING THE GLOBAL WARMING EFFECTS

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ABSTRACT

Global temperature change occurs due to the greenhouse effect created by some gases released into the atmosphere as a result of various artificial and natural activities. This temperature change can be seen as global warming in some parts and global cooling in others of the world. The most important and the most produced greenhouse gas that causes global warming or cooling is carbon dioxide. Therefore, it is extremely important to take under control the carbon dioxide emissions produced as a result of different activities and released into the atmosphere.

In this regard, the main purpose of the study is to investigate the role of hydrogen in reducing the effects of global warming. For this purpose, in the first step, the carbon dioxide intensive processes are discussed. The amount of carbon dioxide produced is determined and the global warming potential of the carbon dioxide released to the atmosphere due to the processes are calculated. In the second stage, the global warming potentials obtained as a result of the use of green hydrogen in carbon dioxide-intensive processes are determined and the role of green hydrogen in reducing the effects of global warming is discussed.

Consequently, green hydrogen can be considered as an important input in achieving de-carbonization and used as a critical feedstock in reducing the global warming potential. Thus, it is expected that this study will be an important reference for developing the strategies and policies in determining and reducing the sectoral global warming potentials of industrial processes.

Keywords: Green hydrogen, global warming, global warming potential.