BOOK OF ABSTRACTS

The 8th International Conference on Energy and Environment Research

" Developing the World in 2021 with Clean and Safe Energy "

September 13-16, 2021

VIRTUAL CONFERENCE

Co-organizers

ROMA TRE UNIVERSITÀ DEGLI STUDI

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ICEER 2021

2021 The 8th International Conference on Energy and Environment Research – "Developing the World in 2021 with Clean and Safe Energy"

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WELCOME MESSAGE

ICEER 2021 is the 8th edition of the ICEER conference series, and the second edition organized in the virtual mode due to the World pandemic situation.

The quality and interest of this event has been increasing continuously as researchers and participants from all over the World share their new findings in the areas of Energy and Environment under a multicultural and informal atmosphere.

This informal discussion space allows fruitful discussions on the topics presented by Keynote and Invited Speakers, as well as by the Authors of research, no matter if they are at their initial careers or if they are well established researchers. And although the **ICEER 2021** is being held online, the face-to-face discussions, that promote direct interaction with each other, are still happening and allowing that different views are presented and discussed in a deep mutual respect, while possible educational or cultural differences that otherwise could introduce barriers to communication are overcome.

Unfortunately, once more we cannot speak in person due to COVID-19, so we still have a screen between us. But this will not be a barrier, as we have been using online communication tools for quite a while. On the other hand, the ability to present live without the need for VISA or to travel for very long distances also allows the increased number of participants from distant countries, where travelling is not easy.

Working from home for about 18 months has brought to light the existing constraints, namely due to the need to manage familiar and professional activities in the same space (often very limited), with limited resources, and sometimes at the expenses of overworking. This change of working paradigm also made us all see clearly the impacts our daily activities have on the Sustainable Development, and this is one of the reasons why the theme of ICEER 2021 is "Developing the World in 2021 with Clean and Safe Energy" was chosen.

The impacts of the sudden cut on long-distance travel and new work models have been felt not only at the economic level, but also and very significantly on the fuels for transportation and energy consumption, and on the air quality. However, with so dramatic effects on substantial part of the population the recovery of some of the pre-COVID-19 activities demonstrated how fragile is the balance and how fast the situation can change from sustainable to unsustainable. Thus, the fundamental issues in our era remain related to the need to find sources of energy that are clean, easily available and that continuously supply the needs, without compromising the development of the World, be it via climate change prevention, or by renewable energy provision that ultimately contribute to environment protection.

The research on renewable energy production, provision and management, associated with the integrated analysis of the whole chain impacts in a life cycle perspective, together with the education of the professionals of tomorrow, are the foundations of capacity building and of Sustainable Development focused in the edition of **ICEER 2021**. Our small contribution to the spread of knowledge and of research results is publication of the Proceedings as a Special Issue of Energy Reports. Thus, the full papers of the research related to energy, presented and discussed in **ICEER 2021**, will be available to anyone, free of charge to the readers, as they will be published in Energy Reports.

The participants will help us disseminate their knowledge and will make **ICEER 2021** an outstanding event.

ICEER 2021 aims to continue to be a privileged space of discussion of current issues related to Energy and the Environment.

ICEER 2021 continues to be a particularly multicultural event.

ICEER 2021 continues to work closely with Editors of International Journals to consider publishing extended versions of a selection of papers in Special Issues of Energies, or Processes or Waste and Biomass Valorization journal.

Welcome to

ICEER2021@online - Developing the World in 2021 with Clean and Safe Energy.

The Conference Chairs

CONFERENCE PROGRAM

	13 Septemmber – Test Day							
	14 September			**15 September**			**16 September**	
	Room A	Room B		Room A	Room B		Room A	Room B
08:30-08:45	**Opening Ceremony** (Room A)		08:30-09:30	Session 8A	Session 7B	08:30-09:45	Session 11B	Session 10B
08:45-09:30	Keynote Lecture by Prof. Weihao Hu (Room A)			E038 E013 E024 E050	E087 E056		E086 E081 E057 E023 E140	E134 E061 E063 E082 E075
09:30-09:45	Coffee Break		09:30-09:45	Coffee Break		09:45-10:00	Coffee Break	
09:45-10:30	Session 1A	Session 2A	09:45-11:00	Session 1B		10:00-12:15	**Oral Flash 2** (Room A)	
	E111 E040 E020	E044 E045 E051		E021 E030 E117 E135 E093				
10:30-10:45	Coffee Break		11:00-11:15	Coffee Break		12:15-13:30	Lunch Break	
10:45-12:15	Session 3A		11:15-12:15	Session 9A		13:30-14:15	Session 3B	
	E076 E009 E123 E094 E088 E143			E095 E102 E130 E144			E042 E089 E100	
12:15-13:45	Lunch Break		12:15-13:45	Lunch Break		14:15-14:30	Coffee Break	
13:45-14:45	Session 4A	Session 5A	13:45-14:45	Session 2B		14:30-15:30	Session 9B	
	E132 E112 E139 E018	E025 E071 E114 E141		E080 E105 E107 E090			E027 E099 E015 E047	
14:45-15:00	Coffee Break		14:45-15:00	Coffee Break				
15:00-16:00	Session 6A	Session 7A	15:00-16:15	Session 6B	Session 10A	15:30-16:00	**Poster Session** (Room A)	
	E041 E120 E121 E125	E026 E104 E065 E031		E069 E070 E064 E119 E003	E074 E091 E007 E017 E067			
16:00-16:15	Coffee Break		16:15-16:30	Coffee Break		16:00-16:15	Coffee Break	
16:15-17:00	Keynote Lecture by Prof. Claudio Corgnale (Room A)		16:30-17:00	Invited Speech by Prof. Pablo Arboleya (Room A)		16:15-17:00	Keynote Lecture by Prof. Hector Ruiz (Room A)	
17:00-18:00	**Oral Flash 1** (Room A)		17:00-18:00	Session 6C	Session 11A	17:00-17:30	**Closing & Award Ceremony** (Room A)	
				E126 E034 E131 E127	E048 E084 E085 E101			

Oral Flash 1	E004, E043, E049, E113, E133, E129, E068, E128, E116
Oral Flash 2	E078, E077, E098, E118, E124, E008, E010, E037, E096, E052, E109, E072, E060, E035, E115, E136, E011, E106, E145
Poster Session	E006, E019, E028, E036, E039, E053, E059, E062, E073, E083, E092, E103, E110, E137, E014

Session Information	
Session 1	Energy Efficiency
Session 2	Advanced Energy Technologies
Session 3	Energy
Session 4	Advanced Control and Monitoring Systems
Session 5	Renewable Energy
Session 6	Life Cycle Analysis Methodologies
Session 7	Education for Sustainable Development
Session 8	Sustainable Buildings
Session 9	Energy Policy, Economics, Planning & Regulation
Session 10	Environment
Session 11	Modelling, Simulation and Forecasting of Energy and Carbon Markets

Room Information		
Room A	Zoom Link: https://zoom.us/j/94813364454	Meeting ID: 948 1336 4454
Room B	Zoom Link: https://zoom.us/j/97976481988	Meeting ID: 979 7648 1988

Time Zone:

Portugal Time (GMT+1)

You're suggested to set up the time on your computer in advance.

Presentation Type:

● Oral: 12 min PPT + 3 min for discussion;

● Oral Flash: 5 min PPT + 2 min for discussion;

● Poster: 2 min for discussion with designed poster

Template Download:

Oral Presentation: http://iceer.net/Oral.pptx

Poster Presentation: http://iceer.net/Poster.pptx

Environment Needed

A quiet place

Stable internet connection

Proper lighting and background

Test before Formal Meeting

Date: September 13th, 2021

Prior to the formal meeting, presenters shall join the test room to ensure everything is on the right track.

Voice Control Rules

● The host will mute all participants while entering the meeting.

● The host will unmute the speakers' microphone when it is turn for his or her presentation.

● Q&A goes after each speaker, the participant can raise hand for questions, the host will unmute the questioner.

● After Q&A, the host will mute all participants and welcome next speaker.

*Conference Recording

The whole conference will be recorded. We appreciate you proper behavior and appearance.

* The recording will be used for conference program and paper publication requirements. The video recording will be destroyed after the conference and it cannot be distributed to or shared with anyone else, and it shall not be used for commercial nor illegal purpose. It will only be recorded by the staff and presenters have no rights to record.

TEST SESSION AT A GLANCE

September 13th			
Time	**Session**	**Paper ID**	**Meeting ID**
9:30-10:30	1	E110, E103, E103, E053, E059, E006, E039, E137, E019, E028, E073, E083, E062	Meeting ID: 948 1336 4454 Zoom Link: https://zoom.us/j/94813364454
	2	E098, E008, E010, E052, E096, E037, E072, E109, E060, E035, E036, E092	Meeting ID: 979 7648 1988 Zoom Link: https://zoom.us/j/97976481988
11:00-12:00	3	E068, E133, E128, E129, E043, E136, E118, E011, E078, E106, E124, E077	Meeting ID: 948 1336 4454 Zoom Link: https://zoom.us/j/94813364454
	4	E040, E086, E038, E111, E113, E115, E116, E049, E004, E112, E114, E041	Meeting ID: 979 7648 1988 Zoom Link: https://zoom.us/j/97976481988
13:30-14:30	5	E104, E074, E091, E044, E051, E056, E013, E134, E020, E045, E076, E087	Meeting ID: 948 1336 4454 Zoom Link: https://zoom.us/j/94813364454
	6	E140, E061, E065, E080, E081, E009, E027, E099, E123, E069, E070, E026	Meeting ID: 979 7648 1988 Zoom Link: https://zoom.us/j/97976481988
	KS IS	Prof. Weihao Hu Prof. Claudio Corgnale Prof. Pablo Arboleya Prof. Hector Ruiz	Meeting ID: 925 7901 7816 Zoom Link: https://zoom.us/j/92579017816
15:00-16:00	7	E117, E119, E082, E057, E021, E023, E024, E030, E034, E093, E107, E139	Meeting ID: 948 1336 4454 Zoom Link: https://zoom.us/j/94813364454
	8	E042, E089, E094, E100, E101, E102, E143, E075, E063, E064, E017, E007	Meeting ID: 979 7648 1988 Zoom Link: https://zoom.us/j/97976481988
16:30-17:30	9	E015, E018, E025, E047, E048, E071, E050, E084, E085, E088, E102, E095	Meeting ID: 948 1336 4454 Zoom Link: https://zoom.us/j/94813364454
	10	E131, E121, E120, E125, E126, E127, E130, E132, E141, E090, E067, E003, E031	Meeting ID: 979 7648 1988 Zoom Link: https://zoom.us/j/97976481988

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Wilson Galvão de Morais Júnior	*ISEP/P.Porto/Programa Horizon 2020 - Instituto Marie Skłodowska Curie*	**PT**
Zita Vale	*GECAD/ISEP/IPP - Instituto Superior de Engenharia do Instituto Politécnico do Porto*	**PT**

CONFERENCE CHAIR

PROF. NÍDIA DE SÁ CAETANO

Coordinator Professor at the School of Engineering (ISEP) of the Polytechnic Institute of Porto (P.Porto); Subject Editor for Biomass section of *Renewable Energy* journal; Editorial Board Member of *The Open Microalgae Biotechnology Journal*; Guest Editor of Special Issues in *Frontiers*, *Energies*, *Waste and Biomass Valorization*, *Sustainability* and *ChemEngineering* journals. Editor of Conference Proceedings in *Energy Reports* and *Energy Procedia*.

Research unit	LEPABE – Laboratory for Process Engineering, Environment, Biotechnology and Energy
Nationality	Portuguese
Institutional Address	Departamento de Engenharia Química ISEP-Instituto Superior de Engenharia do Porto Rua Dr. António Bernardino de Almeida 4200-072 Porto
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Professional category	**Coordinator Professor@ISEP**
Current positions	Coordinator Professor, Researcher at LEPABE, and Sub-Director of Course (MSc in Sustainable Energies), Collaborator with CIETI
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• Nídia de Sá Caetano is Coordinator Professor at the School of Engineering (ISEP) of the Polytechnic of Porto, senior researcher with LEPABE/FEUP, collaborator researcher with CIETI/ISEP. Sub-Director of the Master in Sustainable Energies of ISEP (MSE) from 2018; Director of the MSE from 2013-2018.

• Holding a PhD in Chemical Engineering, her scientific track record is: (1) 101 papers in WoS, (2) 4331 citations (in 3916 citing articles) in WoS, (3) H-index 21 in WoS, (4) PI of 4 projects funded by competitive calls (1 as coordinator of LEPABE), (5) researcher of 10 projects, supervision of (6) 5 doctoral and (7) 80 master theses concluded.

• Major research interests are: Biofuels from Waste; Bioethanol; Biodiesel; Waste-to-Energy; Microalgae for wastewater treatment; Microalgae for CO2 mitigation; Biorefineries; LCA; Sustainable buildings.

• Subject Editor for Biomass of Renewable Energy from March 2020. Member of the Editorial Board, of Green Technology, Resilience, and Sustainability. Lead Guest Editor of 12 Special Issues in indexed journals (Energy Reports; Energies; Sustainability; Energy Procedia, Waste and Biomass Valorization, Processes) and Guest Editor of many other Special Issues (Frontiers; Climate; ChemEngineering). Conference and Program Chair of several International Conferences (ICEER series); Member of the STC of International Conferences (WASTES, CCESG, TEEM, REEE, ENASB, JTIR, etc.). Keynote and Invited Speaker for International and National Conferences. Treasurer of APESB (Portuguese Association of Environmental and Sanitary Engineering) from March 2021 (Vice-President from March 2020 to March 2021). Project evaluator for the EC (H2020 MSCA-ITN) from 2019, USDOA and ANI/AdI from 2006, Israeli Science Foundation, among other international and national agencies.

CONFERENCE CHAIR

PROF. AMBRA GIOVANNELLI

Scopus web page: www.scopus.com/authid/detail.uri?authorId=22934006800
ORCID: 0000-0003-4991-173X

Ambra Giovannelli has been working as Assistant Professor of Fluid Machinery and Energy Conversion Systems at the Department of Engineering - University of Roma Tre. Lecturer of Turbomachinery (MS degree) and Applied Thermodynamics and Fluid-dynamics (BS degree), she received the MSc degree cum laude in Mechanical Engineering (2004) and a PhD in Mechanical and Industrial Engineering (2008).

Author of many papers and technical reports, her research work is focused on turbomachinery modelling (Supercritical CO_2 Turbomachines, Gas Turbines (GTs) fuelled with syngas, Solar GTs, Hybrid GTs), power production from Concentrated Solar Power (high-temperature solar concentrators, reactors and TGs), waste heat-to-power systems, storage systems (PCM storage systems and CAES) and energy-saving in refrigeration and cryogenic plants.

Member of the Editorial Board of the International Journal "Processes", she, currently, serves as a reviewer for several indexed scientific journals (e.g. Elsevier, Wiley, Springer, MDPI) and international conferences in the field of mechanical and industrial engineering (ICEER, ASME, IEEE).

She is member of IEC (International Electrotechnical Commission), ISES (International Solar Energy Society), ASME (American Society of Mechanical Engineers) and AIMSEA (Italian Society of Fluid Machinery and Energy Conversion Systems).

She has been local PI of some national projects related to the design and analysis of supercritical CO_2 turbomachines, and she was involved in several European (FP7-308952, 2013-17 "OMSoP", FP7-239349, 2009-2013 "H2-IGCC", FP6-502704, 2004-2007, STREP, "HYTECH") and Italian projects.

PROGRAM CHAIR

PROF. CORIOLANO SALVINI

University of ROMA TRE, Italy
Research Interests: energy system design and optimization, optimum management of complex plants, power production planning

Coriolano Salvini received M.S. in Mechanical Engineering (1991) and Ph.D. in Energetics (1997) from "La Sapienza" University of Roma. He is currently Associate Professor in Systems for Energy and Environment in the Department of Engineering at "Roma Tre" University. He is involved in research mainly focused on energy system design and optimization, optimum management of complex plants, power production planning.

PROGRAM CHAIR

PROF. CARLOS FELGUEIRAS

Department of Electrical Engineering, School of Engineering (ISEP), Polytechnic Institute of Porto (IPP), Porto, Portugal

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Research Interests: energy quality; energy and buildings; energy and environmental Indicators; renewable energy systems; sustainable energy systems; engineering education

Manuel Carlos Felgueiras received the B.S. and Ph.D. degrees in electrical and computer engineering from the Faculty of Engineering, University of Porto, Porto, Portugal, in 1987 and 2008, respectively. He started is professional career in 1987 as electronic designer for automation systems. Later was invited to supervise a test laboratory for verifying the accomplishment of European Standards in thermoelectric household appliances. He started the teaching activity in 1994 as Assistant Professor and later on as Adjunct Professor and researcher with the Department of Electrical Engineering, School of Engineering, Polytechnic Institute of Porto (P.Porto), Portugal. His research interests include design for debug and test of mixed-signals, remote experimentation in e-learning, renewable energy sources and smart buildings.

Prof. Felgueiras is member of the Portuguese Engineers Association and the Global Online Laboratory Consortium (GOLC). He has published around 90 papers and includes the scientific committee of several conferences.

KEYNOTE SPEAKER

PROF. WEIHAO HU

University of Electronics Science and Technology of China

September 14 | 09:45-10:30   **Meeting ID: 948 1336 4454**

Speech Title: Applications of Artificial Intelligence in Renewable Energy Systems

BIO Weihao Hu received the B.Eng. and M.Sc. degrees from Xi'an Jiaotong University, Xi'an, China, in 2004 and 2007, respectively, both in electrical engineering, and Ph. D. degree from Aalborg University, Denmark, in 2012.

He is currently a Full Professor and the Director of Institute of Smart Power and Energy Systems (ISPES) at the University of Electronics Science and Technology of China (UESTC). He was an Associate Professor at the Department of Energy Technology, Aalborg University, Denmark and the Vice Program Leader of Wind Power System Research Program at the same department. His research interests include artificial intelligence in modern power systems and renewable power generation. He has led/participated in more than 15 national and international research projects and he has more than 200 publications in his technical field.

He is an Associate Editor for IET Renewable Power Generation, a Guest Editor-in-Chief for Journal of Modern Power Systems and Clean Energy Special Issue on Applications of Artificial Intelligence in Modern Power Systems, a Guest Editor-in-Chief for Transactions of China Electrical Technology Special Issue on Planning and operation of multiple renewable energy complementary power generation systems, and a Guest Editor for the IEEE TRANSACTIONS ON POWER SYSTEM Special Section on Enabling very high penetration renewable energy integration into future power systems. He was serving as the Technical Program Chair (TPC) for IEEE Innovative Smart Grid Technologies (ISGT) Asia 2019 and is serving as the Conference Chair for the Asia Energy and Electrical Engineering Symposiums (AEEES 2020 and 2021). He is currently serving as Chair for IEEE Chengdu Section PELS Chapter. He is a Fellow of the Institution of Engineering and Technology, London, U.K. and an IEEE Senior Member.

ABSTRACT Owing to the strong uncertainty and fluctuation of renewable energy generations, renewable energy systems are becoming more sophisticated. Traditional model-based methods will be difficult to address the analysis, scheduling and control problems of the future renewable energy systems. Artificial intelligence (AI), as a data-driven approach, can directly learn useful information from massive data to deal with complex nonlinear problems without making any assumptions and simplifications. The fields of AI, e.g., deep learning and reinforcement leaning (RL), has made great progress in recent years. Advanced AI approaches can promote the development of renewable energy systems. The application of intelligent techniques in renewable energy systems can achieve a substantial improvement in predicting the optimal solutions of design and scheduling variables. Regression techniques learn patterns from massive data, so they can be used to monitor and predict renewable energy generations. Additionally, advanced classification techniques can be applied to assess the security and stability of renewable energy-based power systems. RL techniques can provide operators with emergency control actions amid the uncertainties of renewable energy systems.

In that talk I will give a short Introduction of AI. After that, I will share the application of deep learning in fault diagnosis and image recognition, and AI in renewable energy systems including multi energy systems with large-scale wind power and distribution network voltage control with large-scale PV power.

KEYNOTE SPEAKER

PROF. CLAUDIO CORGNALE

Greenway Energy, LLC

September 14 | 16:15-17:00 **Meeting ID: 948 1336 4454**

Speech Title: High Pressure Hydrogen Compression Using Alternative Efficient and Low-Cost Approaches

BIO Dr. Corgnale is the Chief Technology Officer of Greenway Energy, LLC (Aiken, South Carolina, USA). He is a mechanical engineer, renowned internationally for his experience and expertise in hydrogen energy systems and thermal energy storage systems. He has been involved in the design, assessment and testing of hydrogen production systems, developing process and detailed transport models for thermochemical and electrochemical hydrogen production plants. Dr. Corgnale has also been working on hydrogen storage, thermochemical energy storage systems and hydrogen compression systems. He has been carrying out transport modeling activities, material development research and he has coordinated experimental tests for cryogenic adsorbent systems, high temperature materials and high-pressure hydrogen absorption systems. He was part of the US Department of Energy (DOE) Hydrogen Storage Engineering Center of Excellence, where he developed techno-economic analysis models for solid state hydrogen storage systems and detailed transport models for carbon and metal organic framework adsorption materials. He has been the principal investigator of several DOE funded projects in the field of renewable energy, hydrogen compression and catalyst development for thermochemical hydrogen production systems. He was an invited speaker at the 2019 Hydrogen-Metal Systems Gordon Research Conference. He earned his PhD in mechanical and industrial engineering from the University Roma Tre (Italy) and is currently a visiting research assistant professor at the University of South Carolina. The author can be contacted at: claudio.corgnale@greenway-energy.com

ABSTRACT Hydrogen delivery represents one of the main issues to be overcome to achieve a world hydrogen economy. Three main approaches to transport and delivery hydrogen at large scale have been identified by the US Department of Energy (DOE). Each of the approaches requires the presence of high-pressure hydrogen compression systems. Current mechanical compressors cannot achieve the DOE targets, showing additional drawbacks when operating at the required pressures and conditions, especially in terms of reliability, efficiency and investment and lifetime costs. Valid alternatives are represented by electrochemical compression (EC) systems and thermal compression systems, exploiting the properties of suitable hydrogen absorption materials. A two-stage hybrid compressor system is discussed, with a first stage (lower pressure) EC unit, coupled in series with a second stage (higher pressure) metal hydride (MH) thermal compression system. After a description of the main fundamental properties of MHs, a comprehensive presentation of the second stage of the system, operating at higher pressures and integrated with the electrochemical unit, is given. Results, obtained from a project funded by the DOE, involving Greenway Energy LLC, Savannah River National Laboratory and Skyre Inc, are discussed. Possible improvements, both in terms of material properties and system performance, are also discussed, highlighting the required research and development activities to fabricate and commercialize a full scale system.

KEYNOTE SPEAKER

PROF. HECTOR RUIZ

Autonomous University of Coahuila, Mexico

September 16 | 16:15-17:00 **Meeting ID: 948 1336 4454**

Speech Title: Hydrothermal Processing for Advanced Transport Biofuels Production from Biomass

BIO Dr. Héctor A. Ruiz obtained his B.S in Chemical Engineering (Hons) from the Autonomous University of Coahuila (AUC) (2004, Mexico) and his Ph.D. in Chemical and Biological Engineering from Centre of Biological Engineering at the University of Minho, Portugal in 2011 and was a postdoctoral researcher at University of Minho (Portugal) and University of Vigo (Spain), 2012. Dr. Ruiz worked as lead operating engineer in the chemical industry at Magnelec Industries (Mexico, Feb 2005- Sep 2007). Dr. Ruiz is a Full Professor in the Faculty of Chemistry Sciences, founder of Biorefinery Group and manager of the biorefinery pilot plant at AUC (Saltillo, Coahuila, Mexico) since February 2013, and leader of the biomass pretreatment stage in the Cluster of Bioalcoholes in the Mexican Centre for Innovation in Bioenergy in Mexico.

Dr. Ruiz is Editor-in-Chief of BioEnergy Research Journal (Springer), Associate Editor of Biotechnology for Biofuels (BioMed Central-Part of Springer Nature) and editorial member of Industrial Crops and Products Journal (Elsevier) and Biofuel Research Journal. He was editor of the book: Hydrothermal Processing in Biorefineries by Springer, 2017. Dr. Ruiz was awarded with the Mexican Prize "Dr. Carlos Casas Campillo" of the Mexican Society of Biotechnology and Bioengineering in 2016 (most prestigious award of this society). The National Prize of Research 2021 in engineering and technology area from the Mexican Academy of Sciences. Young Scientist award at the AUC in 2019 (most prestigious award of the UAC, for the academic trajectory of research, innovation and training of human resources). Dr. Ruiz is member of the Mexican Academy of Sciences, and member of the Academy of Engineering, Mexico since 2021. Member of the National Researchers Council in Mexico (CONACYT, Level 2 distinction of 3).

Dr. Ruiz works to advance lignocellulose and algal (micro-macro) biomass biorefining science and technology for the production of high added-value compounds and biofuels (bioethanol), biomass fractionation using hydrothermal processing, biochemical and sugar platform approaches to biomass conversion and bioreactor design. Dr. Ruiz has conducted several research stays: at Brazilian Bioethanol Lab.- CTBE (Brazil), in the Chemical and Biological Engineering Department at the University of British Columbia (Canada), CIEMAT-Biofuels Unit (Spain), Sadar Swaran Singh National Institute of BioEnergy (India), Tokyo Institute of Technology (Japan), Umeå University (Sweden), Stan Mayfield Biorefinery Plant (USA), CSIR- NIIST (India), University of Concepción (Chile) and Federal University of Rio Grande do Norte (Brazil). He has authored or co-authored of 90 publications including papers and chapters, with h-index of 27 and 32 (Scopus and Google Scholar) and citations higher than 2,300 and 3,200 respectively. Dr. Ruiz has presented 36 plenary talks by invitation on biomass conversion into biofuels and more than 137 contributions in scientific events. Dr. Ruiz has supervised many PhD, MSc and undergraduate students (41 concluded thesis).

ABSTRACT Due to environmental considerations concerning sustainable development in the last years, the renewable resources currently attract increasing interest as raw material for industry in the production of advanced transport biofuels as bioethanol. The term "biorefinery" of lignocellulosic materials from agricultural residues and aquatic biomass (macro-micro algae) is analogous to the classical petroleum refinery concept and refers to biomass conversion into biofuels and chemicals with high added value through the integration of clean processes. Moreover, the concept of biorefinery demands efficient utilization of all components of these raw materials. Hydrothermal processing is a potential clean technology to convert raw materials such as biomass into bioenergy and high added-value chemicals. In this technology, water at high temperatures and pressures is applied for hydrolysis, extraction, and structural modification of materials. This presentation is focused on providing the fundamentals, modelling, new technologies and scale-up of hydrothermal processing for the application and conversion of the main components of biomass into advanced transport biofuels and high value-added products in terms of biorefinery concept.

INVITED SPEAKER

PROF. PABLO ARBOLEYA

Universidad de Oviedo, Spain

September 15 | 16:30-17:00 **Meeting ID: 948 1336 4454**

Speech Title: Flexibility in Electricity Systems as the Key to Decarbonisation of the Energy System

BIO Pablo Arboleya received the M.Eng and Ph.D. (with distinction) degrees from the University of Oviedo, Gijon, Spain un 2001 and 2005 respectively, both in electrical engineering. Nowadays, he Works as an associate professor at the University of Oviedo. He is co-founder of the LEMUR research group in which he carries out his research activities related to the modelling and analysis of electrical systems and the implementation of operation and energy management techniques.

Pablo is holding the SmartCities Chair at University of Oviedo funded by the city of Gijón. Aligned with the target of this chair he participated in the development of the Gijón DemoLab in which an IoT infrastructure at city level is being tested and developed. He is also co-founder of Plexigrid, a University of Oviedo spin-off technology-driven company, that develops software tools specially designed for grid operators, aggregators and energy communities.

He is managing editor of the International Journal of Electrical Power & Energy Systems from ELSEVIER a top ranked journal in the power systems field, and associated editor of eTransportation journal, a newly created magazine that aims to be ELSEVIER's flagship for transport electrification in which he has participated since its very creation in 2019.

ABSTRACT Success in the face of the undoubted challenges posed by the change of model towards a low-carbon economy is closely linked to innovation and technological development in the field of energy.   In the process of energy transition towards a sustainable energy system, efficiency and savings measures are complemented by efforts in technological innovation, guided, in turn, by the need to produce more sustainably, efficiently and at competitive prices, reducing external dependence and making it possible to combat climate change.

The main areas in which the main lines of research are structured are basically storage, generation (development of more efficient renewable energies) and the development of electric vehicles, as well as energy distribution and transport. In fact, in recent years, electricity distribution is undergoing more changes than it has for decades thanks to advances in these lines of research. Various technologies such as electric vehicles, photovoltaic generation systems, storage systems and heat pumps have been reducing their costs exponentially, making them more accessible to end users. The massive deployment of these technologies means that what were previously only customers who consumed electricity have become prosumers, customers who produce electricity or consume it flexibly.

The massive deployment of these technologies means that what were previously only customers who consumed electricity have become prosumers, customers who produce electricity or consume it flexibly. The role of prosumers and the flexibility they can provide to the system will be key in the decarbonisation process as set out in the package of measures that will derive from the European guidelines established in the so-called "Clean Energy Package for all Europeans" (https://bit.ly/2YXY28u).   A set of measures framed in various lines of action such as: energy consumption in buildings, renewable energy, energy efficiency and the renewal of the electricity market.

It should be borne in mind that although electrification is one of the keys to the decarbonisation process, it will also mean an increase in both generation and demand at low voltage distribution network level. This will undoubtedly lead to high levels of stress on the distribution grids, which will act as real bottlenecks in the increased penetration of the aforementioned technologies.   The only way to promote the electrification process in the low voltage grid without incurring disproportionate investment costs in the grid is through the management of so-called flexible loads. These loads are those that can be modified, brought forward or delayed without any loss of comfort for the end user, a clear example being electric vehicles. However, managing flexibility in distribution networks is not a trivial task due to technical and regulatory aspects that will be reviewed in this talk.

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Session 1A - Energy Efficiency

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Thermodynamic Analysis of Diesel Engine Ignition Delay under Low Load Conditions

A G M B Mustayen[1], Wang X[1], Rasul M G [1,2], Hamilton J M[1], Negnevitsky M[1]

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ABSTRACT

In recent decades, renewable energies (e.g., wind and solar) were introduced to reduce the dependency of diesel power generation. However, diesel power generation cannot be eliminated entirely due to the uncertainty and intermittent of these renewable sources. In this case, low load diesel operation (below 30% of maximum rated power) is considered for high renewable energy penetration in the hybrid renewable diesel engine power system. Engine ignition delay is one of key parameters to affect engine response and performance in the hybrid power system. This study investigated engine ignition delay for different load operations from 15%, to 100% under different engine speed conditions ranging from 1500 rpm to 2100 rpm. From this analysis, it was found that ignition delay time increased with decrease in engine load. It was also shown that ignition delay time decreased with increase in engine speed. The result showed, at 15% and 25% load condition ignition delay times are 1.16 and 0.98 milliseconds for 1500 rpm, 0.98 and 1.07 milliseconds for 1800 rpm and 1.10 and 0.92 milliseconds for 2100 rpm engine speed operation. These results indicates that the change of engine load and speed did not significantly affect the ignition delay.

Keywords: Diesel engine; ignition delay; renewable power generation; variable speed.

1. INTRODUCTION

The importance of diesel engines for power applications are growing day by day due to its high fuel efficiency, reliability, larger power range, long lifetime, low price of diesel fuel etc.[1]. Diesel engine-driven generator have traditionally been used to supply relatively small power networks such as those associated with industrial complexes, marine applications and island supply systems [2]. However, most of the remote and isolated areas which are not connected to national grid, diesel engine is only reliable source to provide electricity. Due to high emissions and maintaining cost conventional diesel generating mode is not efficient and flexible in island power system [3]. For fixed speed diesel at conventional mode, as the load decreases, engine efficiency decreases. Both emission intensity and fuel consumption increase with decreasing engine load especially at low load (below 30% of maximum rated load) conditions. In terms of flexibility, engine load limits and efficiency are the main factor that arise in hybrid diesel systems [4, 5]. Ignition delay is defined as the time lag between injection and start of combustion. This time lag is due to physical and chemical sub-processes such as fuel atomization and vaporization, fuel-air mixing and chemical pre-reactions [6]. These processes are affected by operating variables and fuel characteristics. As engine load decreases, cylinder combustion temperature and pressure decrease. The aim of this study is to investigate and analyze diesel engine ignition delay period at different operating conditions specially at low load ranges. This paper is focused on thermodynamic analysis of combustion model and ignition delay correlations. To calculate ignition delay time, a bunch of existing correlations are used and figured out the suitable one for diesel engine low load ranges operation.

2. MATERIALS AND METHODS

In this work, a thermodynamic combustion model is developed which includes a semi-empirical ignition delay correlation to predict the engine response time at different engine load conditions especially under low load operations. The main purpose of this models is to understand modified diesel combustion characteristics which has significant impact on engine combustion phenomena and engine delay response. A bunch of ignition elay correlations were considered to predict ignition delay at low load conditions. MATLAB toolkit was used for model simulation. The study focused on the ignition delay performance of diesel engine at low load ranges (below 30% of maximum rated power). The results show that ignition delay is longer at lower loading conditions because residual gas and cylinder wall temperature decreases at lower injection temperature at low load ranges.

3. RESULTS AND DISCUSSION

In recent years, most of the remote and island areas power systems have integrated renewable energy (e.g., wind

and solar) in terms of flexibility and reduce overall system cost of diesel generation. But it is not possible to eliminate diesel engine entirely from the system because of uncertainty of renewable resources. As a result, low load diesel operation is particularly relevant for its potential ability to support huge renewable integration. Unfortunately, low load operation can result in lower combustion performance in comparison with conventional mode (above 50% of maximum rated power) diesel operation. Due to high air–fuel ratio at low load ranges, in-cylinder pressure is relatively low which is the cause of longer ignition delay. In this study a bunch of existing models were considered to quantify the ignition delay under different speeds and loading conditions. Among all results, it has found that Hardenberg correlation shows the shorter ignition delay at low load ranges e.g., 15% and 25% which is one of the focus points of this study. Shorter ignition delay time occurs earlier ignition which starts quick combustion, thus engine (as a generator mode) responses fast. In ignition delay correlations at different engine speeds (1500rpm, 1800 rpm and 2100rpm) at 15% and 25% load conditions were calculated in result section. From this analysis it can be say that Hardenberg correlation is suitable for lower load range operation between all existing correlations.

4.   CONCLUSION

In recent years, diesel generation system has been trying to replace by renewable penetration, but diesel system may not be eliminated entirely. However, in case of higher level of renewable integration in island and remote power systems, reduction of engine load can be beneficial in terms of economically and environmentally. Ignition delay is one of the most significant parameters that affects engine combustion profiles and output response. In this study, an investigation was done among all existing ignition delay models under different engine speeds and loading conditions. The trend of ignition delay versus load and speed is that ignition delay increases when engine load and speed are decreasing. The results have been shown that, at 1500 rpm, 1800 rpm and 2100 rpm speed operations, Hardenberg correlation gives shorter ignition delay time in comparison with other correlations. Considering low load ranges (e.g.,15% and 25%), the ignition delay time is 1.16 and 0.98 milliseconds for 1500 rpm, 0.98 and 1.07 milliseconds for 1800 rpm and 1.10 and 0.92 milliseconds for 2100 rpm engine speed operation. It can be concluded from this analysis is that the change of engine speed and load (at lower ranges) has not remarkable impact on ignition delay and Hardenberg correlation shows the shorter ignition delay (in time scale) for 15% and 25% engine load ranges.

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E040 10:00-10:15

Efficiency Assessment of Technologies Implementation in Vietnam Power Transmission System

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ABSTRACT

Many flaws have emerged on Vietnam power transmission system, such as obsolete technology and aging components. High voltage direct current (HVDC) system, 750kV system, Aluminium Conductor Composite Core (ACCC) conductor are determined by Vietnam government to be implemented because of their proven performance as well as their suitability to the existing system. Newton Raphson load flow method is utilized to analyze different scenarios, in which performance of these technologies are compared with each other to identify the most robust method to decrease real power loss in steady state working condition. As results signified, 750kV system is the solution with highest efficiency, whereas ACCC and HVDC's performance does not match the expectation.

Keywords: ACCC; HVDC; Load flow; Newton-Raphson method; Power loss; Transmission system

1. INTRODUCTION

Vietnam power transmission system has been expanded at the average of 10% each year since its inception in 1994 in terms of transformers capacity, lines length and transmitted power. Its extent ranks second in Southeast Asia, twenty third in Asia. However, there is still a large distance between this system and other advanced systems in the world when efficiency, productivity, etc. are taken into consideration. As directed in Master Plan of Vietnam government, to keep pace with other systems, new technologies are to be examined, such as new conductor ACCC, HVDC, 750kV system. This study investigates the impact of applying these technologies on power loss.

2. MATERIALS AND METHODS

Data of transmitted real power of every month in five years from 2016 to 2021 was collected. Data of resistance, reactance and susceptane was calculated from characteristics of transformers and transmission lines. Collected and calculated data are the input of load flow method, and real power total loss is the focused output. First, this output is compared with reported losses of the organization to verify the accuracy of the load flow method. They are then compared to each other to identify which components hold the highest power loss. Next, multiple scenarios with changes in topology related to these components are proposed to focus on loss reduction. Finally, new anticipated input based on changed topologies is used to generate new power losses, which are later compared with each other to determine the most robust scenario in loss reduction.

3. RESULTS AND DISCUSSION

Losses generated by this method are expected to be different from losses reported by the organization, because many other loss-affecting factors are excluded. However, in Figure 4 (not shown in this Extended Abstract), they share similar patterns. Hence, this method is appropriate for further usage. As processed by Newton-Raphson method, six components on which losses are the highest are 500kV lines, namely L1, L2, L3, L4, L5, and L6. Their losses account for 77.70-86.04% of total loss on entire system. Based on formula of real power loss on transmission lines, in order to reduce loss, voltage, line length, resistance/km, line real power and line reactive power are subjected to change. However, because changes of voltage and line length are not feasible due to drastic changes of lines' structure, scenarios below concentrate on other variables.

In comparison between methods to decrease conductor resistance/km, 6-bundled line appear to be the most efficient solution, whereas ACCC conductor might be the most feasible because we only need to change conductor rather than changing structure of line with other solutions.

In comparison between methods of forming new components to reach N-1 criteria, including double line, new 500kV high voltage alternating current (HVAC) overhead line, new 500kV HVDC overhead line, new 500kV

HVDC cable line, new 750kV HVAC overhead line, new 750kV HVAC overhead line between bus 1-bus 5 is the most robust component.

4. CONCLUSION

To determine which method of power loss reduction is the most suitable and beneficial to this system, there are many other studies to be conducted, namely cost-benefit study, technical selection, geographic selection, economic selection, consumption forecast, etc. This study also needs more accurate and detailed data, such as characteristics of transformers. Many other aspects and parameters require to be assessed as well, especially corona loss which is affected by weather condition. However, it shows that although new technologies might have positive effects on this system, their performance depends greatly on how, when and where they are utilized, for example, the more the power is transmitted, the clearer and higher their impacts are to the system. It is also worth mentioning that basic technologies can be helpful if they are applied appropriately. Combination of multiple methods might obtain even more worthwhile results and needs to be assessed in future works.

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ICEER
2021

Theoretical Calculation Method for Optimal Operation Efficiency of MV Distribution Line

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ABSTRACT

Used in the process of MV power distribution lines currently running efficiency evaluation of the rule of "N-1" hard to reasonable measures under different load structure lines optimal load capacity, failed to fully consider under different load structure lines running economy problem. The paper presents a theoretical calculation method for optimal operation efficiency of MV distribution line considering reliability and economy. Firstly, the operation efficiency of MV distribution lines is defined, and its calculation method is proposed in combination with safety and economy. Then sequential Monte Carlo method is used to evaluate the reliability of MV distribution lines considering the load structures. Finally, the optimal load capacity model of MV distribution lines is developed to optimize operation efficiency. Finally, the effectiveness and practicability of the proposed method is verified by an example analysis.

Keywords: operational efficiency; optimal load capacity; reliability; medium-voltage; distribution line

1. INTRODUCTION

Scientific and reasonable evaluation of the operation efficiency of distribution network is of great significance to improve the utilization level of equipment, ensure reliable power supply and save investment cost. Ref. [1] proposes an analysis method for calculating the correlation of distribution network operation efficiency based on fuzzy clustering analysis. Ref. [2] summarizes the impact factors of the utilization and analyzes the impact of PV on the distribution equipment utilization. In reference [3], combined with the concept of load rate, the equipment utilization rate is defined, and considering the "N-X" criterion, load characteristics, load development and other influencing factors, the evaluation standard of equipment utilization rate of distribution network and corresponding improvement measures are proposed.

The above evaluation methods comprehensively reflect the operating efficiency of distribution network by combining various indicators, such as line loss, equipment utilization rate. Indicator correlation and weight selection impact the accuracy of the assessment.

2. MATERIALS AND METHODS

The paper presents a theoretical calculation method for optimal operation efficiency of MV distribution line considering reliability and economy. Firstly, the operation efficiency of MV distribution lines is defined, and its calculation method is proposed in combination with safety and economy. Then sequential Monte Carlo method is used to evaluate the reliability of MV distribution lines considering the load structures. Finally, the optimal load capacity model of MV distribution lines is developed to optimize operation efficiency.

3. RESULTS AND DISCUSSION

The MV distribution line achieve the optimal operation efficiency when the expense-income ratio at the optimal point with industrial load and commercial load. If the residential load locates at the MV distribution line, the operation efficiency appears a decreasing trend.

The optimal load capacity of distribution lines increases with the increase of the proportion of residential load. This is because the larger the proportion of residential load, the smaller the unit outage loss, the smaller the growth rate of distribution line input, and the larger the load capacity to balance input and output.

4. CONCLUSION

(1) The maximal load capacity of MV distribution line under reliability constraint is equal to the optimal load capacity when not considering the economics of operation.

(2) The topology structure, load type and reliability requirement affect the optimal load capacity of MV distribution lines. The proposed method calculates optimal load capacity with economy and reliability to analyze the optimal operation efficiency of MV distribution lines.

(3) The residential load, industrial load and commercial have different effects on optimal load capacity of MV distribution lines, in which the residential load has the biggest positive impact

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Session 2A - Advanced Energy Technologies
09:45-10:30 @ Meeting ID: 979 7648 1988

E044	9:45-10:00

THD Analysis of Three Phase GTSPPS Via Novel PRESH Controller

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[1] Department of Electrical Engineering, JC Bose University of Science and Technology YMCA Faridabad, India.

ABSTRACT

The proposed paper aims to analysis the THD (Total Harmonic Distortion) of three phase GTSPPS (Grid Tied Solar Photovoltaic Power System) via Novel PRESH (PRES+RESH) Controller. Presently, for eliminating the harmonic from three phase GTSPPS, various filters and controller were already proposed but it either resulted in having THD on higher side or made the system bulky. These techniques get fails in eliminating the harmonic when reference waveform get distorted from its original position. The Novel PRESH Controller proposed here is the combination of PRES (Proportional Resonant) controller in parallel with a RESH (Resonant Harmonic) controller in place of conventional controller which use the above duo controller in series. Novel PRESH controller proposed here can overcome the problem faced by earlier controller/filter even if the reference waveform get distorted. Investigation of Novel PRESH controller is done on a experimental setup in term of harmonic analysis with the standard controller (A combination of PRES and RESH controller in series) along with BP (Bode Plot) analysis to show that proposed controller can tackle the distorted reference waveform in a reliable manner. Further, to show that THD obtained through the help of Novel PRESH Controller is as per IEEE standard 519 and 1547.

Keywords: GTSPPS, PRES, PRESH, RESH, THD.

1. INTRODUCTION

Grid Tied Solar Photovoltaic Power System (GTSPPS) can be connected to grid using converter. Acc. to IEEE standard 519 and 1547, THD (Total Harmonic Distortion) is kept below 5%.

Generally, for reducing current harmonic from GTSPPS, various technique were proposed earlier such as: lead-lag, modified PI, repetitive, dead-beat , PR controller etc. Simplest technique for eliminating the current harmonic is by engaging the PRES Controller [1]-[3] because of its modularity. Several advanced techniques for mitigating the harmonic have been discussed in details. But these control techniques are complex and have high computational loading problem. The alternative for these techniques is achieved through [4]-[5]. The presented paper at first will discuss the design procedure of Novel PRESH controller in brief and its implementation with GTSPPS. In second step, THD Analysis of three phase GTSPPS will be done through Novel PRESH controller. The analysis of Novel PRESH controller is done through the help of bode plot analysis. The main advantage of Novel PRESH controller proposed in this paper is to show that even if reference waveform is distorted one, this controller can tackle it in a very reliable manner, along with its efficiency in eliminating the harmonic close to 1%.

2. MATERIALS AND METHODS
2.1 Design Procedure of Novel PRESH controller
In this proposed Novel PRESH controller, shown by Figure, inverter current is used as input to compensator of lower forward gain instead of applying the difference of reference current signal and grid current.
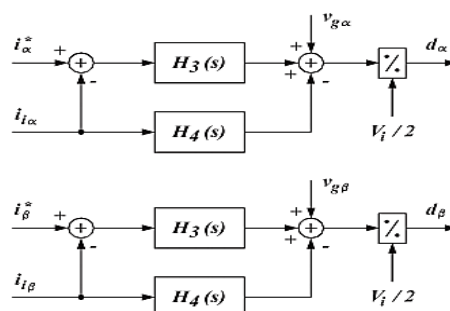
Figure : Proposed Novel PRESH Controller

Where, $H_3(s)$ is PRES (Proportional Resonant) controller and $H_4(s)$ is RESH (Resonant Harmonic) Controller.

3. RESULTS AND DISCUSSION
Harmonic distortion thus calculated is depicted by table comparing the THD without controller and with proposed controller of the system.

Table: THD under different control technique

Control Technique	V_{ga}	V_{gb}	V_{gc}	I_{oa}	I_{ob}	I_{oc}
Standard control without Resonant Harmonic Controller	4.0	4.5	7.5	3.6	3.4	5.7
Standard control with Resonant Harmonic Controller	3.7	4.7	7.8	1.8	1.8	2.3
Proposed Novel PRESH Controller	3.8	4.8	7.8	0.9	0.92	1.12

From above table, it is cleared that standard control gives very poor performance when resonant harmonic controller is not engaged however, the performance improves a bit after engaging the resonant harmonic controller.

4. CONCLUSION
Identification of indirect mechanism is done that was responsible in generating the current harmonic from abnormal grid condition in standard resonant current controller. The proposed Novel PRESH controller overcome this problem by connecting in a different configuration as explained by using case study. Thus, able to track the fundamental component even if abnormal condition arises.

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Experimental Study on Horizontal Tube Spray Falling Film Evaporator in a Low Temperature Geothermal Binary Cycle Power System

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ABSTRACT

Horizontal tube spray falling film evaporator is an efficient evaporation equipment, which has many advantages, such as high heat exchange efficiency, small equipment volume and low equipment cost. A heat transfer experimental system for horizontal tube spray falling film evaporator of organic Rankin cycle (ORC) power generation system was established, and the effects of spray density, initial temperature and flow rate of geothermal water on the heat transfer coefficient outside the tube were analyzed with R245fa as working fluids. The experimental results show that with the increase of spray density, the heat transfer coefficient showed a trend of increasing first and then decreasing. With the increase of hot water temperature, the heat transfer coefficient increases first and then decreases. With the increase of hot water flow rate, the heat transfer coefficient increases first and then decreases.

Keywords: heat transfer coefficients; spray ;evaporation; horizontal tube falling film

1. INTRODUCTION

The earth contains huge geothermal energy resources and plays an important role in the energy development in the new century. Compared with other renewable energy sources such as solar energy, wind energy, tidal energy, and biomass energy, stability and continuity become the greatest advantages of geothermal energy.

In recent years, domestic and foreign scholars have carried out a large number of studies on low and medium temperature geothermal power generation systems, and the research shows that the organic Rankin cycle (ORC) power generation is one of the simple and efficient technologies. The evaporator is the key component of ORC power generation system and one of equipment with the largest exergy loss in the whole ORC power generation system [1, 2, 3]. Improving the heat-transfer and evaporation efficiency in the evaporator is of great significance for improving the system performance and Saving project investment. Horizontal pipe spray falling film evaporator is mainly used in seawater desalination, absorption refrigeration, vapor compression refrigeration and other fields at present, but no research has been found on the application of geothermal power generation system. Therefore, the research on horizontal tube falling film evaporation technology will provide important technical basis and theoretical basis for the design and production of high-efficiency evaporator equipment applied in low-temperature geothermal ORC power generation system and other fields.

2. EXPERIMENTAL SYSTEM AND METHOD

The whole circulatory system contains three sub-circulatory systems:

(1) Hot water circulating system: composed of hot-water boiler A and hot water pump B. A simulates the geothermal water source. The hot water enters the generator through the hot water pump and in which exchanges heat with the working fluids and then returns to A. The circulation is completed.

(2) Cooling circulating system: composed of condenser G, cooling water pump I and cooling tower H. The water in the cooling tower enters the condenser through the cooling water pump, exchanges heat with the working fluids in the condenser, and then returns to the cooling tower, and the circulation is completed.

(3) Working fluids circulation system: composed of evaporator C, working fluids pump J and pressure reducing valve E. The working fluids in the condenser enters the evaporator through the working fluids pump, drops evenly on the horizontal tube under the distribution of the spray film distributor, evaporates after absorption of heat, enters the pressure reducing valve for decompression, and feeds into the condenser for condensation, and the cycle is completed.

3. DATA PROCESSING AND EXPERIMENTAL CONTENT

Experimental content

(1) Effect of spray density of the work on the flow regime and heat transfer performance.

(2) Effect of different hot water temperatures on heat transfer performance.

(3) Effect of different hot water flow rates on heat transfer performance.

4. RESULTS AND DISCUSSION
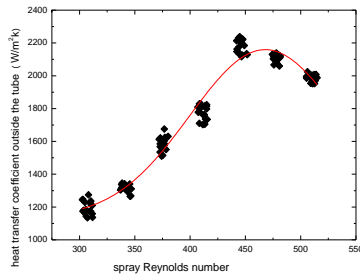
Fig.1 Effect profile of spray Reynolds number on the heat transfer coefficient outside the tube
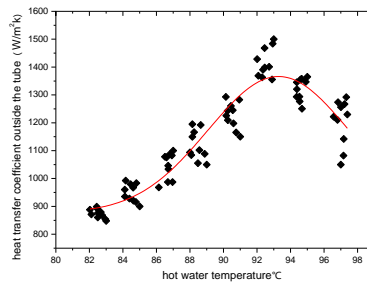
Fig.2   Effect curve of hot water temperature on the heat transfer coefficient outside the tube
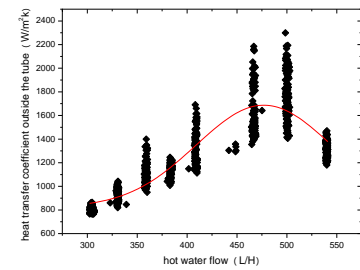
Fig.3 Effect of hot water flow on the tubes exchange coefficient outside

5. CONCLUSION

1) The heat transfer coefficient increases with spray Reynolds number and shows a tendency to rise first and then decrease. And it is known from the experiments that the optimal spray Reynolds number for R245fa is 450.

2) It is experimentally derived that when the hot water temperature is in the range of 82 ~ 98 ℃, the heat transfer coefficient first increases and then decreases as the hot water temperature increases. In order to achieve higher heat transfer efficiency, the temperature of hot water should be increased as much as possible within the permissible range.

3) It is experimentally derived that when the hot water flow rate is in the range of 300-550L/h, as the hot water flow rate increases, the heat transfer coefficient first increases and then decreases, to ensure that no dry spots appear, the hot water flow rate should not be too large.

4) Through the experiment, it can be known that the heat exchange coefficient in the tube is more affected by the hot water flow rate, while it has basically no effect when the other parameters change.

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Annual Average Efficiency of the Duct Oscillating Water Column Wave Energy Converter Device in Random Waves Environment

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ABSTRACT
The present study investigates the annual average efficiency of the duct OWC-WEC under the random waves environment in the local wave climate. For the incident wave spectrum, the Bretschneider spectrum is used to model the local wave climate around the OWC plant. It is found that the annual averaged efficiency of the duct OWC-WEC initially becomes higher as the incident wavelength becomes shorter and attains a maximum. Hereafter, the efficiency of the device decreases for shorter incident waves. Further, the efficiency becomes higher for device having wider chamber. For long incident waves, the amplitude of the efficiency curve decreases for higher values of front wall's draft, and an opposite trend is formed for intermediate and short incident waves.

Keywords: Boundary element method; Duct OWC-WEC; Efficiency; Radiation; Wave power

1. INTRODUCTION

Several studies have highlighted wave energy as a reliable renewable energy option in the global initiatives to decarbonize energy systems due to the numerous advantages such as plentiful and reduce greenhouse gas emissions. Using the Monte Carlo simulations, [1] examined the working mechanism of an U-shaped OWC device. The analysis revealed that an accurate tuning of various parameters related to the device can result into better performance of the OWC device. Recently, [2] studied the performance of an U-shaped OWC-WEC for various angle of incidence of the incoming waves, and reported that the incident angle plays a vital role in improving the efficiency of an OWC-WEC. However, in the real ocean, the incident waves are irregular in nature, and the structural configurations of the OWC devices are complex. [3] developed a dual-mass system to assess the hydrodynamic functioning of an OWC-WEC. It was noted that the addition of a stepped bottom in an OWC-WEC configuration improves the efficiency in the influence of regular and irregular incoming waves. Recently, [4] examined the working mechanism of (i) LIMPET OWC-WEC and (ii) quater circle shaped OWC-WEC in the presence of random waves.

2. MATHEMATICAL FORMULATION AND SOLUTION METHODOLOGY

Here, the mathematical formulation for the duct OWC-WEC placed over an undulated seabed is provided. The schematic representation of the physical problem is shown in Fig:1. The duct OWC-WEC is floating over the corrugated seabed and fixed with the help of mooring lines. The corrugated seabed is finitely extended as shown in Fig:1. Further, the potential flow theory is assumed to be valid the flow motion is time-harmonic with circular frequency ω. Under these assumptions, the velocity potential will exist in the form $\Psi(x,z,t) = \Re\{\psi(x,z)e^{-i\omega t}\}$.

So, the governing equation is given as

$$\nabla^2\psi(x,z) = 0 \tag{1}$$

Now, the linearized free-surface boundary condition on $z = 0$ is given by

$$\frac{\partial\psi^{S,R}}{\partial n} - K\psi^{S,R} = \varsigma\left(\frac{i\omega p}{\rho g}\right), \tag{2}$$

Now, bcs on the impenetrable boundaries $\Gamma_2 \cup \Gamma_5 \cup \Gamma_7$ are given by

$$\frac{\partial\psi^{S,R}}{\partial n} = 0, \quad \text{on } \Gamma_2 \cup \Gamma_5 \cup \Gamma_7. \tag{3}$$

Finally, the radiation conditions on $\Gamma_1 \cup \Gamma_3$ take the form

$$\frac{\partial\psi^S}{\partial n} - ik_0\psi^S = \begin{cases} \dfrac{\partial\psi^{inc}}{\partial n} - ik_0\psi^{inc}, & \text{on } \Gamma_1 \\ 0, & on\ \Gamma_3, \end{cases} \tag{4}$$

$$\frac{\partial\psi^R}{\partial n} - ik_0\psi^R = 0, \quad \text{on } \Gamma_1 \cup \Gamma_3.$$

Here, k_0 satisfy $\omega^2 = gk \tanh(kh)$. Finally, the BEM is used to solve the boundary value problem. (see [5] for details).
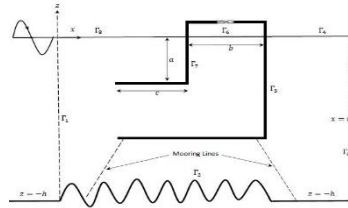
Fig:1. Schematic of the physical problem

3. RESULTS AND DISCUSSION
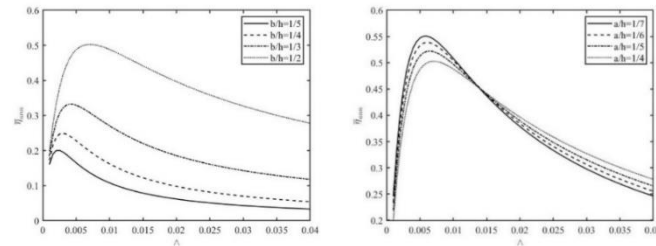
Fig: 2. $\bar{\eta}_{ann}$ vs Λ for various (a) chamber length b/h, and (b) submergence depth a/h associated with the OWC plant on the island of Pico.

In Figs. 2(a) and 2(b), the variation of the annual-averaged efficiency $\bar{\eta}_{ann}$ vs turbine damping coefficient Λ are plotted for various b/h and a/h. Figs. 2(a) and 2(b) show that the efficiency of the OWC initially becomes higher as Λ takes higher values and reach to a maximum. Hereafter, $\bar{\eta}_{ann}$ takes lower values as Λ increases further. Further, with an increase in b/h, $\bar{\eta}_{ann}$ increases. Contrarily, in the long wave regime, $\bar{\eta}_{ann}$ increases as a/h becomes lower. However, opposite patterns formed in the intermediate and short-wave regimes.

4. CONCLUSION

In the present study, the annual-averaged performance of a duct OWC-WEC is analyzed in real sea conditions. The local wave climate at the OWC plant site Pico, Portugal is taken as the incident wave spectrum. It is seen that the annual averaged efficiency of the duct OWC-WEC initially becomes higher as the incident wavelength becomes shorter and attains a maximum. Hereafter, the efficiency of the device decreases for shorter incident waves. In addition, the magnitude of the efficiency is higher for device having wider chamber. Moreover, in the long-wave regime, the amplitude of the efficiency curve decreases for higher values of submergence depth, and an opposite trend is formed for intermediate and short incident waves.

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Session 3A - Energy
10:45-12:15 @ Meeting ID: 948 1336 4454

E076	10:45-11:00

Solar Powered Organic Rankine-Vapor Compression Air Conditioning

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ABSTRACT

In this paper, the solar driven organic Rankine-vapor compression air conditioning is studied. The working fluid type, system design and influencing factors are studied by means of thermodynamic simulation. The results show that the generation temperature and condensation temperature of the working fluid have an important influence on the system performance. The cooling power and total efficiency of the unit area collector first increase and then decrease with the generation temperature of the working fluid, and then decrease with the increase of the condensation temperature. Through the performance comparison, it is found that R123 is the most suitable working fluid. When the generation temperature, condensation temperature and evaporation temperature of the working medium are 120 ℃, 45 ℃ and 5 ℃, the cooling power and total efficiency of the solar collector are 135.97 w / m2 and 43.98%, respectively. The feasibility of the solar driven organic Rankine-vapor compression air conditioning system is demonstrated.

Keywords: Solar ;Air conditioning; Organic Rankine-vapor compression

1. INTRODUCTION

Because air conditioning power consumption accounts for a large proportion of the power consumption of civil buildings, many cities in China have insufficient power supply in summer, which leads to the situation of power limit by closing the gate. China has abundant solar energy reserves, so it is very important to replace or partly replace conventional energy driven air conditioning system for environmental protection and energy conservation.There are four main ways of solar air conditioning: absorption air conditioning, adsorption air conditioning, jet air conditioning and dehumidification air conditioning. Some scholars have carried out experimental research on solar energy absorption air conditioning and developed corresponding prototype [1-3].

2. SYSTEM DESIGN
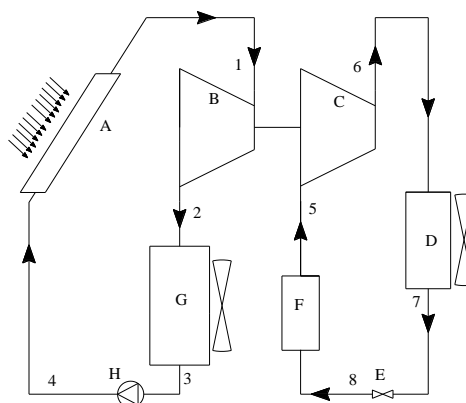
Fig. 1 The system schematic drawing

A-solar collector (generator), B-expander, C-compressor, D-condenser for cooling system, E-throttle valve, F-evaporator, G-condenser for power system, H-working fluid pump.

3. THERMODYNAMIC MODEL

Based on the following assumptions, the thermodynamic study of the system was carried out
(1) Ignore the heat loss between the system and the environment;
(2) The flow resistance of the working fluid on the power side and the refrigeration side is ignored;
(3) The power consumption of condenser on power side and refrigeration side is ignored.

4. RESULT ANALYSIS
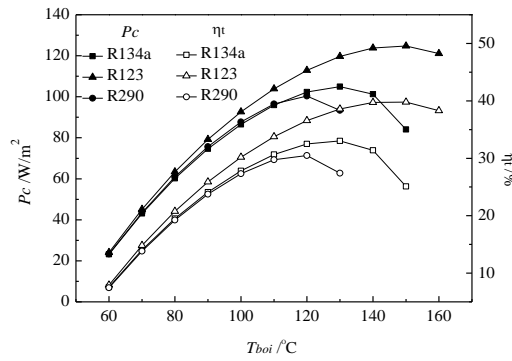
Fig.2 Effect of T_{boi} on Pc and η_t
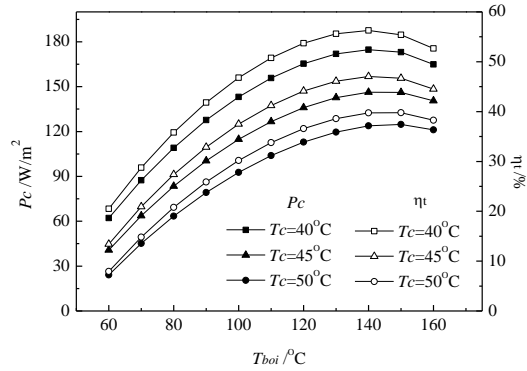
Fig.3 Effect of T_c on Pc and η_t
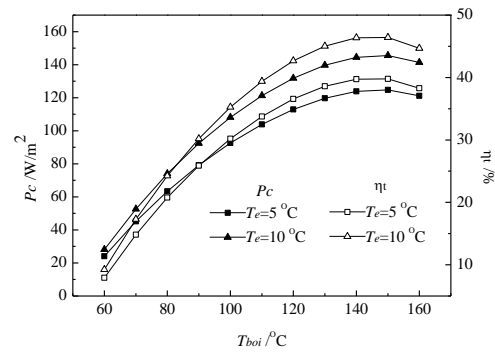
Fig.4 Effect of T_e on Pc and η_t
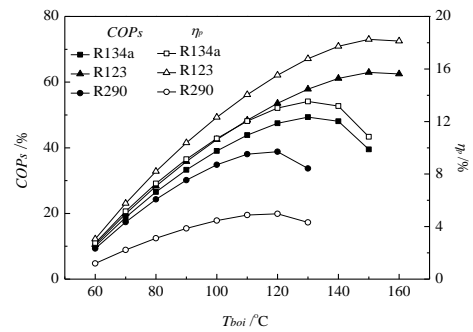
Fig.5 Effect of working fluid type on COP_s and η_p

4. CONCLUSION

(1) The feasibility of organic Rankine steam compression air conditioning system driven by solar energy is demonstrated. When the generation temperature, condensation temperature and evaporation temperature of the working medium are 120 ℃, 45 ℃ and 5 ℃, the cooling power and total efficiency of the unit area collector are 135.97 w / m2 and 43.98%, respectively;

(2) The generation temperature of the working fluid has an important influence on the system performance. The cooling power and total efficiency of the unit area collector first increase and then decrease with the generation temperature of the working fluid. There is an optimal generation temperature of the working fluid, which makes the cooling power and total efficiency of the unit area collector reach the maximum.;

(3) The condensation temperature has a great influence on the system performance. With the increase of condensation temperature, the cooling power per unit area and the total efficiency of the system decrease. The cooling power of the unit area collector at 40 ℃ is 1.21 times of that at 45 ℃ and 1.45 times of that at 50 ℃;

(4) Among the three refrigerants R123, R134a and R290, the refrigeration power per unit area of the collector, the total efficiency of the system, the total coefficient of performance of the expander compressor and the power cycle efficiency of the system using R123 are higher than those of the other two refrigerants.

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E009   **11:00-11:15**

Investigation of Flame Acoustic Excitation of a Gas Fuelled Burner

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ABSTRACT

Imposing acoustic oscillations on flame front enhances the turbulent mixing, resulting in reduced NO_x and CO emissions and reduced flame length. The acoustic intensity can be adjusted by modifying the pressure of feeding air or the nozzle size. The numerical model was validated against experimental data on CO concentration and temperature and was used to study the burner performance for different operation conditions (different air pressures and different nozzle sizes). For a given air pressure and nozzle size, the NO_x emissions drop from 200 mg/Nm^3 to 150 mg/Nm^3, the CO emissions decrease from 125 mg/Nm^3 to 100 mg/Nm^3 and combustion efficiency increases from 94% to about 96%. The temperature field, with slightly lower temperatures, has more uniform distribution in the furnace.

Keywords: combustion, gas-dynamic acoustic waves generator, NO_x and CO emission

1. INTRODUCTION

A clean and high-efficiency combustion technique is combustion in acoustic field, initially developed for fuel atomization in internal combustion engines and then used for combustion improvement of liquid, gaseous and solid fuels in stationary combustion plant [1-3]. The purpose of the present investigation is to develop an ultrasonic vibration generator with annular nozzle to be attached to a natural gas burner and to determine, through experimental and numerical simulation, the proper air pressure and nozzle size for simultaneously reduced NO_x and CO emissions. It is possible to generate vibrations with a wide range of frequency only by varying the pressure of the air passing through the nozzle or the nozzle size without changing the dimensions of the ultrasonic generator. The sonic pressure waves are generated by the annular sonic nozzle, which behaves like a whistle.

2. THE AIR-JET ACOUSTIC GENERATOR

The sonic generator (Fig. 1) was designed for a burner with nominal fuel flow rate of 15 Nm^3/h (Fig. 2). The inner diameter of the resonator is $\Phi = 40$ mm and the nozzle size is $\delta = (0.1-3)$ mm. By varying the pressure drop in the nozzle, it is possible to generate wide-range frequency vibrations without changing the dimensions of the ultrasonic generator, but just the nozzle size.
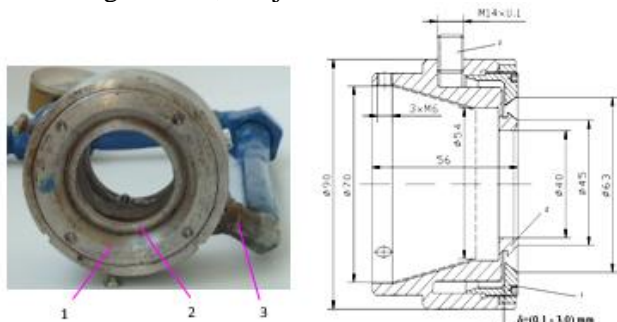
1 - annular nozzle; 2 - resonator; 3 -compressed air supply
Fig. 1. Experimental annular sonic nozzle.

Fig. 2. Natural gas burner with attached annular sonic generator.

3. RESULTS AND DISCUSSION

The best results, that is to say, the maximum combustion efficiency, maximum flame temperature and minimum CO emission, were obtained for 0.15 MPa nozzle feed air pressure and 0.25 mm nozzle size (Figs. 3, 5). The minimum NO_x emission was obtained for 0.25 MPa nozzle feed air pressure and 0.25 mm nozzle size (Figs. 4, 6). At high air supply pressures of the sonic nozzle, the flame is shortened so that it no longer touches the lower part of the furnace. The flame temperature has a very slight increase with increase of air pressure followed by a decrease. The NO_x emission increases very slightly and then decreases with air pressure increase as the flame is cooled down. The CO concentration drops with increase of air pressure until a minimum and then increases slightly. The combustion efficiency has approximately the same variation with flame temperature.
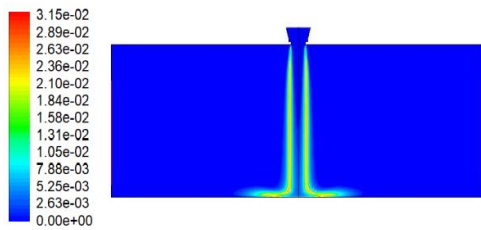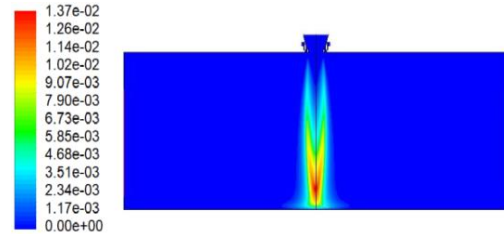
a) without sonic nozzle   b) with sonic nozzle (p=0.15 MPa; δ=0.25 mm).

Fig. 3. CO concentration (mass fraction)
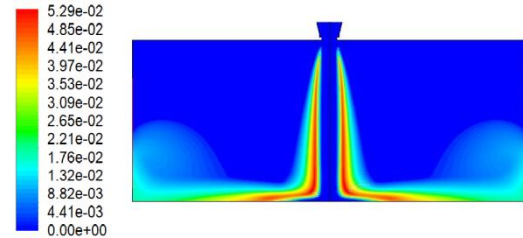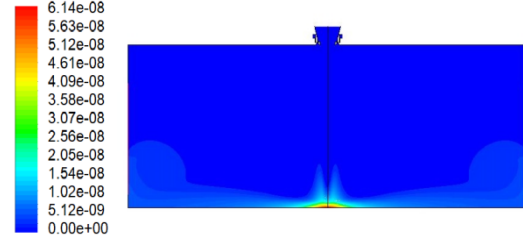
a)   without sonic nozzle   b) with sonic nozzle (p=0.25 MPa; δ=0.25 mm).

Fig. 4. NO_x concentration (mass fraction).
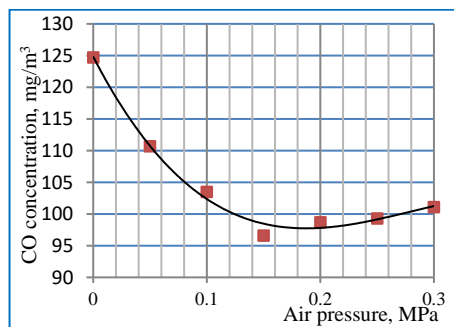
Fig. 5. CO concentration variation with air pressure (δ = 0.25 mm)
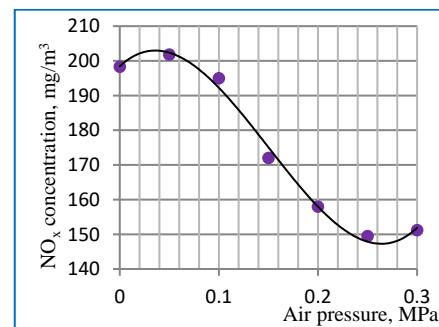
Fig. 6. NO_x concentration (mass fraction) versus air pressure (δ = 0.25 mm)

4. CONCLUSION

Both numerical simulation and experimental measurements carried out on a burner fitted with an annular sonic nozzle show that the flame becomes shorter, the flame temperature slightly lower and uniformly distributed in the combustion chamber. For the same size of the annular sonic nozzle, as the compressed air pressure increases, flame temperature, combustion efficiency and NO_x emissions tend to increase to a certain amount after which they decrease (due to the decrease of temperature), and CO emission tends to drop to a minimum (due to a better mix of reactants) after which it increases (due to flame cooling).

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E123   **11:15-11:30**

Integration of MED & HDH Desalination for an Energy Efficient Zero Liquid Discharge System

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ABSTRACT

The Persian Gulf hosts densely located desalination plants that represent 50% of the global seawater desalination. The salinity levels in this gulf, especially in Qatar, are very high because of constant brine discharge and shallow seawater. With the growing population, more desalination plants need to be installed to meet freshwater demands. The rising salinity levels and the ambient and sweater temperature will raise the specific energy consumption to produce a unit distillate because of climate change. Furthermore, the brine discharge affects the marine ecosystem and deteriorates the soil and groundwater quality. Thus, it is imperative to design and innovate a low or zero liquid discharge (LLD/ZLD) desalination system to mitigate climate change impacts and guarantee a safe marine environment. One such ZLD system is proposed and assessed in this study. The multi-effect desalination (MED) with higher top brine temperature (75 °C) is integrated with humidification dehumidification (HDH) system for brine concentration. In the final stage, the salts are removed via an evaporative crystallizer using thermal energy. The performance ratio (PR) with top brine temperature and temperature difference across each evaporator is evaluated and discussed. Finally, the specific energy consumption of the ZLD system is analyzed for different operating conditions.

Keywords: Climate Change; Desalination; Energy Efficiency; HDH; MED; ZLD

1. INTRODUCTION

With the growing population and depleting freshwater resources, the Middle East will be affected the most as the region is arid, and most freshwater needs are met by seawater desalination [1–3]. The current desalination technologies can distillate a certain seawater percentage, and the rest of the seawater with higher salinity is discharged back to the sea [4–6]. Because of the densely located desalination plants and shallow seawater, the salinity levels of seawater are higher as compared to the world average. The higher salinity results in higher desalination energy consumption, and the continuous brine discharge will increase the average seawater salinity. These factors will raise the required energy to desalinate seawater and limit the brine disposal to secure the marine ecosystem. Thus, salt buildup prevention in the Persian Gulf requires energy-efficient solutions that offer zero liquid discharge-based desalination (ZLD). In the past few years, many modifications and enhancements in the MED design have been proposed to enhance the energy efficiency [7–9]. Furthermore, the heat source can be provided by low-grade heat from renewables [10,11]. In this work, a ZLD system comprising MED, HDH, and a crystallizer is investigated. The effect of higher operating range and temperature difference between the evaporators on the performance ratio (PR) is also examined. Finally, the overall specific energy consumption (SEC) of the ZLD system is estimated and discussed.

2. MATERIALS AND METHODS

The MED unit is solved first, the output of the MED unit is used as the inputs for the HDH system, and then the crystallizer unit is solved accordingly in the engineering equation solver (EES). The total seawater feed will be converted into salts and freshwater. The distillate production capacity of the MED unit is 1 kg/s. The seawater salinity and temperature are fixed at 42,000 ppm and 27 °C, respectively. The saltiness of the rejected brine from the MED unit is kept at 70,000 ppm. The heating steam for the MED unit is 5 °C higher than the top brine temperature, and the condensate is used to heat the brine in the HDH unit.

3. RESULTS AND DISCUSSION

The PR increases with the top brine temperature as more evaporators can be accommodated, resulting in higher distillate production with a little rise in the heat source. The PR at 85 °C (19 evaporators) is 32% higher than the PR (11 evaporators) at 65 °C. The lower temperature difference allows room for more evaporators. The effect of temperature difference on PR for different top brine temperatures. At 85 °C, the PR is augmented by 25% when the temperature difference reduces from 3 °C to 2 °C. The MED unit's specific energy consumption is 214 kJ/kg for 75 °C (top brine temperature) and a temperature difference of 2.5 °C. The rejected brine salinity from the MED unit is 70,000 ppm, which enters as the feed for the HDH system. The brine salinity reaches 110,000 ppm – 120,000 ppm at the HDH unit exit. The concentrated brine is heated, and it enters the evaporative crystallizer. The recovered heat from the crystallizer is used in the HDH system. The lower temperature difference across

MED evaporator, higher top brine temperature, higher PR of HDH unit, higher GOR of HDH unit, and energy recovery from crystallizer has positive effects on the total energy consumption.

4. CONCLUSION

A ZLD system is proposed and studied in this work that comprises MED, HDH, and an evaporative crystallizer. It is found that the PR of the MED plant significantly improves for higher top brine temperature and lower temperature differences. The maximum PR of 12 is found for the top brine temperature of 85 °C and the temperature difference of 2 °C. The HDH can further extract fresh water from the rejected brine of the MED unit. The recovery ratio is found to be in the range of 30% – 40%. The HDH unit lowers the load on the evaporative crystallizer. The salts from the concentrated brine from the HDH unit are removed in the crystallizer. The minimum specific energy consumption of 720 kJ/kg can be achieved at lower temperature difference across MED evaporator, higher top brine temperature, and higher GOR of HDH unit.

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Clustering Distributed Energy Storage Units for the Aggregation of Optimized Local Solar Energy

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ABSTRACT

Active communities are emerging thanks to the necessity of creating a cleaner and safer energy system. Furthermore, the growing concern regarding climate change urges removing fossil fuels from the production equation. The Distributed Generation (DG) technologies are a substitute, but the main resources' behavior is highly uncertain. Therefore, flexibility from the demand side is needed. In this way, the authors resort to mixed-integer linear programming optimization to schedule the active resources introduced by the Smart Grid concept: DG, Demand Response programs, and Energy Storage Systems. In this study, the last one is the focus where the impact of these technologies in an active community is analyzed and discussed. The authors performed a clustering method to identify patterns on Energy Storage System (ESS) profiles, finding the optimal number of clusters first. The results show the importance of ESS from both Aggregator and active consumer perspectives.

Keywords: Clustering, K-means, Energy Storage, Scheduling, Prosumers.

1. INTRODUCTION

The Smart grid concept works to find new ways to provide clean and safe energy in the energy sector. One of the main questions starts with the exchange of fossil fuels for a solution more environmentally friendly. So, increasing the penetration of Distributed Generation (DG), namely Renewable-based, such as solar and wind technologies, is considered a reliable solution [1]. However, these technologies are characterized by volatile behavior due to their primary sources. In this way, the demand-side must provide more flexibility to achieve system balance. So, the consumers' role is changing act more directly on the market transactions. First, allowing Demand Response (DR) programs, where the Aggregator will signal the participants to change their consumption, with the bidirectional communication [2]. After the redefinition of the consumers, now able to produce their energy – the so-called prosumers, can sell to the grid or used to suppress their consumption. Moreover, the Energy Storage System (ESS), widely used to cover and manage DG uncertainty [3]. With these tools, both Aggregator and the active consumers of the future should manage consumption/production to avoid discomfort and make a profit, keeping the system secure and reliable. In this way, the authors propose a method capable of dealing with all the resources mentioned above, resorting to a mixed-integer linear programming optimization. Being a continuation of previous works [4], the focus of the study presented in this paper is the ESS, understanding the impact on the active communities. A clustering method, k-means, was used to identify patterns in the ESS profiles. Also, since this method needs à priori the number of clusters, the Silhouette method was used to find the optimal number of clusters (kopt) in each dataset.

2. MATERIALS AND METHODS

The goal is to minimize the operation costs, from the Aggregator perspective, regarding the interaction between active consumers and the external suppliers. Firstly, the scenario definition requires information from all the resources in the community. Besides generation means by the main network, the method supports DG, ESS, and flexibility provided by participants in DR events. The active community includes both consumers as well as prosumers – consumers with the capability of producing. In this way, the prosumers can use the generation to suppress their demand, battery charge, or inject into the main network considering a bidirectional interaction. In the Scheduling phase, a mixed-integer linear programming optimization was performed. Eq. 1 represents the objective function – ($P_{(t)}^{grid_{in}} \cdot C_{(t)}^{grid_{in}}$) represents the costs when supplied by an external supplier, $P_{(t)}^{grid_{out}} \cdot C_{(t)}^{grid_{out}}$, represents the revenues when injecting power to the main network, $P_{(c,t)}^{DR} \cdot W_{(c,t)}^{DR}$ represents the DR curtailment costs. The term Δt was introduced to adjust the consumption in a 15-minute basis to the tariff basis, which is hourly. The parameter T represents the total number of periods.

$$\min EB = \sum_{t-1}^{T}\left[\left(P_{(t)}^{grid_{in}}.C_{(t)}^{grid_{in}} - P_{(t)}^{grid_{out}}.C_{(t)}^{grid_{out}}\right).\frac{1}{\Delta t} + \sum_{c=1}^{C}P_{(c,t)}^{DR}.W_{(c,t)}^{DR}\right]$$

$$\begin{cases} P_{(t)}^{grid_{in}} = P_{(t)}^{grid}, if\ P_{(t)}^{grid} > 0 \\ P_{(t)}^{grid_{out}} = P_{(t)}^{grid}, if\ P_{(t)}^{grid} < 0 \\ \qquad \forall t \in \{1,...,T\} \end{cases} \tag{1}$$

Since the ESSs are the aim of this study, the next phase, Aggregation, intends to find groups of batteries with similar behavior for each period t. The clustering method used was one of the well-known partitional methods – k-means. The idea is to understand which ones should discharge according to the status at the event period. The group with the ones with higher values is chosen, and a merit order is defined. The participants are then remunerated with lower tariffs in the following periods.

3. RESULTS AND DISCUSSION

One of the main problems for the k-means method is finding the optimal number of clusters in a dataset. So, the authors resort to the Silhouette method, and kopt is found through the maximum value of silhouette score. With this, the k=2 has the most appropriate clustering configuration for all the datasets. Figure 1 represents the results for the ESS status. The centroid has a similar behavior between both groups throughout the day. However, Cluster 1 aggregates the ones with higher values and has a total of 14 ESS. It should be noticed that high values of ESS status were recorded when the PV generation also has higher values.
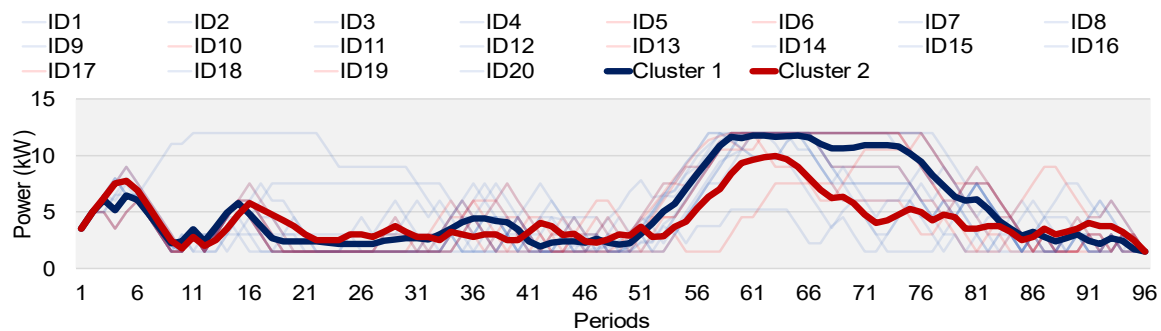
Figure 1. Clustering Results for the ESS status: Cluster 1, Cluster 2, and the ID in each group with a similar color

4. CONCLUSION

In this paper, the authors proposed a method to deal with the several uncertain resources introduced with the Smart Grids concept, focusing on ESS. The results show that ESS status reached higher values when the PV generation was also higher. ESS charging and discharging strategy were applied since there were different price intervals – during off-peak periods, the selling price to the grid is higher than the buying price. With lower consumption values, the consumer tactic could result in high revenues. From the Aggregator perspective, the PV generation erratic behavior can mitigate by combining DR programs and ESS, resulting in lower requests to external suppliers and fossil fuels.

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E088   **11:45-12:00**

Hour-Ahead Energy Resource Scheduling Optimization for Smart Power Distribution Networks Considering Local Energy Market

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ABSTRACT

Energy resource management is a concept that should be considered in energy systems, given the high penetration of distributed resources that is occurring. This scheduling gives better efficiency in the electrical network operation, reducing costs for the end-user. Here, the aggregator needs to provide flexibility in production and demand to the network for a better quality of energy to the end-user. This study presents a model for intraday energy resource management (hour-ahead) considering local market transactions between players. The model is solved using a deterministic solver (CPLEX) and is formulated as mixed-integer linear programming. To exemplify the implementation of the proposed model, a 180 bus distribution network with a high penetration of distributed energy resources is employed. The results indicate the intraday scheduling of the resources considered and the impact of forecast error and contractual limits with energy storage systems and electric vehicle charging stations on hour-ahead scheduling costs.

Keywords: Aggregator; energy resources management; local energy market; distribution network

1. INTRODUCTION

Today's electric power system is already an old and aging system that has difficulty meeting energy needs. It will most likely not be able to withstand the high penetration of renewable resources efficiently. The continued high integration of distributed energy resources (DER) in the electricity grid [1], despite having certain advantages, such as the distributed generation (DG) that reduces losses in energy distribution, also brings severe problems for the traditional grid. One of the significant disadvantages of this type of resource is its uncertainty, which can cause issues in voltage levels and frequency stability. To fully harness the promise of DER, investments in smart grid technology, such as smart grid communications and smart meter data, must be made [2]. In this situation, end-users must participate actively in the energy community to achieve a sustainable energy system [3,4]. One of the mechanisms that encourage this integration of the end-users is local energy markets (LEMs) [5].

The focus of this paper is energy resource management (ERM). The ERM problem is highly challenging to optimize in energy systems due to the large-scale of these systems, leading to many variables and constraints [6,7]. This paper presents a mathematical model based on deterministic processes to solve the ERM problem in the intraday time horizon by scaling to hour-ahead on a 15-minute scale considering transactions in the local market, taking into account the modeling already done in day-ahead for the 180-bus distribution network used in the case study of this paper [3,8]. A two-stage stochastic mixed-integer linear programming model is applied to find a benchmark solution for this optimization problem.

2. MATERIALS AND METHODS

According to the hour-ahead energy resource management scheduling (H-ERM) paradigm, the aggregator must be able to control and operate several DERs in the network or in a specific sector of the grid. The model also requires a database including all of the DERs features as well as the necessary forecasts for the next hours with a 15 minutes time slot resolution. The results from the day-ahead and the last time slot of the preceding hour are also required. As a result of the model, we now have a decision in hour h for the energy resource scheduling of the hour h+1 with a 15 minutes time slot resolution. The results from the day-ahead obtained from work proposed by [8] will be considered in this study. Thus, a realistic distribution network with 180 buses, 30kV, and one substation [8,9] was used to demonstrate the implementation of the proposed method. The original data was changed to incorporate a large penetration of distributed generator units, corresponding to approximately 70% of the total installed capacity power.Photovoltaic (PV) accounts for nearly 40% of the 70%, with wind accounting for 35% and biomass contributing to 15%. It is also considered an aggregator capable of managing 116 DG units, energy purchased from an external supplier and market, energy sold to the market, 7 energy storage system units, 90 load points aggregated by bus, and 5 electric vehicle (EV) charging stations (parking lots).

3. RESULTS AND DISCUSSION

Ten degrees of disturbance are considered in load demand forecasting ranging from -25% to +25%, as well as ten levels of disturbance in non-dispatchable RES forecasting ranging from -25 to +25%. These disturbances are

applied to day-ahead data (demand and Non-dispatchable renewable energy sources (RES) forecast) to depict a likely variation in that data throughout the intra-day time horizon. Furthermore, there are two additional limits for energy storage systems (ESS) and EV charging stations in both circumstances, stating that the aggregator cannot vary more than 10% and 5% of the day-ahead forecast data in the intra-day on those components, respectively. These limits could be a contract between the resource owners and the aggregator, for example. The differences between H-ERM and day-ahead objective function findings tend to increase as the error forecast increases. It's also confirmed that with positive load demand forecast error, the differences are higher, leading to the aggregator's need to apply more demand response operations and use more energy stored in the ESSs. However, when non-dispatchable renewable generation perturbations are considered, the differences between the hour-ahead objective functions values compared to the day-ahead values present a small significance (the higher difference is verified when the non-dispatchable generation forecast error is +25% - around 3%).

4. CONCLUSION

This paper presented a methodology for aggregators to handle the difficult problem of large-scale energy resource scheduling in a smart grid over an hour-ahead time horizon. Through the obtained results, it was possible to verify the impact of the forecast errors and the contractual constraints between the aggregator and ESSs and EV charging stations can cause in the hour-ahead scheduling costs. In this way, the results suggest the need for adequate tools for energy resource scheduling problems to deal with the uncertainties.

ACKNOWLEDGEMENTS

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E143   12:00-12:15

Recyclable Waste Collection – Increasing Ecopoint Filling Capacity to Reduce Energy for Transportation

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ABSTRACT

Urban waste production is increasing around the world. In the present Covid-19 context, an emergent flow of waste growth, as well as of pollution in general, stems from confinement and the use of protective masks. Although part of the waste is considered commingled, much is recyclable, if properly disposed off. Hence, recycling plays today, more than ever, an extremely important role, not only in terms of pollution prevention, but also from the point of view of the circular economy and of resources efficiency. Thus, this work is focused on developing an approach to assist in recycling wastes. As a management option, recycling depends on a collective behavior, that relies on individual acts. Therefore, the individual use of plastic/metal compaction systems can help reaching the recycling targets, even as a complement to conventional commingled waste bins. Thus, we present a proposal for a plastic/metal collection station with a built-in compaction element that allows one to compact separated waste, individually, in an easily accessible drawer. Sorting and compaction of waste in the pre-treatment phase will then result in a reduction of the number of collection/transportation stops, which will also translate into higher efficiency, reduction of costs, optimization of resources, and profitability.

Keywords: Compaction; Cyclea; Ecopoint; Optimization; Recycling; Routes

1. INTRODUCTION

Our society is one based on consumption, which has contributed heavily to the current and previously unimaginable levels of pollution. Pandemic diseases like Covid-19 have further aggravated an already delicate situation. It is true that, with confinement and the use of disposable protective masks, waste production has increased considerably. On the one hand, there was an increase in plastic waste, probably resulting from online purchases and home delivery in plastic packaging. It was also observed an increase in metallic packaging, for drinks and meals, from *take-away* options.

Municipal solid waste must be treated to avoid environmental problems, which are increasingly serious and harmful to the planet [1], and contribute to climate change. Towards this end, it is mandatory that the rates of waste prevention and reuse of waste products increase, diminishing the need for raw materials and the production of untreated waste [2]. Thus, prevention/reduction, reusing, and recycling are the first steps towards avoiding the need for elimination and allowing the conversion of waste into raw materials and new finished products. Recycling reduces and rationalizes energy use, the need for big waste treatment facilities and greenhouse gas emissions. This goal of waste elimination can only be achieved through citizen awareness of the need for waste reduction and recycling behaviors [3].

Recycling begins in the mind of every human being, when someone decides to separately dispose off a certain waste material, instead of just throwing it away to the commingled disposal bin. Then, selective collection and transportation to the processing facility where the waste materials are further sorted and purified are needed to allow waste valorization, while the remaining residual fraction of non-valuable waste (reject) needs to be disposed off in dumps or landfills or incinerated. Thus, separate collection of packaging waste is a common practice in Europe [4], that also impacts on waste management cost (Cialani and Mortazavi, 2020)[5].

2. MATERIALS AND METHODS

In the initial discussion, we started by analyzing the existing Cycleas with the aim of optimizing the selective collection rounds that involve the exchange of current metallic and plastic packaging. Thus, taking advantage of the current configuration of Cyclea containers, we intend providing not only the deposition of metal and plastic, but also the separation of these two recyclable waste flows. This change aims to replace the traditional collection holes, with a manual compaction system, capable of reducing the volumes of plastic cans and bottles, deposited directly in a selective collection drawer.

3. RESULTS AND DISCUSSION

In conventional models, the separation of metal and plastic can only be done in the waste treatment phase. In the model that was developed and is presented here, the selection of metals and plastics is made at the receptacle of the container. This separation, under the responsibility of the depositor, is done by means of a selective collection drawer that stores plastic or metal waste with a collection capacity of about 200 L. Each type of waste will be allocated individually on one side of the drawer and deposited directly in containers designated for each type, which will allow removal, by a specialized operator using the drawer method, or by using a crane, as per the current method of operation.

It is also noteworthy that the drawer methodology facilitates the extraction of waste, properly separated, and bagged/contained, enhancing the possibility of using transport vehicles with smaller dimensions. This possible reduction in the volume of collection vehicles can allow easier access to urban areas with restricted access, such as historic areas, where narrow streets could hinder the access of conventional vehicles. Where bigger vehicles are allowed to travel, the reduction in transportation costs will be achieved due to less number of travels from collection to treatment units.

4. CONCLUSION

The use of plastic/metal recycling units and compactors will optimize the carrying capacity of Cyclea containers used in recycling dumps. The approach presented, in addition to considerably increasing the amount of product collected, contributes to increasing the awareness of citizens, as an intervening actor in the recycling process, since they would need to conduct an act of screening at the time of waste deposit.

Another factor that can translate into a profitable management act would be the reduction of the required weekly rounds and the additional economic return, reorganization of routes and time spent. It is notoriously a very important contribution to encourage the fulfillment of the goals stipulated by PERSU2020.

On the other hand, they could migrate to a "smart" society where a connected online information system, which could transmit information on the quantity of product/filling level, scheduling the collection in advance, optimizing the management of collection routes, making it more profitable for the stakeholders involved.

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Session 4A - Advanced Control and Monitoring Systems

13:45-14:45 @ Meeting ID: 948 1336 4454

E132	13:45-14:00

Image Recognition Method for Frost Sensing Applications

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ABSTRACT
Frost formation in the heat exchangers of refrigeration systems is a well-documented phenomenon. This frost accumulation creates a thermally insulating barrier that can restrict, or even block, the airflow between fins, resulting in decreased efficiency and degradation of the food products. Several methods of frost detection and defrosting have been developed, although there is not an efficient mainstream method to measure and control frost formation. In previous works, the results of a small low-cost resistive sensor for frost detection were shown to be promising. This paper extends that research using computer vision to compare the results of this sensor with the frost formed on the heat exchanger, allowing for a better study of the sensor. This method allowed to trace and plot a frost formation curve of the sensor detected values.

Keywords: Computer Vision; Defrosting; Frost Formation; Frost Sensing; Refrigeration

1. INTRODUCTION
Frost formation in air conditioning and refrigeration systems is still a problem that causes a significant decrease in efficiency. If subfreezing temperatures are demanded, a frost layer usually forms on the fin [1].The frost buildup restricts, or even blocks, the airflow passage between fins, if no defrost method is applied. This results in higher energy demand, thermal performance reduction and in extreme cases, system damage [2].
Timed defrost operations, one of the most used methods to control defrosting operations, must be timed for the worst-case scenario, not taking in consideration the fluctuation of parameters that influence frost formation. These fluctuations cause different frost formation along the day and season, that would require different defrosting cycle period [3].
Demand defrost tries to solve this problem by predicting frost formation. Either by computing the parameters that influence frost formation, measuring symptoms of frost accumulation, or directly measuring frost formation [4].

2. MATERIALS AND METHODS
The detection of water accumulation and frost formation in a HX can be measured by a simple, small, and low-cost resistive sensor. This sensor was developed in previous works [5] and has different voltage drop values for water, air or frost.
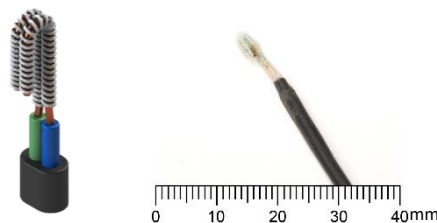
Fig. 1 - CAD model (left) and picture (right) of the sensor used [5]

To corroborate the sensor measurements, a Logitech C920 webcam was placed facing the intake front of the heat exchanger. The images are captured and processed in MATLAB version R2018b by converting the capture into a B&W binary image. The proportion of black to white pixels is measured.

3. RESULTS AND DISCUSSION
The relation between the sensor and image processing values is clear, as shown in a plot of the sensor and camera values for a frost-defrost cycle, detailed in Fig. 2:
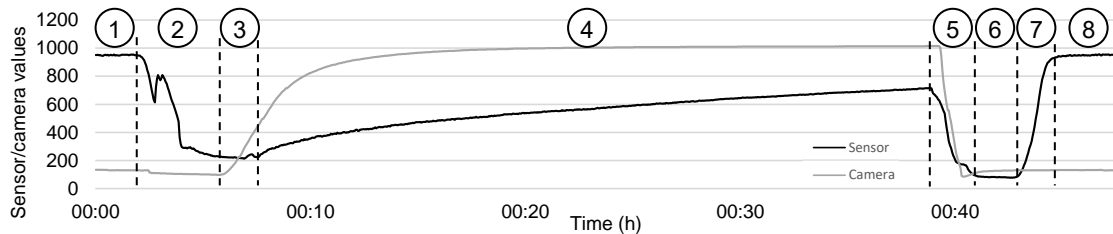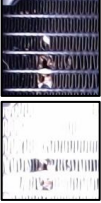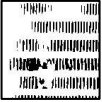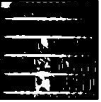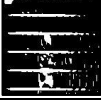
Fig. 2 - Sensor and image processing values for a single frost-defrost cycle

This cycle can be divided in 8 phases, (in which phase 8 is the phase 1 of the next cycle). Dry HX (1), condensation (2), camera frost detection (3), sensor frost detection (4), defrosting (5), water aumulation (6) HX drying (7) dry HX (8). The HX is shown across phases 1, 5 and 8 in Table 1.

Table 1 - Samples of the image processing across phases 1, 5 and 8.

Phase	RGB Images	B&W Binary Images
1		
5		
8		

The uneven frost formation across the HX explains the different times in detection of frost formation by the sensor and image recognition method.

4. CONCLUSION

In this paper, an image recognition method for frost detection corroborated by data obtained from other frost sensing methods was implemented. The main conclusions are:

1) Image recognition is a reliable and effective way of frost detection, although it is not as compact, low-cost, and resistant to damage as a small sensor. It allows for data to be crossed with that of other sensors.
2) Image recognition allows for a creation of a frost formation map that can be used to better apply sensors in a HX.
3) The resistive sensor is an effective way of detecting frost formation in heat exchangers, and the image sensing data corroborates this claim.
4) This method was tested in a copper HX covered in black paint, effectiveness in non-treated metallic HXs should be lower, because of the lower contrast between HX surface and frost layer, but this has not been tested yet.

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E112   14:00-14:15

Electric Vehicles Local Flexibility Strategies for Congestion Relief on Distribution Networks

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ABSTRACT

Due to the rising concern for the environment and sustainability issues, the transportation system is experiencing important changes to its paradigm, with the increasing substitution of internal combustion vehicles with electric ones. Consequently, the electric systems need to adapt to the ever-increasing load demand from the grid and the challenge to identify driving patterns in electric vehicle users' behavior. To prepare the grid for these changes, it is necessary to study the behavior of EV users and develop strategies to cope with the growing demand for electric vehicles. Knowing that electric vehicles experience long-parked periods at the charging stations (more than necessary to recharge the battery fully), this research proposes an EV charging strategy that intelligently explores these long-parked times. It interrupts EVs charging with enough battery to start their trip from certain charging stations to alleviate problems in the network in exchange for a certain incentive. This methodology is then applied in a realistic smart city to investigate its application. The results show that the proposed methodology brings benefits to the distribution network to relieve line congestion and improve the voltage magnitude at the buses.

Keywords: Distribution system; Electric vehicles; Flexibility strategies; Smart charging

1. INTRODUCTION

To reduce gas emissions and stem the rising concern about using energy more sustainably, electric vehicles (EV) will replace internal combustion engines, contributing to about 16% of the global man-made carbon dioxide emissions [1]. The increasing number of EVs necessitates a continued development of new infrastructure for EV charging, which leads to a growing energy demand [2]. These charging set-ups will burden the distribution power grid [3], namely the high charging loads of fast EV charging stations.

With the high penetration of EVs and distributed generation in the grid, the distribution network is suffering changes to its characteristics, posing new challenges to the Distribution System Operator (DSO) [3]. EV owners have a certain pattern of behavior that can be exploited, e.g., they have much higher long-parked times than necessary to charge the battery fully). The DSO can exploit this behavior, and coordination of EV charging can be a good asset for ancillary services, therefore, keeping the grid more stable. This paper proposes a model to help the DSO improve the distribution network's stability, seeking to take advantage of the flexibility that EVs provide in their charging. As such, the methodology proposes multiple scenarios with several additional costs for the DSO that it must pay the EV user to remove its car from charging since it has enough energy to complete its trip based on the data obtained from an EV user behavior simulator [4].

2. MATERIALS AND METHODS

An EV user behavior simulator [4] and an innovative smart DLMP-based distribution network operation/reconfiguration were used for the proposed methodology. For the network reconfiguration, an optimal power flow (OPF) was performed using the Benders decomposition method since this problem is classified as a mixed-integer nonlinear programming (MINLP) problem [5]. This optimization model provides important information such as: distribution locational marginal pricing (DLMP); network topology and switching; power flows; voltage magnitude, and power losses. The data from the EVs are also analyzed here, and a price is proposed to be paid by the DSO for the flexibility of these vehicles to ease congestion that may exist in the network. With this information, the DSO will then analyze if there is a problem in the grid and where it is occurring and, as such, will ask the EVs to stop their charging once they have enough energy to make their trip. It is important to mention that in the EV behavior simulator, the EVs with the battery State-of-Charge (SoC) equal or lower than 20% are immediately sent to the nearest charging station, and, for these users, the prices of flexibility are altered to values higher than the energy price in the charging station bus.

The proposed methodology was applied to a 13-bus distribution network with high distributed energy resources (DER) penetration. This distribution network has one 30 MVA substation, 25 load points, 4 EV charging stations, 15 distributed generation (DG) units, and 4 capacitor banks of 1 Mvar. The 19th of march was used to test and analyze the results derived from this method. The market prices in each period were taken from the Iberian Electricity Market Operator (OMIE) to calculate the DLMP.

The case study was divided into 4 scenarios. The scenarios are all similar, changing only the EV users' minimum

price to stop charging, making it possible to observe the strategy's applicability for different flexibility prices.

3. RESULTS AND DISCUSSION

In the first proposed scenario, the average price of EV users' minimum price to stop charging resulted in 0.095 €/kW. In this scenario, there was a reduction 80 EVs at the charging stations, which led to a significant improvement in the voltages at all the busbars of the network. The total flexibility cost paid by the DSO was 150.19 €. This results in a total cost to the DSO of 535.79 €, even though there was a reduction in congestion and power losses of 38.45 €, whereas before it was 424.05 €. In the second scenario, there was a change in the cost of the flexibility of the EVs to 0.041 €/kW. The operation cost before the strategy remained the same at 424.05 €. In this case, only 75 vehicles were removed from the stations since these vehicles had a lower cost than the DLMP. Here the total cost of flexibility was 56.11 € resulting in a total of 446.40 € for the costs payable by the DSO, even though there was a reduction of 33.76 € in congestion and loss costs. In the third and fourth scenarios, the average price of EV users' minimum price to stop charging was 0.022 €/kW, and 0.017 €/kW, respectively. For both scenarios, the number of EVs removed from charging was the same as in scenario 1. This resulted in a total cost of EV flexibility of 34.78 € for scenario 3 and 26.87 € for scenario 4. There was also a reduction in congestion costs and power losses of 38.45 € for both scenarios. The total operating costs for the two scenarios were 420.38 € and 412.47 €. It can then be said that these last two scenarios start to become interesting from the DSO perspective due to the low flexibility costs.

4. CONCLUSION

The results showed that it is possible to make the grid perform with a lower operation cost, mainly in scenario 4 where the minimum price to stop charging is the lowest of all the proposed scenarios being lower than the sum of the congestion and power loss costs. This situation is the most beneficial for the DSO because network efficiency improves, and the operation costs are also reduced. But, to make this strategy interesting for both the DSO and the EV users, it is necessary to make sure that the removal of the EV from charging in this period will not affect the scheduled trip from these EVs and that the owners of these EVs receive a certain amount of money for their available flexibility.

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E139   **14:15-14:30**

Novel Nanocomposite Electrospun Polyaniline / Zirconium Vanadate for LPG Gas Detection

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ABSTRACT

Novel polyaniline (PANI)/zirconium vanadate (Zr-V) hybrid nanomaterials were prepared successfully via sol-gel technique of Zr-V onto the polymerization process of PANI. The most prepared nanohybrid was characterized using SEM, XRD, FTIR, and TGA. The optimum ratio was recorded using the first route to be 1 PANI: 1.5 Zr-V. The synthetic nanohybrid showed a highly crystalline structure with nanotube branching (like cauliflower) morphology. Electrospinning technique was used to fabricate a composite nanofiber matrix using polyvinyl alcohol (PVA) with the optimum prepared PANI/Zr-V nanocomposite. Electrospinning parameters including flow rate, collecting distance, and applied voltage were optimized to attain uniform composite nanofibers. The gas sensitivity of the synthetic nanofiber composite towards liquefied petroleum gas (LPG) as a function of temperature was determined by measuring the resistance of two sputtered platinum electrodes for sensor's devices. The nanofiber matrix showed the highest sensing performance for LPG within 10 sec at 200 ℃.

Keywords: gas sensor; LPG; nanofiber matrix; polyaniline; XRD; zirconium vanadate

1. INTRODUCTION

Many industrial and commercial activities require the protection of the environment from hazardous and harmful gases. To detect these gases and define the quantities and hazardous levels; we should develop a new sensor whose application is empirically optimized [1]. Among the conducting polymers, PANI is often used as an organic part to prepare nanohybrids because of its easy preparation, low cost, controllable unique properties by protonation and oxidation state and excellent environmental stability. One of the inorganic nanomaterials; Zr-V nanoparticles have received excessive attention due to their unique electrical properties where they were presented good electrical conductivity which is attributed to semiconductor n-type behavior, that ranges from 10^{-5} to 10^{-6} Ω^{-1} cm^{-1} [2]. This work aims to investigate PANI/Zr-V nanocomposite through simple interfacial polymerization and then fabrication a composite nanofiber matrix using PVA via electrospinning technique. The sensitivity of the fabricated composite nanofiber matrix towards LPG will be measured and examined.

2. MATERIALS AND METHODS

2.1. Preparation and characterization of PANI/ ZrV nanofiber using electrospinning technique

ZrV nanoparticles were prepared using sol-gel technique by adding sodium vanadate into a solution of zirconium oxychloride octahydrate. The PANI nanotube was prepared using interfacial polymerization. 1 PANI: 1.5 ZrV was dissolved in 10 ml DMF 99%. 1.8 g PVA was dissolved in 16.2 ml distilled water with stirring for 2 h at 70 °C. Then, the PVA solution was added to the nanohybrid solution. The resulting viscose solution was then transferred to the electrospinning machine at 17.5 kV with an average distance between the needle and the collector of 16 cm and flow rate of 0.5 ml/h. The prepared nanohybrid was characterized using SEM, XRD, FTIR, and TGA.

3. RESULTS AND DISCUSSION

3.1. Characterization of prepared PANI / ZrV and hybrid nanofiber

All prepared materials were characterized by XRD which shows two strongest peaks appeared at 2θ = 22.8° and 23.5°, reveal that PANI nanostructure has semi-crystalline properties. Three strongest peaks appeared at 2θ = 45.4°, 31.7° and 32.3°, reveal that some degree of the crystalline structure of ZrV. The average diameter of prepared zirconium vanadate was calculated between 14.7 nm and 54.8 nm. The strongest two peaks at 2θ = 20° and 2θ = 25° are corresponding to typical crystalline properties of PANI [3].

For SEM images, It's clear that the particles of the PANI have branched nanotube with a diameter of about 70–130 nm. This form allows further studies with Zr-V for obtaining a nanohybrid. These measurements are identical to XRD results.

FT-IR spectrum of the prepared PANI, Zr-V, PANI / Zr-V hybrid nanomaterials and PANI/PVA/Zr-V nanofiber were investigated for a range of 400-4000 cm^{-1}.

The thermal stability of the prepared PANI was studied by TGA.

3.2. Gas sensing performance of LPG

The characteristics of the fabricated nanofiber matrix gas sensor for LPG were measured as a function of time with gas concentration of 800 ppm and at working temperature of 50 °C, 100 °C, and 200 °C using DC resistance measurements is shown in Fig. 1. In this experiment, sensor's sensitivity sharply increased when exposed of LPG, where it reaches 100% force [4].
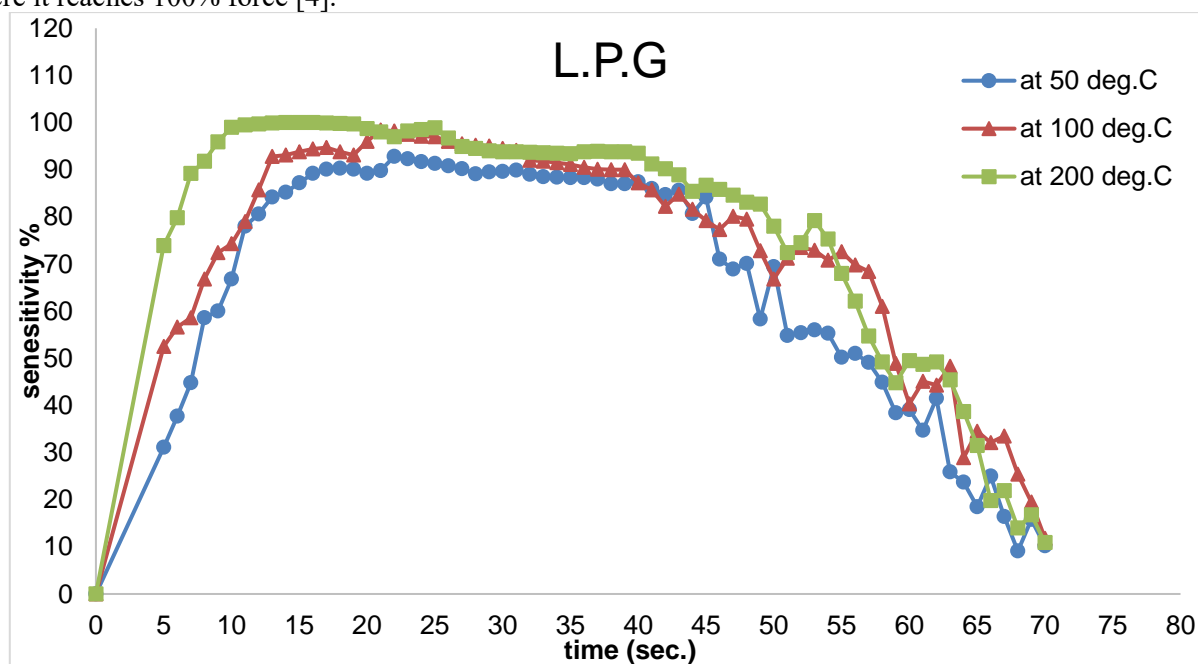
Fig. 1. Sensing performance of PANI/ Zr-V/PVA nanofibers for LPG at different temperatures

4. CONCLUSION

PANI/ Zr-V/PVA nanofiber matrix have been synthesized successfully. SEM, XRD, FTIR, and TGA were used in the prepared materials characterization. It was indicated that the PANI has a highly crystalline structure with nanotube branching (like cauliflower) morphology. Gas sensitivity of the PANI/Zr–V/PVA composite nanofiber sensor depends on the variation of the resistivity by exposure to LPG at working temperature of 50 °C, 100 °C, and 200 °C. The maximum sensitivity scored at 100 % sensitivity.

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E018   **14:30-14:45**

Impact of Increasing Electric Vehicles Demand on the Distribution Network: A Power Balance Analysis

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ABSTRACT

In the coming years, we will witness a change in the current car fleet sales, from traditional fuel engines towards electrical vehicles (EVs), particularly passenger light-duty vehicles. They plug into the grid and store the electricity in rechargeable batteries; therefore, the widespread adoption of EVs will bring many challenges for the distribution network. Forecasting the impact of EVs on distribution networks is a difficult task given the uncertainty on the potential evolution of their sales.

This study forecasts the EVs sales growth for the 2020-2030 decade in 3 possible evolution scenarios, carried out for a given Portuguese regional area. The demanded energy for charging the batteries was estimated, considering one long and one short route. The analysis was applied to three EVs models: Nissan Leaf, Tesla Model 3, and Renault Zoe.

The impacts on the rated power of the distribution network are calculated for the three scenarios, and the results are presented, standing out the considerable insufficient power at peak hours.

Keywords: Car fleet; Charging batteries; Distribution network; EVs growth; Power balance

1. INTRODUCTION

The electric mobility (e-mobility) strategy aims to accelerate the transition to low (and zero) emission vehicles. In the last decade, we have witnessed the movement towards the adoption of individual electric vehicles (EVs), an option that requires plugging into a home charging point, taking electricity from the distribution grid, and storing it in rechargeable batteries. An affordable charge infrastructure is essential for the EVs widespread adoption [1].

At present, EVs sales growth is a reality all over the world [2], and e-mobility has reached a point of no return. Although the transition to EVs is inevitable, its massive penetration will, undoubtedly, impact energy system management, mainly, in distribution networks [3]–[5].

This paper aims to forecast the EVs increase over the 2020-2030 decade and their energy consumption analysis for two pattern routes (short and long-distance). It was applied in the top 3 EVs brands best-selling in Portugal: Nissan Leaf, Tesla Model 3, and Renault Zoe, those getting the first three places from the top 10 list [6].

The impact of the growing EVs fleet on a regional Portuguese distribution network is assessed,   particularly the influence of the load demand increase on the installed rated power.

2. ELECTRIC VEHICLES BY 2030

To support this study, it was necessary first to ascertain the current EVs market situation in Portugal, the population growth rate and the EVs sales development forecast, between 2020 and 2030. The study was applied to a regional low voltage network, the north area of Ave, Tâmega, and Sousa, including both urban and rural areas. We analyze the impact of the EVs increase on the installed power at peak and off-peak hours, a 100% electric vehicles, with a wallbox battery charging system.

We present the EVs evolution between 2020 and 2030 in 3 projection:

Projection 1 - based on the existing EVs data projected for the evolution of the population in the described geographical region

Projection 2 – EVs account for 1/3 of total sales in 2030

Projection 3 – EVs account for 20% of the car fleet in 2030

For each scenario, we evaluate the power required to charge the EVs all over the ongoing years.

To support those projections, we calculate the regional population evolution up to 2030, based on the national standards [7]. About the car fleet development for the next decade, the data used in this work was gathered from official bodies [8]-[9]. Results are presented in Table Table *1*.

Table 1- EVs Evolution in 3 Projections

Year	Projection 1 From existing data	Projection 2 1/3 Sales in 2030			Projection 3 20% from car fleet in 2030	
	EVs	EVs	Sales	EVs in sales	EVs	EVs in car fleet
2018		12 000	4 073	1,77%	12 000	0,23%
2019		22 486	10 486	4,40%	100 652	1,87%
2020	19 209	39 838	17 352	7,03%	192 170	3,52%
2021	25 469	64 534	24 696	9,66%	286 623	5,17%
2022	34 623	97 078	32 543	12,29%	384 082	6,82%
2023	48 007	137 997	40 920	14,92%	484 620	8,47%
2024	67 578	187 851	49 854	17,55%	588 311	10,11%
2025	96 194	247 225	59 374	21,18%	695 231	11,76%
2026	138 037	316 737	69 512	22,81%	805 456	13,41%
2027	199 219	397 035	80 298	25,44%	919 067	15,06%
2028	288 680	488 802	91 767	28,07%	1 036 143	16,70%
2029	419 489	592 756	103 954	30,70%	1 156 767	18,35%
2030	610 759	709 651	116 895	**33,33%**	1 281 023	**20,00%**

3. IMPACT ON POWER RATING

The impact on grid is assessed in terms of power balance, calculated by subtracting the sum of EVs necessary installed power from the available installed capacity for charging.

The results have shown that, with the current grid capacity power, the EVs charging on peak hours will be possible only in scenarios 1 and 2. If the EVs growth follows the scenario 3 pattern, the grid will only last until 2026. By encouraging the EVs charging in off-peak hours, even though the network will withstand for two more years, until 2026, in scenario 3.

4. CONCLUSION

Distribution systems in Portugal face an important challenge: the oncoming mass penetration of electric vehicles (EVs) for the next decade. Many questions arise about the distribution network´s ability to support the increased energy consumption demanded by the growing EVs. Major congestion problems may appear, notably, if the battery charging period coincides with the higher energy demand hours.

From this study we conclude that the installed power on the low voltage network will not stand for the projection 3, even for the charging in off-peak hours, distribution network reinforcement is urgently needed. EVs growth is a reality for the near future and its impact will be felt soon.

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Session 5A - Renewable Energy
13:45-14:45 @ Meeting ID: 979 7648 1988

Effect of Catalyst on the Producer Gas Composition from Co-Gasification of Glycerol/fat Mixtures

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ABSTRACT

In this work, steam reforming of crude glycerol and animal fat mixtures was studied. The tests were carried out at temperatures of 700 ºC and 750 ºC in a fixed bed reactor using activated alumina or dolomite particles, to evaluate the catalytic capacity of these minerals in the removal of tar from the producer gas. The gas produced was quantified and analyzed by gas chromatography, and it was concluded that its composition is greatly influenced by the bed material used. The results obtained showed that dolomite is more effective in reducing the tar content, evidencing its ability to catalyze the tar reform reactions and promoting the water-gas shift reaction. Consequently, using dolomite as a catalyst, a producer gas rich in H_2 and CO_2 was obtained, while using a bed of alumina particles, a gas with a high CO content and lower H_2 content was produced.

Keywords: alumina, dolomite, fat, co-gasification, glycerol, steam reforming

1. INTRODUCTION

In the global energy and environmental landscape, there has been an increase in the dynamics inherent in the move to renewable energy sources. The possibility of valuing waste is presented as a fundamental strategy in the context of environmental and economic sustainability, contributing to the model of transition to a circular economy and intensifying the use of renewable energy sources.

In Portugal, there are by-products and industrial wastes for which it is urgent to find alternatives that aim at their recovery. In this context, the present study intends to evaluate the technical feasibility of the gasification process of two industrial by-products/wastes: crude glycerol from the biodiesel industry and animal fat from the leather industry. In this work the results of the effect of the use of dolomite as a catalyst in the composition of the produced gas are presented.

Despite the advances achieved in recent years in the design of more efficient gasifiers, the cleaning process of the gas produced is still a limitation on the use of biomass for electricity generation. The presence of tars (condensable organic compounds) in the producer gas can cause clogging and corrosion and reduce the overall efficiency of the process. For this reason, interest in the catalysis of biomass gasification has grown in recent decades.

Dolomite is a biomass gasification catalyst that has been studied by several researchers [1-4].

Delgado et al. [5] investigated the use of Norte dolomite for the steam reforming of biomass tars.

Perez et al. [6] investigated the biomass gasification in a bubbling fluidized bed gasifier using steam-oxygen mixtures as gasification agent and calcined dolomite located downstream from the gasifier.

Gil et al. [7] investigated the performance improvement of a fluidized-bed biomass gasifier, by in-bed use of calcined dolomite.

Andrés et al. [8] studied the catalytic gasification of sewage sludge in a fluidized bed reactor using air and air-steam mixtures as the gasification agent. The aim of the study was to study the influence of three catalysts: dolomite, olivine and alumina in the composition of the producer gas and in the production of tars during the gasification process.

Pinto el al. [9] studied the gasification of lignin-rich solids in a bubbling fluidized bed gasification reactor where 33% by mass of minerals such as limestone, dolomite or olivine were added to the silica sand bed.

2. MATERIALS AND METHODS

The co-gasification of crude glycerol/fat mixtures was studied in a down flow fixed bed reactor using steam as the gasification agent. Tests were performed with a fixed bed composed of catalyst particles of dolomite or alumina. The experimental tests were performed at 700 ºC and 750ºC using a mixture composed by 59% of glycerol, 3% of fat and 38% of water. Dolomite (MgCO3CaCO3) is one of the most common materials used as a catalyst in biomass gasification and is used with the main objective of reducing the tar content in the producer gas.

3. RESULTS AND DISCUSSION

The results obtained clearly show that when is used a bed of dolomite particles the gas phase yield is greater than that obtained when using alumina particles. They also show that the increase in temperature favors the production of the gas phase and the decrease of liquid phase production, for both materials studied.

The results show that the composition of the producer gas is strongly dependent on the material of the particle bed. Using dolomite as a catalyst, a producer gas rich in H_2 (47-48 vol%) and CO_2 (27-30 vol%) was obtained, as indicated in several studies [8, 3, 9, 10]. When using a bed of alumina particles, it was observed that CO (45-48 vol%) was the predominant component followed by H_2, as reported by [11]. This behavior is indicative that dolomite appears to be a suitable material to promote the destruction of tars by its action as a catalyst for tar reform reactions, resulting in the promotion of the water gas shift reaction as well. As a result of the higher level of H_2 and lower level in CO in producer gas, a large increase in the average value of the H_2/CO ratio was observed in the presence of dolomite.

4. CONCLUSION

The results showed that dolomite is more effective than alumina in reducing the tar content of the producer gas. In the tested range temperatures, it was also found that the use of dolomite promotes the production of a producer gas rich in H2 and CO2 and with a high mass ratio of H2/CO, which gives the gas more suitable properties for its use in combustion engines and in chemical synthesis for biofuels production, than the gas produced using alumina.

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ICEER 2021

E071	14:00-14:15

Kinetic Prediction of Biochemical Methane Potential of Pig Slurry

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ABSTRACT

Empirical Kinetic Models have been used to describe and establish the Anaerobic Digestion kinetics of pig slurry´s (8% TS) Biochemical Chemical Potential. A wide selection of Empirical Kinetic Models were fitted to the experimental data collected in batch assays of different Substrate to Inoculum ratios of 0.65 (BMP1) and 1 (BMP2). For the selection of the most suitable model for each BMP assay, the statistical tools R^2 and the RMSE, along with the Information Criterion AIC and BIC, were taken into consideration. From all the studied models, Weibull model proved to be the most suitable for kinetic parameter prediction for both BMP1 and BMP2 assays. This model presented the lowest values of AIC and BIC, along with the highest value of R^2 and the lowest RMSE. In this regard, a R^2=0.998, and a RMSE=0.004, was obtained for BMP1, and a R^2=0.999 and a RMSE=0.008 for BMP2.

Keywords: Anaerobic digestion; Biomethane potential test; Kinetic evaluation; Kinetic study; Numerical computation; Pig slurry

1. INTRODUCTION

Anaerobic Digestion (AD) is a natural process that allows microorganisms to decompose organic matter in the absence of oxygen. This process can be divided into three stages, hydrolysis, where the long carbon chains are shortened; acetogenesis, in which the short chains are converted into acetic acid; and methanogenesis, where the acetic acid is converted into methane [1]. The biodegradability of a given substrate is usually measured by Biochemical Methane Potential (BMP) assays. BMP is defined as a simple batch procedure that decomposes the substrate anaerobically. The biogas produced during the experimental period is measured and its' methane content is evaluated [2]. This test can only provide the maximum production of a given substrate. However, by using Empirical Kinetic Models (EKM), other parameters such as the adaptation time of the substrate or the rate that the substrate is converted into biogas can be predicted.

AD process, being a biological system, can be modelled as a cellular growth process. Hence, the Empirical Kinetic models for AD are based on microbial growth, including statistical distribution and enzymatic or chemical kinetics [1], [3]. These are in constant development and adjustment to promote an adaptation to a given operation or to experimental data observation. For AD analysis, the curve of the methane accumulation over time obtained from the BMP is the crucial point for the kinetic evaluation. Once the BMP curve describes an exponential function, a mathematical equation is commonly used to describe the AD kinetics under different models such as the Exponential model, Transference or Transfer function of the First-Order kinetic [3]. For instance, the Gompertz model used to describe the human demography was modified to adjust to all phases of the AD process [1]. Some probability distributions such as in the Weibull and Cauchy models are also applied to describe the AD process, along with the Cone model that was primarily used to evaluate the gas production in ruminates digestive system [4].

This study presents an evaluation of the kinetic performance of AD for BMP assays of Pig Manure (PM) at 8 % concentration (on a Total Solid (TS) basis), aiming for the determination of kinetic parameters for this substrate. The experimental BMP assay was performed in two tests at two different Substrate to Inoculum Ratios (SIR), 0.65 (BMP1), and 1.0 (BMP2).

2. MATERIALS AND METHODS

The experimental set of data was acquired from a BMP assay at Lab-scale. The BMP assay was conducted at mesophilic conditions (37 ± 1 °C and 1 atm), using pig slurry as substrate at 8 % TS and inoculum from a municipal wastewater treatment station. The two Substrate to Inoculum Ratio (SIR) employed were 0.65 and 1.0, BMP1 and BMP2, respectively. The experimental data allowed for determining the experimental accumulated methane production as a function of time.

The kinetic performance of the BMP was evaluated using the former EKM, First-order Kinetic, Modified Logistic,

Feller, Chen-Hashimoto, Weibull, France and Cauchy, using the MATLAB®. To assess the most suitable model, the coefficient of determination, denoted R^2 and the Root-Mean-Square Error (RMSE), but also the second-order Akaike Information Criterion (AIC) test [5], along with the Bayesian Information Criterion (BIC) [6], were analysed.

3. RESULTS AND DISCUSSION

In the BMP1, the Weibull model adjusts better to the data since it presents the lowest value of RMSE as well as the highest value of R^2, which can be translated into a lower deviation between the predicted values and the experimental data. It was also determined the difference between the experimental value of BMP0 and the one predicted by each model, divided by the experimental value of BMP0 (Diff %). This second experiment, carried out under a higher Substrate to Inoculum Ratio (BMP2), confirms that the Weibull model was the one that better fits the experimental data since it presents the higher determination coefficient, R^2 (0.999), and the lowest RMSE of all tested models. Comparing the experimental BMP0 (0.643 L CH4/g VS) with the predicted one, both Gompertz and Logistic models predicted the BMP0 with the same deviation (0.937%). However, Gompertz achieved the closest BMP0 to the experimental value with the highest R^2.

There is no mathematical model capable of describing the biomethane formation kinetics precisely. To select the best model, the lower value of the AIC and BIC must be considered. The Weibull model presents the lowest AIC and BIC values for both essays, providing the perspective that this model produced the best fit. Regarding BMP2, the Weibull model shows the lowest AIC and BIC. Consequently, it is the best model to fit the BMP2 data. Thus, the criteria validated the efficiency of the statistical tool R2 as a good indicator of the model fitting.

4. CONCLUSION

The Empirical Kinetic Models proved to be very useful tools to predict the kinetic parameters of a specific growth profile in biological systems. The low deviations obtained between the theoretical and experimental values (nearly equal to or lower than 10%) were achieved for the First-Order, Modified Gompertz, Logistic, Feller, Cone, Weibull, and France models in the BMP1 test. For the BMP2, the low deviations were observed in the Modified Gompertz, Logistic, Feller, Weibull, and France models.

Statistical tools, such as the R^2 and the RMSE, along with the Information Criteriums AIC and BIC were employed to select the most suitable model for each BMP assay.

The Weibull model is shown to be the most suitable model to predict the kinetic parameters for both essays, presenting the lowest AIC and BIC values. Regarding the statistical tools, this model in the BMP1 gave the highest value of R^2 (0.998) and the lowest RMSE (0.004). Likewise, in the BMP2, this model reached the highest value of R^2 (0.999) and the lowest RMSE (0.008).

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E114 **14:15-14:30**

Study of A Solar Energy Drying System - Energy Savings and Effect in Dried Food Quality

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ABSTRACT

It is estimated that in Portugal per year, 132 kg/person of food is wasted due to imperfections in weight, shape and due to their perishability, resulting in foods that cannot be marketed. Solar drying can be used to extend food life. However, it usually does not meet the current productivity and quality requirements of the dried product. Solar energy is renewable, very available in Portugal, which can make an important contribution to reducing the specific energy consumption and carbon footprint intensity associated with drying. This work aims to optimize the drying process using a solar dryer with electric support. The conditions of temperature and humidity in the dryer and their influence on the physical and chemical properties of blueberries and raspberries: ash, protein, fat, sugars, total phenolic compounds and antioxidant capacity, were studied.

It is concluded that the blueberries and raspberries, after drying underwent slight changes in some chemical parameters, namely the reduction of fats and phenolic compounds. The results of the drying tests showed a strong dependence on atmospheric conditions. Under the most favorable conditions it was possible to record reductions in electricity consumption of 35%.

Keywords: Circular Economy; Food Drying; Food Waste; Renewable Energy; Solar Dryer; Solar Energy

1. INTRODUCTION

Drying is usually defined as an operation that converts a liquid, solid, or semi-solid material into a solid material with lower moisture content relatively to the initial state. According to Erbay and Icier [1], despite its great importance, drying is one of the most complex and least understood processes at the microscopic level, because of the difficulties and deficiencies in mathematical descriptions. In addition, the drying of food materials is further complex due to the fact that physical, chemical, and biochemical transformations may occur during drying. Although the study of drying theory and its mathematical description are very relevant, experimental developments proved to be of great importance [2,3,4].

This work aims to optimize a food drying process using a solar dryer with electric support, with a previous evaluation of the fruits drying curves under different drying conditions. The effect of the operational conditions on dried food quality is also assessed.

2. MATERIALS AND METHODS

For this work, blueberry *(Vaccinium myrtillus)* and raspberry *(Rubus idaeus)* were studied. The selected products were subjected to a drying process with controlled relative humidity and temperature conditions. The drying curves, equilibrium moisture content and the period to reach equilibrium determination was performed to 40, 50 and 60 °C and 10% of relative humidity. A field test for energy saving evaluation was carried with 7.5 kg of spinach. The first field test was done with a food product more abundant and with lower cost, due to the larger amounts needed. The solar dryer used was model Avatar (CHATRON) with a capacity of 800 liters. It integrates an electrical resistance of 1 kW to compensate for the insufficiency or absence of solar energy.

For the evaluation of the drying effect in the food products, the levels of ash, fat, protein, total phenolic compounds were determined, and the antioxidant capacity was also assessed. All analyses were done in triplicate following standard methlogies.

3. RESULTS AND DISCUSSION

An expected shape of the drying curves was achieved, with a low drying rate in the first period of adaptation to the test temperature and relative humidity. After that, the drying curves present a nearly constant rate of drying with a significant decrease of moisture content, ending with a falling rate drying period until reach the equilibrium moisture content.

The effect of the drying conditions on the chemical characteristics of the fruits under study showed that only fat, antioxidant activity and total phenols decreased, with higher effect with the tempertura increase.

It was observed globally, regardless of the drying condition, that phenolics were degraded, and the loss of these compounds increases when the products are subjected to drying conditions above 50 °C..

Food antioxidant activity is one of the most appreciated characteristics due to its benefits in health. Drying causes a decrease in the antioxidant activity that may be related to the decrease observed in the content of phenolic compounds after drying [5,6].

The field test in the solar drier allowed to study the potential of energy saving when the drying process is performed in real conditions, using solar energy as the main energy source. Although the atmospheric conditions were not the most favorable during the seven days it took for the product to be dried, it is possible to verify that, during sunny periods, there is a reduction in the average electrical power that reaches 35%. Alhtought it is a prelimary evaluation, considering this reduction of electrical power need for the drying process, and the characteristics of the green house gases (GHG) emission related with the electrical power, it can be expected a reduction of CO_2 emissions.

4. CONCLUSION

The analysis of the results shows the importance of drying temperature during the process: the increase in temperature decreases the drying time, as well as the equilibrium moisture content reached. Additionally, it can be verified the influence of the structure and morphology of the product, both in the drying progress and time. Raspberry takes less time to start the constant drying phase and to reach the equilibrium moisture than blueberries. The evolution of fats, proteins, phenolic compounds and antioxidant activity in drying products are related, but further studies are needed to be better understand the transformations occurring on molecular level. The field test with solar drier demonstrated the importance of using solar energy in drying processes. A significant reduction in electricity consumption was observed with the utilization of solar energy and consequently, a reduction in CO_2 emissions. Further tests will be performed to better understand and evaluate the advantages of the use of solar energy as the main energy for high-quality food drying.

ACKNOWLEDGEMENTS

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Algae-Based Bioenergy Production Aligns with the Paris Agreement Goals as A Carbon Mitigation Technology

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ABSTRACT

Strategies to mitigate climate change have been developed and applied in the productive sector. Carbon capture and storage technologies might decrease the impact of CO_2 emissions on the environment. Biological technologies consist an important tool to mitigate CO_2 emissions and microalgae cultivation emerges as a promising tool, due to the important role of these organisms on the environment, the capacity of growing in different conditions, and the possibility of converting the microalgal biomass into a wide range of value-added products and biofuels. This study evaluated the potential algae-based CO_2 mitigation by coupling industrial flue gas of a Brazilian cement plant into a microalgae cultivation system and biodiesel production from microalgae biomass. The microalgae plant facility was projected to occupy a reminiscent area of 3.8 ha in the cement plant boundary. Two different scenarios of mitigation were analyzed and the results showed that by using 15% of CO_2 from the cement industry in the microalgae cultivation system it is possible to mitigate 1,268 $tCO_2 \cdot year^{-1}$ and to produce 2,317 $L \cdot year^{-1}$ of biodiesel. This study provides support information to decision-making to implement carbon capture strategies to the future carbon market to mitigate the environmental impacts of climate change.

Keywords: *Chlorella sp*, Climate change, CO_2 biofixation, CO_2 mitigation, Microalgae cultivation

1. INTRODUCTION

Parties of the United Nations Framework Convention on Climate Change (UNFCCC) extended a landmark agreement to combat and mitigate climate change at COP 21, realized in Paris in 2015. The Paris Agreement aims to strengthen the global effort to keep the global temperature below 2 ºC and to implement finance mechanisms to increase the ability of countries to deal with the transition to a low carbon economy [1]. Brazil has signed the Paris agreement and extended commitments of the former Kyoto protocol and reaffirms the country's commitment to reduce total net greenhouse gases (GHG) by 37% in 2025 and the total Brazilian emissions by 43% in 2030 [2].

Microalgae are organisms with high biomass productivity, compared with traditional crops. They can grow throughout the year, and their biomass production provides the mitigation of GHG, due to the high photosynthetic rates and the potential of coupling the cultivation system with industrial flue gas emissions [3].

This work aims to analyze the algae-based carbon capture strategy from the cement industry, by coupling the microalgae cultivation system to the flue gas emissions and ultimately using the microalgae biomass as feedstock to biodiesel production.

2. MATERIALS AND METHODS

To simulate the microalgae growth it was applied a derived Monod growth model [4], using different CO_2 concentrations in a tubular photobioreactor designed in this study. The model considers an on-off flue gas input mode, in which flue gas was modeled to pulse into the photobioreactors at a specific frequency of 1 min gas-on (15% CO_2), and 29 min gas-off (0.04% atmospheric CO_2) [4].

In this work, it was designed a carbon capture system based on microalgae cultivation coupling to flue gases from a cement industrial plant located in the city of Cubatão, São Paulo, Brazil. Dataset was obtained from the public "Project Design Document" sent to the UNFCCC to obtain carbon credits by a former Kyoto Protocol. Two different scenarios described in the CDM project sent to the UNFCCC was used to calculate the amount of CO_2 mitigated by microalgae cultivation in the cement industry: (1) the base scenario, that corresponds to the emission of about 22,461 tCO_2 per year using fuel oil; and (2) The CDM scenario, that corresponds to the emission of about 12,000 tCO_2 per year using natural gas.

Finally, The production of biodiesel was estimated according to the adapted methodology published by Branco-Vieira et al. [5].

3. RESULTS AND DISCUSSION

The microalgae biomass production using atmospheric CO_2 concentration (0.04% of CO_2) showed a yield of about 0.408 kg·m^{-3} of biomass on the 12th day of cultivation, and an average productivity of 0.254 kg·m^{-3}·d^{-1}. The production of microalgae biomass fed with 15% of CO_2 from cement plant flue gases was around 1.44 kg·m^{-3}, and an average productivity of 0.681 kg·m^{-3}·d^{-1}. The values achieved using flue gas correspond to an increase of 28.33% on the microalgae growth rate and 37.30% on microalgae daily productivity.

The PBR designed for microalgae cultivation was set to have a tubular shape and the total volume of each PBR module is 34 m^3. The total amount of biomass that it will be possible to achieve when microalgae are cultivated under atmospheric CO_2 is 473 tonnes of biomass per year. Otherwise, when 15% of CO_2 from industrial flue gas is used to feed the microalgae cultivation system, it would be possible to achieve a maximum of 1,268 tonnes of biomass per year.

Considering the proposed model, it is necessary about 1 kg of CO_2 for the production of 1 kg of dry biomass of *C. vulgaris* which corresponds to mitigation of about 0.68 kg.m^{-3} of CO_2 per day of microalgae growth. Therefore, these values also correspond to an amount of 1,268 tCO_2·year^{-1} of mitigated CO_2 using 15% of CO_2 from the flue gas to microalgae cultivation.

Considering the base scenario of this study, which is used fossil oil as the primary energy source in the cement production system, the total CO_2 mitigation corresponds to 5.65% of the annual emissions, when 15% of industrial flue CO_2 is applied to the culture medium. Otherwise, in the CDM scenario, in which the use of fossil fuel was replaced by natural gas on the CDM project, the additional algae-based CO_2 mitigation reaches the value of 10.57%.

The total content of lipid for *C. vulgaris* considered in this study was 22% and the maximum volume of crude oil that can be recovered from the microalgae biomass using the supercritical CO_2 method is 2,090 kg.year^{-1}. After lipid extraction, the oil is refined and biodiesel production is performed by using the alkali-catalyzed transesterification reaction. The maximum potential amount of biodiesel achieved is 2,037 kg·year^{-1} or 2,317 L·year^{-1} using an oil density of 880 kg·m^{-3}.

4. CONCLUSION

The algae-based carbon capture alternative was analyzed in this study, using two different scenarios of CO_2 mitigation from a cement plant located in Cubatão, São Paulo, Brazil, and the microalgae biomass used for biodiesel production. Simulations indicated that *C. vulgaris* exhibited promising growth using 15% of CO_2 from cement industry flue gas that can generate a maximum microalgae biomass of about 1,268 t$CO2$·year^{-1}, reaching the same amount of CO_2 mitigation. These results indicated that the total CO_2 mitigation corresponds to 5.65% and 10.57% of the annual emissions in the base and CDM scenarios, respectively. The total amount of biodiesel produced was about 2,317 L·year^{-1}. In this regard, the utilization of microalgae-based CO_2 biofixation has been identified as a good alternative to traditional carbon capture technologies, since microalgae biomass is highly versatile and can be used to generate valuable compounds and biofuels, and could be a competitive alternative in the future emission credits market.

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Session 6A - Life Cycle Analysis Methodologies
15:00-16:00 @ Meeting ID: 948 1336 4454

Life Cycle Assessment Studies on Lightweight Materials for Automotive Applications – An Overview

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ABSTRACT
Lightweight materials have the potential to reduce vehicle fuel consumption and emissions. This study critically reviews Life Cycle Assessment (LCA) studies focused on lightweight materials (Advanced and High-Strength Steels (A/HSS), Aluminium (Al), Magnesium (Mg), and Composites) for automotive chassis and body-in-white components, to identify the materials with the lowest environmental impacts, trends and improvement opportunities. Since most impacts are associated with the vehicle use-stage (due to fossil fuel consumption), lightweight materials have environmental benefits in a cradle-to-grave approach. Greenhouse gas (GHG) emissions and energy consumption are the most reported categories. Several studies simplify their inventory and overuse assumptions, which lead to higher results uncertainty. In addition, the primary and secondary mass reductions, recycling rates and driven distances have been identified as crucial hotspots. A/HSS is identified as the most preferable lightweight material, followed by Al. However, there is a lack of scientific consensus. To formulate sound conclusions, this review recommends that future studies should present clearer inventory data, GHG break-even driving distances, uncertainty and/or sensitivity analysis, as well as assess other impact categories to unveil more hotspots for improvements. When substantial technology change is assumed, consequential LCA should be used to assess the predictive market uptake.

Keywords: Life Cycle Assessment; Literature review; Vehicle's lightweight materials

1. INTRODUCTION
Most vehicle life cycle (LC) energy and greenhouse gases (GHG) emissions are associated with its use-stage: 84-91% [1]. Lightweight materials can enable a reduction of 23% in fuel consumption at the use-stage due to vehicle mass reduction [2]. The goal of this study is to identify the lightweight materials with the lowest environmental impacts reported in Life Cycle Assessment (LCA) studies, some trends and improvement opportunities.

2. MATERIALS AND METHODS
This review study addresses the components, chassis and body-in-white (BIW), and lightweight materials that can contribute to a major vehicle mass reduction [3], namely, High-Strength Steels (HSS), Advanced High-Strength Steel (AHSS), Aluminium (Al), Magnesium (Mg) and Composites. The methodology adopted followed the search of specific terms ("HSS" or "AHSS" or "Al" or "Mg" or "Composites"; and "vehicle" and "lightweight" and "LCA") by using different search engines in the last trimester of 2020. In addition, the authors selected and prioritised the studies that included a comparison between lightweight materials following and a cradle-to-grave approach (total of 12 studies). LCA is a methodology to assess the potential LC impacts (ISO 14040:2006; 14044:2006) that enables to track the environmental impacts trade-offs, e.g. shift of lightweight material impacts between LC stages.

3. RESULTS AND DISCUSSION
Most of the studies pointed out environmental benefits associated with the production and use-stage of lightweight materials when compared to conventional steel. GHG emissions and energy consumption are the most reported impact categories (which have a similar trend, since GHG emissions are strictly related to energy consumption). However, this trend could not be reliable for other environmental impact categories, such as toxicity [4].
Al is the most common lightweight material included, followed by A/HSS (AHSS and HSS), Mg and composites. Use-stage dominates the overall impact results (due to fossil fuel consumption), followed by material production stage. Despite there is a lack of scientific consensus regarding the lightweight material with the lowest environmental impacts. It can be concluded that, for Al the studies reported that its lowest impacts are related to its potential to achieve the highest mass reduction rates, which directly decreased fuel consumption in the vehicle use-stage. A/HSS lower impacts are related to a lower energy-intensive production process and to its highest

recycling rates. The environmental benefits of using Mg appeared to be more ambiguous and strongly depend on two factors: achieving the complete phase-out of sulphur hexafluoride (SF6), used as a cover gas in its production process, and the establishment of a separate closed-loop recycling scheme. And, most authors reported that, composites' EoL is a critical stage, due to its insignificant recycling rates, which does not offset their energy and GHG emissions reductions achieved at the vehicle use-stage.

Due to the key-parameters used and/ or assumed by the different authors (e.g. fuel economy, primary and secondary mass reduction rates, recycling rates, and useful lifetime) and different functional units chosed, direct comparison among studies can be challenging. Different authors simplified their inventory data by overusing of assumptions, and neither all of them performed a sensitivity and/ or uncertainty analysis (influence of key-parameters in the results). This source of variability is the major factor behind the controversial results, depending on the values assumed impact results and GHG break-even driving distance (the distance from which a lightweight material offsets its additional embodied burdens) changed and consequently, the identification of the lightweight material with the lowest environmental impacts switched. Another issue that brought additional ambiguity to the impact results achieved was the secondary mass reductions. Lightweight chassis and BIW components allow downsizing of secondary components (e.g. powertrain) which can represent 35 to 41% of the total mass reduction [1]. In this way, the accurate benefit of lightweight materials was not assessed in some studies since secondary vehicle mass reductions were neglected.

4. CONCLUSION

This study reviewed LCA studies mainly focused on lightweight materials (A/HSS, Al, Mg and composites) for automotive chassis and BIW components to identify the materials with the lowest environmental impacts, trends and improvement opportunities. By performing a critical analysis, A/HSS is identified as the most preferable lightweight material, followed by Al. A/HSS was referred as presenting higher recycling rates and Al with higher mass reduction rates. Mg production was mentioned as having environmental burdens associated with high GHG emissions (use of SF6 as cover gas) and composites with near-zero recycling rates at EoL. The rates of mass reduction and recycling were identified as crucial hotspots for the aimed environmental benefits of lightweight vehicles. At the use-stage, fuel economy, vehicle and powertrain type, and driven distance (useful lifetime) are among the most common factors contributing to the GHG emissions. Different authors assumed different assumptions and key-parameters for critical hotspots. These studies show that the overall conclusions of LCA studies should not be generalized to different vehicles models (and components), since each model may have distinct key-parameters. Therefore, to support decision at design stage dedicated LCAs should be used with integration of specific vehicle key-parameters. To formulate sound conclusions, the authors recommended that, inventory data on production and use-stage should be clearer, GHG break-even driving distance disclosed, and uncertainty and/or sensitivity analysis are recommended. Other impact categories than GHG and energy should be considered to unveil other hotspots for improvements and when substantial technology change is assumed, consequential LCA should be used to assess the predictive market uptake.

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E120 15:15-15:30

Life Cycle Energy and Carbon Emissions of Essential Oil Extraction from Rosemary

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ABSTRACT

The search for essential oils from aromatic plants has been growing worldwide due to its potential applications in the food, cosmetic and pharmaceutical industries. This work aims to evaluate the life cycle's primary energy and carbon emissions of essential oil extraction from Rosemary grown in Portugal, following the LCA methodology. Two different functional units, 1 g of aromatic extract and 1_g of α-pinene, were selected for the study. Life cycle inventory data were mainly obtained from lab scale experiments, comparing three essential oil extraction processes, based on hydro-distillation (HD), HD followed by lyophilization (L) and supercritical fluid extraction (SFE). Results show that for extracting essential oil from fresh samples, SFE is the best method, with 290 MJ and 15 kg CO2-eq of energy and carbon emissions per 1 g of aromatic extract, while for extracting from dried samples the HD is preferable, with respectively 166 MJ and 8 kg CO2-eq per 1 g of aromatic extract. On the other hand, for obtaining 1 g α-pinene the HD is the best method with 465 and 1398 MJ of energy and 23 and 69 kg CO2-eq of carbon emissions, for respectively the fresh and dried samples.

Keywords: Carbon emissions; Life cycle; LCA; Primary energy; *R. officinalis*; Rosemary

1. INTRODUCTION

The agri-food industry is one of the biggest economic sectors in the European Union. This industry face several challenges, namely to efficiently produce food while protecting resources and biodiversity, to satisfy the present needs without compromising those of future generations, and to meet expectations of more conscious EU consumers, looking for healthier and sustainable foods and natural food additives [1]. Frequently called rosemary, Rosmarinus officinalis L. (R. officinalis) belongs to the Lamiaceae family [2]. It contains several compounds, such as α-pinene, camphor and borneol, with different health benefits [3]. Nevertheless, prior to the commercial scale process, more research is needed, specifically to support the current development of R. officinalis extracts in a Portuguese context. Applying the LCA principle, this work aimed to evaluate the primary energy, and the carbon emissions (kg CO2-eq) associated with the production of 1 g of aromatic extracts (essential oils) in Portugal, using primary data from different lab scale extraction processes.

2. MATERIALS AND METHODS

This work analyses in which state of the raw material (fresh or dried R. officinalis) the life cycle results are more favorable. Two functional units (FU), 1 g of aromatic extract and 1 g of α-pinene, were selected for the study. Regarding the extraction process steps, three alternative scenarios are analysed:

• HD+L: after transportation, raw materials (fresh and dried) are prepared manually and submitted to hydro-distillation (HD). At the end of the process it is obtained an essential oil and an hydrolat. In order to recover the low content of essential oil, existing in the hydrolat, a lyophilization (L) is performed. The final aromatic extract is a mixture of the essential oil obtained by HD and the essential oil obtain by lyophilization of the hydrolat;

• HD: hydro-distillation is performed for obtaining the essential oil and an hydrolat. The essential oil in the hydrolat is not recovered as in the HD+L scenario;

• SFE: the fresh and dried rosemary samples are submitted to supercritical fluid extraction (SFE), using carbon dioxide (CO2) as solvent.

For the life cycle inventory (LCI) analysis it is mainly used primary data obtained from lab experiments, complemented with data from the EcoInvent database (v3.7) using the SimaPro (v9.1) software.

The life cycle impact assessment methods used to quantify the direct environmental impacts from energy consumption and CO2 emissions considers the: (1) Cumulative Energy Demand (CED v1.11) that quantifies both the direct and indirect primary energy used during a product's life cycle, based on the fuels high heating values; and the (2) Inter Panel on Climate Change (IPCC 2013 v1.03) for a time horizon of 100 years, which measures the global warming potential (GWP).

3. RESULTS AND DISCUSSION

Results show that the HD+L extraction method is the most energy intensive, since its total primary energy (non-renewable plus renewable) accounts to 10992 and 5258 MJ/1 g of aromatic extract, for respectively the fresh and dried samples. In this method, lyophilization one, accounts for 97 % of the total primary energy. Concerning the HD scenario, the total primary energy is 363 and 166 MJ/1 g of aromatic extract, for respectively the fresh and dried samples. Regarding the SFE extraction method, its total primary energy is 290 and 383 MJ/1 g of aromatic extract, for respectively the fresh and dried samples. The transportation step accounts for less than 2 % of the total primary energy in all scenarios analyzed. Therefore, for extracting the essential oil from the fresh R. officinalis samples, the SFE is the lowest energy intensive method, as it requires less 24 % of primary energy than the extract obtained by SFE from the dried sample. However, for extracting the essential oil from the dried rosemary samples, the least energy intensive process is the hydro-distillation extraction method, consuming less 57 % of primary energy than SFE.

As concentration of α-pinene varies, depending on the extraction method used, and depending on the sample is fresh or dried, the life cycle primary energy was calculated also for the functional unit of 1 g of α-pinene. Overall, the SFE method showed the highest cumulative energy demand of 91578 MJ/1 g of α-pinene, for both dried and fresh rosemary samples. For the fresh rosemary samples, the HD scenario is the lowest energy intensive, with a primary energy consumption of 1398 MJ/1 g of α-pinene, representing 99 % reduction in the primary energy in comparison with the SFE method. For the dried rosemary samples, the HD+L and HD methods present respectively, less 52 % and 98 % of cumulative energy demand than the SFE method. Considering the HD+L scenario, the GWP accounts to 541 and 259 kg CO_2-eq for the essential oils obtained from respectively, fresh, and dried rosemary samples. Lyophilization is responsible for 97 % of the carbon emissions in both fresh and dried rosemary samples. The HD method contribution to GWP is 18 and 8 kg CO_2-eq/1 g of aromatic extract, for respectively, the fresh and dried rosemary samples. The SFE method showed lower GWP for obtaining the aromatic extract from fresh than from dried rosemary samples, of respectively 15 and 20 kg CO_2-eq/1 g of aromatic extract. Similarly, to what is concluded for the primary energy demand, regarding the GWP, the best method for obtaining essential oils from the fresh raw material is the SFE method, although HD has the lowest carbon emissions for the dried feedstock.

4. CONCLUSION

This work analyses the cumulative energy demand and global warming potential of essential oil extraction from R. officinalis, following the LCA methodology. The energy intensity is the main critical factor affecting the environmental performance of the extraction processes. To obtain the aromatic extract from fresh rosemary samples, SFE is the best method, because it has the lowest energy consumption and carbon emissions, while for extracting from the dried samples, the HD is the best method. On the other hand, for obtaining 1 g of α-pinene, the SFE is less selective than HD and presents the highest energy and carbon emissions.

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E121   **15:30-15:45**

Life Cycle Energy and Carbon Emissions of Colorants Extraction from *Hibiscus Sabdariffa*

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ABSTRACT
Nowadays, there is an growing interest in natural (plant-based) and innovative food additives to replace the synthetic ones in food industry. This study aims to support the development of natural-based food colorants. Using Life cycle assessment (LCA), the primary energy (CED) and the global warming potential (GWP) of three different H. sabdariffa bio-colorant extracts obtained by: maceration (A), ultrasound assisted extraction (UAE) during 36.5 min (B), and UAE during 11.5 min (C) were assessed. Overall, CED and GWP results had the same trend and showed that energy consumption is the factor that influence them the most. The extraction of the bio-colorant based on H. sabdariffa by UAE within 36.5 min (B) has the best environmental performance, having the lowest primary energy (109 MJ), and carbon emissions (5 kg of CO2-eq) to obtain 1 g of colorant extract.

Keywords: Carbon emissions; Food colorant; Life cycle; LCA; Primary energy; Roselle

1. INTRODUCTION
Several food additives, mainly synthetic, have been developed by food processing industry to improve food properties such as taste, flavor, color and time-shelf [1]. Different studies have been focusing on developing natural (plant-based) colorants as a substitute to synthetic ones [2], mainly for the non-toxic and bioactive properties found in natural colorant ingredients. Hibiscus sabdariffa L. (H. sabdariffa), frequently known by roselle, has red stems and calyces and it is used to flavor and color some beverages and medicinal teas [3]. Alternative extraction processes for natural colorant extracts from roselle have been studied, but to support decision an environmental perspective should be considered. Therefore, this study aims to support the development of bio-colorant extracts from an environmental point of view, using a life cycle assessment (LCA) approach to evaluate the environmental impact (life cycle energy and carbon emissions) of using alternative green extraction processes (maceration and ultrasound assisted extraction) to produce H. sabdariffa food colorant extracts to be applied in food industry.

2. MATERIALS AND METHODS
The LCA methodology was followed to support the development of natural colorants extracts. Hence, considering a functional unit of 1 g of colorant extract based on H. sabdariffa and a cradle-to-gate approach, the primary energy and carbon emissions of three extraction scenarios of were evaluated:
- A: after transport, the sample of roselle is frozen and grinded. Then, it is submitted to the process of maceration, using a solution with ethanol and water as solvent, and filtered. The solution with the colorant extract is subjected to the evaporation process to recover the ethanol content. To dry the extract, the spray-drying is executed using maltodextrin as an encapsulant agent.
- B: after transport, the sample of roselle material is grinded, and the colorant extract is processed by UAE with a solution of ethanol and water as solvent during 36.5 min. At the end of the process, the sample is centrifugated, and filtered. To recover the ethanol and dry the colorant extract, evaporation and spray-drying are performed, using maltodextrin as an encapsulant agent.
- C: this scenario follows the same processes of scenario B. However, the extraction time is reduced to 11.5 min.

Primary data for the life cycle inventory (LCI) were collected from lab experiments and available data from published literature [2]. This information was completed with background data from EcoInvent database (v.3.7), using SimaPro (v9.1) software. To assess the energy consumption and CO2 emissions, the environmental impacts were quantified using two usually applied life cycle impact assessment methods: (1) – Cumulative Energy Demand (CED) v.1.11 that measures the primary energy in MJ, based on the fuels' high heating value; (2) – Inter Panel on Climate Change (IPCC) v1.03 for a time horizon of 100 year that quantifies the global warming potential (GWP) in kg of CO2-eq.

3. RESULTS AND DISCUSSION
Regarding scenario A, the total primary energy consumed amounts to 157 MJ (66 % non-renewable and 34 % renewable energy). Spray-drying, which is the unit-process with the highest electricity consumption is the procedure with the highest quantity of primary energy (135 MJ), representing 86 % of the total cumulative energy demand of extraction A. The maceration process represents only 4 % of the total, from which 93 % is primary energy based on non-renewable resources (6 MJ). The high percentage in non-renewable energy is observed

mainly because of the use of ethanol as solvent that is recovered in evaporation process. This stage accounts to 13 MJ of the total primary energy. The UAE process with running time of 36.5 min (scenario B) takes 109 MJ of the total primary energy. Once more, spray-drying is the process with the highest contribution to the total primary energy. Evaporation and UAE processes have similar environmental performance, accounting for 9 % and 10 % of the total primary energy, respectively. As it happened in scenario A, the use of ethanol as solvent increases the share of non-renewable energy of UAE. This impact is minimized in evaporation process, where the ethanol is recovered. Scenario C (UAE with a lower extraction time) is the one with the worse performance from an energy point of view (244 MJ of non-renewable primary energy, and 126 MJ of renewable primary energy). Spray-drying and UAE account for 9 % and 5 % of the total primary energy, respectively.

On the other hand, for all scenarios, the processes of transport, freezing, grinding, centrifugation and filtration have no significant impact, accounting less than 1 % of the total primary energy.

In general, GWP results showed the same trend as the CED results. Scenario B has the best environmental performance with an amount of 5 kg of CO_2-eq emissions, 31 % and 72 % lower than scenario A and C, respectively. Scenario C has highest carbon emissions (18 kg CO_2-eq).

One more time, spray-drying is the process that has higher amount of carbon emissions (B – 81 %, and C – 85 %), and the processes of transport, freezing, grinding, centrifugation and filtration are not meaningful in these outcomes.

4. CONCLUSION

An LCA approach was used to support the development of H. sabdariffa bio-colorant extracts for food industry, at an early stage. A cradle-to-gate analysis was performed to quantify the life cycle primary energy (CED) and carbon emissions (GWP) of three alternative green extraction processes: maceration (A), ultrasound assisted extraction (UAE) during 36.5 minutes (B), and UAE during 11.5 minutes (C). The electric consumption of the equipment used in the three extraction routes is the factor that influences the most the CED and GWP results. Spray-drying is the unit process with highest impacts in all scenarios, accounting for more than 80 % for both total primary energy and carbon emissions. Although the use of ethanol as solvent mainly increases the non-renewable primary energy consumed in maceration and UAE, its environmental impacts are minimized because it is recovered in evaporation process. Overall, the same trend is identified by both CED and GWP results.The scenario with the best environmental performance is the extraction process by UAE with a running time of 36.5 min (B). On the other hand, scenario C has the highest cumulative energy demand and global warming potential (370 MJ and 18 kg of CO_2-eq) due to its lower extraction yield. This research is a first step to increase the knowledge, from an environmental point of view, on H. sabdariffa bio-additives at an early stage of development. However, future work should consider other environmental impact categories, and a scale up of the production processes.

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Energy Consumption and Carbon Footprint of Perovskite Solar Cells

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ABSTRACT

Despite the tremendous and successful effort for obtaining perovskite solar cells (PSCs) devices with high power conversion efficiencies, little efforts have been devoted to study fundamental engineering aspects essential for future industrial production. In particular, this work makes an analysis of the energy consumed and the carbon footprint of producing a mesoscopic PSC $8x3cm^2$ module in a life cycle perspective. A "cradle-to-gate" study was performed, using as much as possible primary data. Considering the PSC module as the functional unit the results show that the mesoporous layer deposition is the dominant term concerning the energy consumption. For the carbon footprint the gold layer, and especially gold, is the main term. Changing the electricity source to renewable photovoltaic energy reduces significantly the carbon footprint. The results stress the need to replace gold, and use less severe operational conditions in order to improve the environmental performance of the perovskite solar cells.

Keywords: Life Cycle Assessment; Perovskite Solar Cell; Energy Consumption; Carbon Footprint

1. INTRODUCTION

Recently, PSCs emerged and promise to break the prevailing solar energy paradigm by combining both low-cost and high-efficiency. PSC technology actually shivered the solar photovoltaic (PV) community as a strong candidate to rival the efficiency of traditional PV devices; in less than 12 years its efficiency was improved from 3.8 % to almost 26 % [1]. This rapid efficiency progress, together with facile, fast and low-cost deposition methods, validates PSC practical relevance in solar field. Before commercialization of any technology, a sustainability assessment should be carried out to assess what are its environmental impacts. The objective is to ensure that in the current state of development of PSCs, the best technical options are considered, analyzed and implemented, supporting the development and commercialization processes. Thus, an evaluation of the sustainability of current development stage of the PSC technology is of utmost importance. The assessment results will help its future development ensuring that the new generation of PV power will maximize its contribution for a more sustainable development, in particular from an environmental point of view.

2. MATERIALS AND METHODS

This study aims to assess the direct energy consumption and the carbon footprint associated with the construction and assemblage of a mesoscopic PSC 8x3 cm^2 module, following the Life Cycle Assessment, LCA, methodology defined by ISO 14040:2006 and ISO 14044:2006 standards. The functional unit selected for this study is the cell itself, one PSC module. A "cradle-to-gate" attributive study was done, including the extraction and processing of raw materials, module construction and assemblage. Portuguese and European settings were considered as much as possible, and standard equipment was used in making the module. The generation of energy (electricity or fuel), and the production of the auxiliary materials used in the process were also taken into account, for which European conditions were used as much as possible. The Life Cycle Inventory, LCI, was done using primary data obtained from the module construction and assemblage, as described above, complemented with information from the literature or from the Ecoinvent version 3.5 LCI database. No allocation rules were defined, as the process system only involves one product. A cut-off of 2 % was considered, meaning that all materials that correspondent to less than 2 % of the overall were not considered. The quantities of materials and solvents used in the construction of the PSC module are available following the procedure described above. The transportation was accounted for, assuming that the materials are shipped from the supplier nearest geographical location by truck if it is located in Europe, or by ship if located outside Europe, namely the US or China. The waste generated, that consists of all used solvents and non-used materials, corresponding to the main system emissions, were grouped together and treated as hazardous solvents by incineration. The energy consumed is obtained directly from the inventory calculations, as this work focus its attention in the production process. Concerning the carbon footprint, taking into account the previous LCA studies about perovskite solar cells available in the literature, and the PEFCR (Product Environmental Footprint Category Rules) released by the European Union [2] the

methodology defined in the 2013 IPCC report was considered. The calculations were done using the International Reference Life Cycle Data System (ILCD), more specifically the ILCD 2018 MidPoint as implemented in the LCA software Simapro V8.5.2.

3. RESULTS AND DISCUSSION

The production of the PSC module defined as the functional unit has an energy consumption of 32.55 kWh. Results show that the mesoporous layer, where the two layers of TiO_2 are deposited, is by far the most relevant production step in terms of energy consumption, followed by the deposition of the gold layer. This is due to high temperatures and large times of operation at those temperatures involved that require a large consumption. In particular, the energy consumed in the oven used represents 99 % of the energy consumed. In fact, the lower the operating temperature required the lower the energy consumed, allowing one to conclude that a reduction in the operating temperatures is necessary in order to reduce the direct energy consumption. The carbon footprint is also a measure of the energy consumption, as the energy generation is currently the main generator of greenhouse gases. A carbon footprint of 32.96 kg CO_2 eq is necessary to produce one PSC module. To determine what are the most relevant factors that influence the carbon footprint, and to make the analysis more objective, due to the large amount of inventory terms it is necessary to aggregate them by type. Thus, four classes were considered: (1) materials, that include all raw materials and solvents used in the production of the PSC module, (2) energy, (3) transportation, and (4) waste treatment. Results show that the impacts of both transportation and waste treatment are very small when compared to the other two. This is due to the small size of the PSC module considered, that require small quantities of raw materials and solvents, with the corresponding small transportation and waste treatment footprints. The material and energy classes have similar carbon footprints, indicating that improvements in the environmental performance concerning the carbon footprint should focus both on the materials and energy source used. Concerning the later, as only electricity is used in the process, changing from the Portuguese energy mix to renewable electricity produced by standard silicon panels reduces the energy carbon footprint by 82 % to 2.48 kg CO_2 eq. The relative importance of each production step is maintained, as all use electricity. For the materials, the results show that the gold layer is the dominant factor, contributing more than with around 99% of the overall value. Gold is a rare precious metal that requires a significant amount of resources, either energy and materials, to be produced, thus it overwhelming dominance. Although options with lower environmental impact exist, such as carbon based materials [3,4], gold continues to be used as it is corrosion resistance and has a long operational life. Thus, both energy source and gold layer should be replaced to improve the environmental performance of producing PSC modules.

4. CONCLUSION

The mesoporous layer has the largest energy consumption, mainly due to high temperatures required. Regarding the carbon footprint, both materials and energy are the main factors with comparable importance. Gold dominates the carbon footprint of the materials, and when the PSC module production steps footprints are compared, it is the deposition of the gold layer that is also dominant. Replacing the electricity mix by renewable photovoltaic energy resulted in a significant reduction in the carbon footprint due to energy consumption. A focus should be given initially to reduce the temperatures used in the production process, in particular in the mesoporous layer deposition, and in substituting the gold layer by other material with lower environmental impacts in their production.

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E026   **15:00-15:15**

Disentangling the SDGs Agenda in the GCC Region: Priority Targets and Core Areas for Environmental Action

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ABSTRACT

The agenda of the Sustainable Development Goals (SDGs) is a key international outcome for guiding development efforts of nation states. However, SDG targets cover vast areas of action, and they are difficult to breakdown and monitor for countries with different developmental situations and needs. This paper presents a highly needed prioritization of the SDG targets for the Gulf Cooperation Council (GCC) region. It maps SDGs targets and outlines priorities and the key areas for environmental action. Sustainability in resource use, consumption and production are primary areas for investments. Education and awareness represent crosscutting priorities and low-hanging fruits for action. Tackling climate change, emerging supply risks and the management of ecosystems are other areas where GCC governments can intensify interventions.

Keywords: ecological footprints; education for sustainable development; Gulf Cooperation Council; global sustainability agenda; sustainable consumption and production; Sustainable Development Goals

1. INTRODUCTION

The SDG agenda also represents an umbrella for policies towards low-carbon and green developments. As this paper will discuss later, SDGs related to clean energy, efficiency in resource use and low-carbon development are key priorities worldwide. They are linked through the SDG agenda to other global endeavors such as energy transition policies or climate change agreements (e.g. the 2015 Paris agreement). However, not all SDG targets are relevant for all countries, while the large number of targets can make it difficult to monitor and institutionalize progress of the SDGs' implementation. Therefore, the periodic reportings on progress towards the SDGs are often done ad hoc. They have been lacking consistent and evidence-based frameworks [1]. There is a need for a SDG prioritization at the level of national states, or of regions that share similar economic or hydro-climatic characteristics. This paper responds to this need by analyzing the prioritization and relevance of the SDG targets with regard to the environmental action needs in the GCC region. Using a mapping of targets and data from SDG monitoring instruments, the paper presents the priority targets for the GCC region. It later outlines the core areas of environmental action relevant to achieving the SDGs, and discusses the progress of GCC countries in these areas. In this sense, the paper provides valuable insights for policymakers in terms of priority issues for public investments and pathways for integrating the SDG agenda into local strategies.

2. MATERIALS AND METHODS

This paper proposes a mapping of the SDG targets in order to gauge relevancy for the GCC region, with a particular focus on environmental outcomes. The mapping methodology can be explains in this section. The first step is to eliminate non-relevant targets. Therefore, the mapping results shows only little, moderately or highly relevant targets. The targets not shown in this mapping are deemed of no relevance due to a high achievement or the high economic development levels. These are largely targets related to poverty, food security, access to basic services, control of infectious diseases or safety, all of which are more oriented towards developing or least-developed countries.

Second, the SDG targets with little or unclear relevance represent issues based on either one of the following criteria. They should have not been highlighted as relevant areas in national policies such as national visions and correspondent by-laws and strategies. Alternatively, the relevance of some of these targets can be unclear due to the lack of data on the compliance with these targets. The targets include issues such as official development assistance (ODA) for certain areas, specific forms of crime or specific inequality indicators. Third, targets with moderate relevance are determined based on the baseline criteria of being mentioned in national policies as important issues as well as three additional criteria. As additional criteria, the paper considers the issues of moderate importance if 1) the performance of the GCC states on these issues is relatively fair, 2) the issues are not marked as (high) priorities in national policies, and/or 3) the issues are of limited national relevance. In the

final step, targets designated as highly relevant are determined based on two baseline criteria of 1)uncompetitive scoring on these goals and 2) being mentioned as high priorities in national strategies. Alongside issues related to the situation of labor workforce, industrial development, traffic safety and societal participation, most of the highly relevant targets are environmental ones, which to be highlighted in Section 3 as core areas for environmental action.

3. RESULTS AND DISCUSSION

Three core areas for environmental action are identified for the GCC region as a result of the mapping exercise. The first area is sustainable resource use, production and consumption. This area is represented by SDG targets related to encouraging the sustainable use of the key resources of water and land, and reducing the large footprints in consumption and production. Besides, the issue of clean energy is a central issue within the SDGs. It is also related to reducing pollution and ecological footprints, and renewables targets have thus been incorporated in all national visions of GCC states [2]. The second area is climate change, supply security and emerging risks. Alongside climate change related targets, SDG targets related to disaster risk assessment and reduction are quite important due to mounting risks facing the largely costal supply infrastructure, e.g., desalination and electricity plants, aquaculture or coastal industry [3]. These risks can stem from industrial accidents, human failure, attacks by non-state actors or failures due to increased integration of water and energy production through large-scale plants supplying major cities in the GCC region. The third area is represented by sustainable development education. Education to increase awareness of sustainable development and climate change has been mentioned in several SDG targets, and it is a key priority for the GCC region in order to address the large ecological footprints, encourage sustainable consumption and increase societal resilience to threats such as climate change. Mapping the SDGs for the GCC region provides opportunities for policymakers for aligning their national strategies to the global sustainability agenda and identifying future areas for development-related investments. The analysis of SDG priorities for the GCC region allow for some observations. First, GCC states can improve their SDG rankings substantially through action in the highlighted environmental areas. Second, for the facilitating SDG-related environmental actions, GCC states can start with low-hanging fruits such as education, local participation and awareness on sustainable development, climate change and sustainable consumption. These issues are both separate SDG targets and pre-conditions for achieving other environmental targets.

4. CONCLUSION

The mapping exercise of the SDG targets in the case of GCC states has shown the importance of environmental targets for the region. The core areas for environmental action have been delineated. They include sustainable resource use, sustainable production and consumption, ecosystem protection and management, risk management including climate change, and sustainable development education. By addressing targets in these areas, and aligning national strategies to the SDG agenda, GCC states can improve environmental outcomes and their global standings with regard to sustainability. They can immediately target low-hanging fruits such as education and awareness, while they facilitate demanding actions such as clean or circular production, energy transition and low-carbon development.

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E104   **15:15-15:30**

Exploring the Significance of Resilience Qualities in the Context of the Middle East Built Environment

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ABSTRACT
Despite applying green urban development concepts and technologies to uphold legacies, the resilience of the urban built environment (UBE) remains a significant challenge. A robust system with high flexibility to climate change can withstand different climate variations with the lowest possible degradation of its performance indicators. An urban system could be designed to be responsive, absorptive, and adaptive to the potential shocks and stresses and utilized to meet particular needs that help rapidly restore the system's functionality. This paper reviews the major impacts of climate change and investigates the resilience challenges to the cities in the Middle East (ME) from the perspective of resilience qualities. The findings of this study indicate that many cities in the ME are projected to suffer from severe climate change impacts. However, there is an argument that there is still room to develop the necessary risk management plans and invest in building resilient infrastructure and utilities. Considering the resilience qualities and strategies to the built environment components and urban infrastructure can result in robust, flexible, redundant, resourceful, inclusive, and integrated systems. The paper identifies directions of needed work to improve the adaptation of the built environment to climate change.

Keywords: Climate change, Middle East, resilience qualities, urban built environment, urban resilience

1. INTRODUCTION

Climate change is a severe issue of the ME and specifically in the Gulf region, as it impacts the luxury and wealth of people. Changes in temperature, precipitation patterns, flooding, storm surges, and sea-level rise (SLR) are considered critical impacts [1]. The temperature increases lead to more energy and water consumption [2]. Marine life and land quality will be affected, biodiversity degradation will appear, and groundwater salinity will increase [3]. In addition, with the growing water demand and water supply deterioration, most countries in the ME may suffer from severe water shortages in the future [4]. Furthermore, any impact on marine life will turn into a problem for the water desalination plants, resulting in a significant effect on many Gulf Cooperation Council countries (GCC) [5].

Climate change resilience is essential to characterize communities' ability to recover after undergoing a climate shock or disaster. Therefore, the resilience in the critical infrastructure, including electrical and renewable energy systems, water networks, and transportation networks, is of great importance [6]. In light of that, cities should be managed to reduce the potential hazards. They should also accommodate resilience approaches that make the city-systems less prone to disturbances, enable quick responses to cope with the disturbance, and allow flexible responses to such events.

2. MATERIALS AND METHODS

This paper investigates the urban built environment (UBE) and relevant climate change impacts in the ME region and highlights the urban resilience directions. It focuses on identifying and determining the significance of incorporating resilience qualities to planning and assessing the built environment.

3. RESULTS AND DISCUSSION

The cities in the ME are estimated to suffer from high warming of more than 4 K by 2100 [7]. In the GCC countries, the extreme wet-bulb temperatures could exceed the critical threshold [8]. Hence, with sea breeze circulation and business as usual GHG emissions, high wet-bulb temperatures will be witnessed in the GCC coastal cities, making them more vulnerable to climate change. In addition, floods due to heavy precipitation and SLR are expected to increase in the region. The dust storm is another hazard that could cause a major disaster, especially in the arid and semi-arid regions.

Incorporating resilience requirements into planning and assessment and ensuring the robustness of the delivered infrastructures in the face of climate change is essential. Therefore, systems need to be enabled to respond promptly and prevent the failure or breakdown that could occur due to external disruption. This could happen through incorporating the resilience qualities: reflectiveness, robustness, redundancy, flexibility, resourcefulness, rapidity, inclusiveness, and integration. Fig. 2 summarizes the categories of the most potential climate change impacts in the ME (a). Also, it indicates the groups of the UBE systems (b) and outlines the applicable UBE resilience qualities (c).
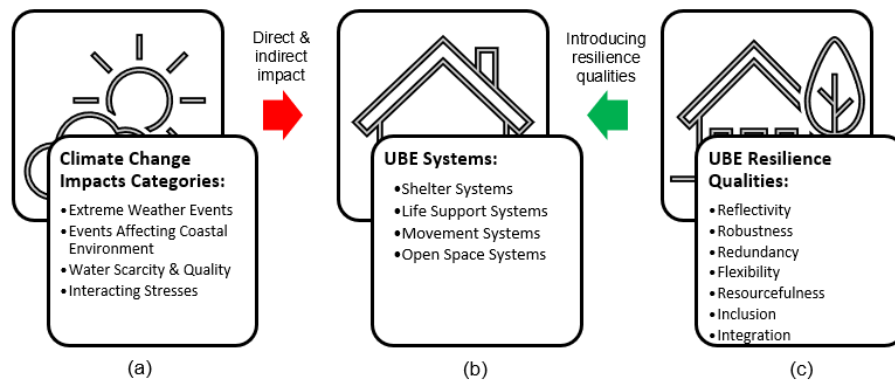
Fig. 2: Categorization of the (a) potential climate change impacts in the ME, (b) urban built environment (UBE) systems, (c) relevant UBE resilience qualities

4. CONCLUSION

The resilience of the UBE against climate change impacts is crucial. However, in the ME, many countries lack the strategies to build environmental resilience, such as community and country resilience strategy, risk and resilience governance, risk and safety plans, disasters and crises management plans, and resilience frameworks. Therefore, the communities and households in the ME countries should have the ability to manage to transform living standards in the face of climate change shocks and stresses. In addition to the optimal engineering design, the strategy would include adopting a robust approach to projected risks and potential shocks and stresses through incorporating different resilience qualities and indicators. The resulting options would incorporate more flexibility, robustness, and redundancy into the design and bring elements and ideas into concrete actions. It will also allow for accepting the inherent uncertainty and emerging evidence to feed current standards and regulations and imply the ability to rapidly find alternatives to achieve goals and meet needs during a shock.

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Identification of Potential Landfill Sites in Bengaluru Metropolitan Region, India through GIS-AHP Framework

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ABSTRACT
Uncontrolled open dumping and burning of municipality solid waste (MSW) has resulted in soil, water, and air pollution in many urban cities in India. Landfills are the most common cost-effective solution for MSW management in many developing countries like India. However, the identification of suitable landfill sites always remains a challenging task as it involves selection of several environmental criteria set by the local authorities. The objective of this study is to identify the most potential landfill sites proposed by the Government in Bengaluru Metropolitan Region, Karnataka state, India using Geographic Information System enabled Analytical Hierarchy Process based multi-criteria evaluation technique. Several criteria and constraints as recommended by the local authorities along with the proximity to the solid waste processing plants are used to identify the potential landfill sites in the study region. The study identified three highly suitable sites (Neraluru, Gudhatti, Madivala) for landfills which are not only environmentally sustainable but also economically attractive as they are closer to the solid waste processing plants minimizing the transportation cost involved in the disposal of solid waste from the source to the final disposal sites in the study region.

Keywords: Bengaluru Metropolitan Region; Circular Economy; GIS enabled AHP technique; Landfill site selection; Municipal solid waste

1. INTRODUCTION
Management of Municipal Solid Waste (MSW) has been a major challenge and is receiving growing attention in many urban cities because of its environmental and economic impact [1]. MSW can be converted into energy using advanced conversion technologies, known as Waste to Energy (WtE) systems. However, uncontrolled open dumping and burning of MSW result in soil, water, and air pollution and thus landfills are one of the most preferred waste management techniques due to its least-cost solution in developing countries like India [2].

At present, Bengaluru Metropolitan Region (BMR) generates around 3056 tonnes of MSW per day with a per capita waste generation of 363 grams. By 2031, BMR is expected to generate 13911 tonnes of MSW per day. Thus, there is a need for additional landfill sites for the proper disposal of the generated waste considering the population growth and city expansion plan [3]. The current study identifies the most suitable sites for potential engineered landfill sites closer to MSW processing plants in the disposal of solid waste in BMR considering the environmental criteria through the methodological framework based on Geographic Information System (GIS) and Analytical Hierarchy Process (AHP) based Multi Criteria Evaluation (MCE) technique.

2. MATERIALS AND METHODS
To identify potential landfill sites in BMR, general, geological, and socio-economic criteria as recommended by [4] are considered including (i) Road network, (ii) Soil types, (iii) Water bodies, (iv) Depth to Groundwater, (v) Residential Areas, (vi) Built-Up areas and (vii) Slope. For each of the criterion, weight maps were prepared based on AHP analysis. Through overlay analysis, the weight maps were used in the preparation of suiltability map for landfill site selection in the study region. From the suitability map, the highly suitable sites for landfills were selected based on the distance from the MSW processing plants located in BMR.

3. RESULTS AND DISCUSSION
Results suggest that the Government proposed sites at Madivala, Neraluru, Gudhatti are considered highly suitable for landfill establishment as they fall within the high suitability index for landfill selection and lie within 10 km from the solid waste processing plants. Galipuje, Honnaghatta, Samanduru, Gowrenahalli sites fall under moderate landfill suitability index and lie 20 km away from the processing plants making them moderately suitable landfill sites in BMR. Bendiganahalli and Chikkabanahalli sites lie closer to the solid waste processing plants (within 5km). However, these regions are expected to undergo urban developments in the future [3] and are not recommended for the setting up of landfill sites considering the negative impacts of a landfill on the health of the people living nearby them.

4. CONCLUSION

In the current study, to identify potential landfill sites in BMR, GIS enabled AHP technique was implemented based on general, socio-economic, geological criteria and constraints. The landfill suitability map prepared through AHP analysis categorized the study region into five categories as excluded, unsuitable, suitable, moderately suitable, and highly suitable. Considering the increasing solid waste generation, the Government has proposed to set up new landfill sites in the study region by 2031. Based on the landfill suitability map, the study categorized the proposed landfill sites as highly suitable, moderately suitable, less suitable and unsuitable based on its location to the solid waste processing plants. Results of this study identified three potential sites at Gudhatti, Madivala and Neraluru as highly suitable which would help the local authorities while planning to set up the landfill sites in the future. The metropolitan region is thriving to achieve sustainable waste management in the future through reusing, recycling, and energy conversion of solid waste which might reduce the amount of waste disposed in the landfills thereby increasing the lifespan of the existing landfills and may possibly reduce the need for new landfills in the future. This needs further attention in the research.

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Understanding Citizens´ Environmental Concern and Their Pro-Environmental Behaviors and Attitudes and Their Influence on Energy Use

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ABSTRACT
To reduce the amount of solid waste from households that reach the landfill and the quantity of electrical demand, it is necessary to understand individual citizen´s determinants for positive eco-friendly everyday choices. Thus, an extended study of the underlying political ideologies that influence human behaviors and their relationship with the environment is necessary for policy making. The objective of the present research is to examine the relationship between an individual´s political ideology and his/her environmental concern and pro-environmental behaviours and attitudes, and how these las two influences on pro-electrical consumption attitudes. To achieve the objective, we based the research on information from two surveys effectuated two years apart. A total of 3,395 household heads were interviewed (84.5% from 2019 and 15.5% from 2021). Four hypotheses were launched and only one validated through our study which proved the relationship between environmental concern and pro-electrical consumption attitudes. However, the study additionally shows a gradual decrease in environmental concern and pro-environmental behaviours and attitudes from centre ideology to the extreme left and right, being the values of the left-wing (extreme left and left-centre) higher than those of the right-wing (extreme right and right-centre). Additionally, a strong influence of environmental concern in pro-environmental behaviours and attitudes was found, meaning that environmental knowledge is necessary to develop greener attitudes and behaviours. These findings make the discussion on the effects of political ideology on environmental concern and pro-environmental behaviours and attitudes clearer and contribute to the wider discussion on the policy preferences among the general public.

Keywords: Attitudes, Behaviours, Concern, Political ideology, Pro-Environmental

1. INTRODUCTION

Identifying the determinants and factors that have a meaningful impact to predict waste generation and electricity consumption for a country is of great importance and a key step towards the design and implementation of policies and laws. The authors have already tried to correlate many factors with the residential electricity consumption and waste generation, such as: behavioral, socioeconomic, demographic, using tools as ordinary least square regressions or sorting algorithms with the help of general surveys (Hidalgo-Crespo et al., 2021; Hidalgo et al., 2019 (a); Hidalgo-Crespo et al., 2019; Hidalgo et al., 2019 (b)). However, after all this research, the authors have explained as far as 10 percent of the variability and found as a general conclusion that Ecuadorian households do not behave as other third world countries.

To reduce the amount of waste from households that reach the landfill, and the quantity of electricity demanded from the residential sector, first it is necessary to understand citizen´s environmental concern and their pro-environmental behaviours and attitudes. Additionally, we´re interested in knowing if these are influenced by an individual´s political ideology and if they can affect their pro-electrical consumption behaviours. This could help policy makers to understand if whether a law to support sustainable models for waste generation and household electricity demand can expect approval from the population. For this reason, the aim of this study is to examine the relationship between an individual´s political ideology and his/her environmental concern and pro-environmental behaviors and attitudes and their influence in pro-electrical consumption habitudes.

To obtain the results, we used information from two surveys conducted in 2019 and 2021. The first one, which was conducted to 2,869 household heads, had the objective to correlate environmental concern and pro-environmental behaviors and attitudes with pro-electrical consumption habitudes. The second survey, which was taken to 526 household heads, due to the difficulty imposed by the pandemic, had the purpose to correlate political ideology and environmental concern and pro-environmental behaviors and attitudes.

2. MATERIALS AND METHODS

This study defines four hypotheses:

- Hypothesis 1 (H1). An individual´s political ideology will influence his/her environmental concern.
- Hypothesis 2 (H2). An individual´s political ideology will influence his/her pro-environmental behaviors and attitudes.
- Hypothesis 3 (H3). An individual´s environmental concern will influence his/her pro-electrical consumption attitudes.
- Hypothesis 4 (H4). An individual´s pro-environmental behaviors and attitudes will influence his/her pro-electrical consumption attitudes.

3. RESULTS AND DISCUSSION

In relation to political ideology influence on environmental concern, H1, results show that EC diminishes when we move from extreme left to extreme right (β = -0.001966), and PEBA augment with the same displacement from left to right (β = 0.0347). However, both these values don´t show the enough significance to validate hypothesis 1 and 2. We can see there is not a linear relationship between them, but more of a quadratic reaching the maximum at the middle (Centre PI). There is a strong positive relationship between EC and PECA (β = 0.03421), and PEBA and PECA (β = 0.01293). We can validate hypothesis 3, because of the significance value, but for the same reason, hypothesis 4 can´t be validated. Additional information confirms a strong relationship between PEBA and EC (β = 0.62689), which shows the highest value for significance in all done regressions.

4. CONCLUSION

The relationship between political ideology and environmental concern and pro-environmental behaviours and attitudes was analyzed, jointly with their influence on pro-electrical consumption attitudes. There is a gradual decrease in EC and PEBA from centre ideology to the extreme left and right, being the values of the left-wing (extreme left and left-centre) higher than those of the right-wing (extreme right and right-centre). A strong influence of environmental concern in pro-environmental behaviours and attitudes was found, meaning that environmental knowledge is necessary to develop greener attitudes and behaviours. To the best of our knowledge, this paper presents the first empirical analysis of this issue for the country. These findings make the discussion on the effects of political ideology on environmental concern and pro-environmental behaviours and attitudes clearer and contribute to the wider discussion on the policy preferences among the public.

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Oral Flash 1

17:00-18:00 @ Meeting ID: 948 1336 4454

E004	17:00-17:06

Different Taxation Between Diesel and Gasoline: is it Justifiable in Portugal?

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ABSTRACT

We question the fiscal advantage enjoyed by diesel fuel in Portugal based on economic and environmental grounds. To do so, we estimate price and income elasticities for diesel and gasoline. Our results show that diesel consumption is inelastic to price changes in Portugal, and instead, this consumption is highly dependent on economic growth, given its strong use for commercial purposes. Consequently, higher taxes on diesel are not very effective to moderate demand and would hinder firm´s competitiveness. To protect the environment other policy options should be explored, such as environmental standards and incentives to electric mobility. Hence, our results partially help to explain the different taxation between diesel and gasoline in Portugal, since a higher diesel taxation would not significantly decrease diesel demand or improve the environment, but would on the other hand potentially harm the economic activity of the country.

Keywords: Environmental policy; Fuel demand; Income elasticity; Price elasticity; Road transport; Tax differentiation

1. INTRODUCTION

Contrarily to what happens in the United States of America (USA), most European countries charge lower taxes on diesel than on gasoline [1]. This has contributed to the so-called "dieselization" process, where gasoline automobiles have gradually been replaced by diesel ones. In 2011, there was a proposition for the revision of the European Commission's Energy Tax Directive which intended to tax fuels based on their energy content and on CO_2 emissions. This revision would eliminate the tax advantage of diesel, but it faced strong opposition from the automobile industry and ended up not being approved.

The lower diesel taxation remains a controversial issue. Both diesel and gasoline have different polluting characteristics, efficiency features, and applications. Diesel fuel contains around 10% more energy and emits about 18% more CO_2 per liter than gasoline [1]. Additionally, diesel exhaust has several harmful gases and carcinogenic airborne fine particulates, which lead to the obligation of specific filters [1]. However, due to their higher thermodynamic efficiency diesel engines can potentially generate around 10% less CO_2 than gasoline ones for the same number of kilometers driven [2]. Some authors defend that a higher share of diesel vehicles will have a non-negligible impact on total fuel demand [3], while others (e.g., [1], [4]) say that there is a rebound effect due to, e.g., heavier diesel cars, more intense car use, more travel needs of diesel cars buyers. Overall, the final environmental effect is not straightforward. Despite the controversy, diesel remains cheaper than gasoline in most Western European countries due to lower taxation.

The lower diesel taxation has not received a lot of attention in the literature. The existing studies generally defend that diesel should face a higher taxation than gasoline (for example, [1], [5], [6]).

The aim of this paper is to further investigate the grounds for the lower diesel taxation, focusing on Portugal, a small European country which has gone through several economic crises.

2. MATERIALS AND METHODS

We use data on gasoline and diesel consumption per capita, Gross Domestic Product (GDP) per capita, and fuel prices. Fuel consumption and prices were retrieved from Direcção Geral de Energia e Geologia (DGEG), while GDP data was from the National Statistics Institute (INE). We cover the period from 1995 to 2015 using quarterly data. To estimate price and income elasticities we use the Autoregressive Distributed Lag (ARDL) methodology.

3. RESULTS AND DISCUSSION

The estimated coefficients have the expected signs and show that long-run price elasticities are -0.368 for diesel and -0.911 for gasoline while long-run income elasticities are 2.338 for diesel and 0.877 for gasoline.

Hence, if confronted with an increase in the taxation level, diesel consumption would not decrease significantly. This shows a relative ineffectiveness of this instrument regarding environmental purposes. On the other hand, if the purpose is to increase revenues, it would be a relatively effective instrument. Gasoline consumption is nearly price elastic, hence an increase in the taxation level would more effectively moderate demand.

Simultaneously, diesel has a very high income elasticity while gasoline has an elasticity below one. This result clearly reflects the fact that diesel is used not only for domestic purposes, but also and very importantly for commercial purposes. Commercial transportation is less sensitive to price changes due to contractual obligations, but very sensitive to income changes. These aggregate income changes represent the economic cycle in the country. High income happens when the economic activity is boosting, while low income is associated with periods of economic crises. Diesel consumption is then very dependent on economic conditions while gasoline consumption has a relatively lower response to them. This lower response is explained by the agents' preferences which, in Portugal, are highly turned to private transportation. As referred, this can be explained by the relatively poor net of public transportation, but also cultural aspects.

4. CONCLUSION

Overall, our results partially explain the political option behind the lower taxation for diesel. However, it is relevant to refer that this differentiation decreased over the last years with a tendency to convergence in taxations. This can be explained by environmental pressures, due to the harmful effects of diesel, due to the acknowledgement that private fleet is increasingly working on diesel and eventually also due to revenue collection purposes.

It is important to refer that this study is not intended to recommend alterations in the taxation levels, which are already very high for gasoline in Portugal. Our purpose is just to discuss and reflect on the rationale behind the tax differentiation existing in the country.

FUNDING

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Perceptions of Forest Experts on the Impact of Wildfires on Ecosystem Services in Portugal

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ABSTRACT

In Mediterranean Europe, one of the expected consequences of climate change is the intensification of wildfire events. Given the importance of forests in helping regulate climate and the many ecosystem services they provide, it is crucial to identify how wildfires might impact them. In this context, the present work aims to identify the wildfire impacts caused to the ecosystem services in Portugal. This is done through a survey directed to Portuguese fire experts. Using The Economics of Ecosystems and Biodiversity (TEEB) definitions, experts were asked to share their perceptions on the fire impacts to forest ecosystem services in the short and long-term and indicate which services they feel require more policies to mitigate the impacts. The results showed that all ecosystem services are impacted to various degrees and different lengths of time. Regulating services were overall the most affected group and the most in need of specific policies. This study helped identify fire impacts, policy needs, and priorities in the perception of the experts in Portugal, which is valuable for guiding future research in various knowledge fields, especially related to raising awareness about behavioural adaptation to prevent and mitigate wildfire impacts in a changing climate.

Keywords: Ecosystem services; Expert perception; Impact assessment; Portugal; Wildfire

1. INTRODUCTION

Among the most notorious consequences of climate change predicted for Mediterranean Europe is an increase in wildfire risk, an extension of the fire season, and an intensification of extreme events during the fire season, possibly leading to more intense and frequent fires [1], [2]. The Mediterranean region is considered a biodiversity hotspot, and its forests have provided numerous ecosystem services to human societies for millennia [3]. The European Commission acknowledges that the biodiversity crisis and the climate crisis are linked. Climate change accelerates the degradation of the natural world through more extreme climatic events, such as wildfires, while the unsustainable use and loss of nature are drivers of climate change [4]. Within Mediterranean Europe, Portugal has the highest number of wildfires and the second with the larger burnt area [5], having its ecosystems highly impacted by fires.

The Economics of Ecosystems and Biodiversity (TEEB) define ecosystem services as "the direct and indirect contributions of ecosystems to human well-being." One of TEEB's goals is to provide a better understanding of the economic significance of the loss of these services and the consequences of policy inaction on halting biodiversity loss at various scales [6].

In fire-prone landscapes, recognizing the nuanced roles that fire plays in ecosystem services is essential to distinguish the trade-offs amongst people's needs and desires and the sustainability of complex socioecological systems [7]. However, despite the growing literature on the subject, the roles that fire plays in ecosystem services have not yet been thoroughly identified [7]. In this context, the present work aims to identify the wildfire impacts caused to the ecosystem services in Portugal and the policies needed to address them.

2. MATERIALS AND METHODS

A survey was conducted via an electronic form sent to official bodies of wildfire experts. It had an introduction to the questionary and two sections. The first described the respondent in terms of: *Institution* (in which they work); and *Position* (they occupy currently). In the second section, three questions were asked: *From your perspective, which of the following ecosystem services are impacted by wildfires in Portugal in the short-term?*; and *From your perspective, which of the following ecosystem services are impacted by wildfires in Portugal, in the long-term (more than 3 years after the fire)?*. All the 22 TEEB ecosystem services were enumerated following these questions. A Likert scale correlated with each service, from which the respondent had to decide from 0 (no impact) to 5 (severe impact). Lastly, to gain perspective on Portugal's current post-fire policy state, we asked the following question: *From your perspective, is there a lack of policies or guidelines to address the impacts to one of these services? Select as many alternatives as you see fit.* Once again, all 22 TEEB ecosystem services were listed, but for this question "checkboxes" were used, and respondents were instructed to select as many services as they believed were relevant.

3. RESULTS AND DISCUSSION

A total of 12 experts answered the survey. Most of the respondents were practitioners (6), followed by managers (3) and researchers (2). More than half of the respondents work at ICNF (7), which is the main responsible for dealing with post-fire issues.

Regarding the Provisioning services, the survey indicates that the impacts tend to diminish somewhat over time but remain mostly on the side of severe, even three years after the fire. It is noticeable that the impact on the "Raw materials" service is one of the most significant and enduring, with half the respondents believing that the impact is still severe in the long-term.

The Regulating services were overall the most impacted in the short-term, and most experts thought that they improve their condition in the period following the wildfire. As for the Habitat services, most experts signaled that despite being quite severely impacted, they recover a bit in the period after the wildfire. The Cultural & Amenity services have more varied results. For some, the impacts are thought to increase over time; for others, there is an improvement, while a few continue essentially unaltered. Regarding post-fire policies, it can be highlighted that Regulating services seemed to be thought of as the group most in need of specific policies. This is coherent with the fact that this group was perceived as the most impacted by the wildfires, both in the short and long-term.

Despite the focus of this study being on fire impacts, these policies might not necessarily aim at recovering the impacted land. In this sense, European guidelines are shifting their focus from fire suppression to prevention and increasing the awareness and preparedness of populations at risk [8]. Therefore, it would make sense for environmental policy to follow the same trend as it is better to avoid fires and their impacts than mitigate them.

4. CONCLUSION

In Portugal, climate change is noticeable in the form of increasing wildfire occurrences. This study's results indicate that all the 22 TEEB ecosystem services are impacted to various degrees and different lengths of time. The Regulating services were overall the most affected group and presented the most lasting impacts. Not surprisingly, this was also the group of services that are considered to require more remediation policies. Namely, Climate regulation has an important role in this context, as forests help balance carbon cycles [9], which in turn tend to decrease wildfire occurrences. This study helped identify the most notorious wildfire impacts, policy needs, and priorities in the perception of Portuguese fire experts. This information will be further investigated in upcoming studies, and it is valuable for guiding future research in various knowledge fields, aiming to value and protect biodiversity, prevent wildfires, and avoid climate change.

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Are the Energy Literacy, Financial Knowledge, and Education Level Faces of the Same Coin?

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ABSTRACT

Education, financial knowledge, and energy literacy are seen as powerful tools that empower citizens and help them make informed decisions. Considering that both education and financial knowledge are often associated with better levels of energy literacy, we consider it important to check if there are common determinants between these three variables. Using a questionnaire applied to Portuguese university members (students, teachers, and technicians), we also tried to infer whether the factors that influence these variables are common among men and women. The results show that energy knowledge has an influence, not only on the level of energy literacy but also on the level of education and the level of financial knowledge.

Keywords: Education level, Energy literacy, Financial Knowledge, Portugal

1. INTRODUCTION

Climate change, extreme weather phenomena, and the lack of drinkable water in some regions have raised awareness of the need to adopt more sustainable behaviors. Although the bet on renewable energies is already a reality, there is still much more to be done in this sense, as much of the energy produced still comes from fossil fuels. Another way to overcome the problem is through demand management and reducing energy consumption, with simple behaviors, such as turning off the light whenever space is abandoned. However, behavior change is not easy, because most of the daily behaviors, related to energy, are determined by intrinsic habits and executed without much thinking [1].

In this context, education levels, energy literacy, and financial knowledge represent important tools to provide citizens with the necessary information, awareness of the need to change behaviors, and the willingness to actively engage in energy-saving actions. It is therefore important to understand whether levels of education, energy literacy, and financial knowledge depend or not on the same factors.

2. METHODS

Using the questionnaire defined on Martins et al. [2], we seek to verify whether there are common determinants of the level of education, knowledge about energy, financial knowledge, attitude, behavior, and energy literacy. The questionnaire includes multiple-choice questions - 31 to measure energy knowledge and 4 to measure financial knowledge - which were assigned 1 point for each right answer and 0 points for each wrong answer. This also includes questions on the Likert scale - 19 to measure attitude and 11 to measure behavior - to which points from 1 to 5 were assigned depending on whether the answer was less (1) or more (5) suitable for sustainable attitudes and behaviors. In addition, the questionnaire also includes some sociodemographic information such as age, education, responsibility for paying the electricity bill, living in "your own house or a rented house", among others.

Considering that the nature of the dependent variables used, we used the ordered logit model [3] to verify whether there are common determinants between energy literacy, the level of education, and the energy literacy dimensions.

3. RESULTS AND DISCUSSION

Regarding the education level, we found that women tend to have higher levels of education, and the older the age and the higher the energy knowledge, the greater is the likelihood of having a higher level of education. Turning to financial knowledge, we find that women tend to have lower levels of financial knowledge and that age and energy knowledge positively influence the probability of having financial knowledge. Energy literacy is positively influenced by energy knowledge, financial knowledge, attitude, behavior, and also by age.

Then we analyze the differences between the factors that influence education level, financial knowledge, and energy literacy for women and men. Regarding the level of education, the factors that influence it, seem to be the same for both men and women. Financial knowledge seems to be positively influenced by age and the level of energy knowledge in the case of women, while in the case of men it is only influenced by the level of energy knowledge. Finally, and analyzing the factors that influence energy literacy, we find that for both men and women it is positively and significantly influenced by knowledge about energy, attitude, and behavior.

4. CONCLUSION

This paper seeks to verify whether there are common determinants of the level of education, financial knowledge, and energy literacy. Using the ordered logit model, we seek to determine the factors that influence these three variables and additionally explore the differences in the factors that influence these variables for women and men. The results show that energy Knowledge is a common determinant of the level of education, financial knowledge, and energy literacy. Gender is also an important factor, positively influencing the level of education, with women showing higher levels of education, and negatively influencing financial knowledge, with women showing lower levels of financial knowledge. From the analysis of the differences between the factors that influence the level of education, financial knowledge, and energy literacy for men and women, we conclude that age increases the probability of having financial knowledge only in the case of women and that financial knowledge and age increase the likelihood of having energy literacy only in the case of men. According to our results, energy knowledge seems to be fundamental for an individual to have a good energy literacy level, and it is also related to good levels of financial knowledge and higher levels of education. For this reason, we argue that is urgent to invest in energy education at all levels of education, but especially at the lowest levels of education, where children still do not have such ingrained habits.

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E113   **17:18-17:24**

Evaluation of the Environmental Impacts Related to the Wind Farms End-of-Life

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ABSTRACT

In the last decades, the adoption of renewable energy, namely wind source, in Europe, have increased significantly. And it will continue to grow, as part of a strategy to reach the Paris Agreement and the Carbon-neutrality by 2050 goals. Simultaneously, the oldest wind farms are getting into their end-of-life (EoL) and uncertainties regarding the main aspects of the possible scenarios still remain, such as standards procedures, legislation and environmental impacts (emissions, pollution, etc). Regarding the waste management, 85% to 90% of all the components of the wind turbine may be recycled, however the final disposal of the blades represents a unique concern, as this process is not completely well-established. Thus, the environmental impacts and relevant aspects related to the wind project flow may be assessed using the life cycle assessment. Moreover, the environmental study of new projects is a good source to identify possible impacts. Thus, this research aims to identify and analyse the main environmental impacts related to the end-of-life of wind farms scenarios, based on the state of the art and a literature review. Moreover, it gives floor to the discussion regarding the uncertainties about this very important stage, the final disposal of wind farms' components emphasising d the application of the principles of the circular economy.

Keywords: Wind farms; LCA; end-of-life; waste; environmental impacts

1. INTRODUCTION

The use of the wind source may be considered an answer for current environmental concerns as climate change and other negative impacts as pollution [1]. For the horizon of 2021-25, it is expected to install 105 GW of new wind farms. In contrast, in 2020, 388 MW of wind power were decommissioned [2]. For ref. [3], by 2028, waste will become a crucial issue, as the first wind farms are reaching the end-of-life (EoL). In this sense, by 2034, ref. [4] it estimated a generation, around the world, of 225.000 ton of waste blade material and 100.000 ton in Europe per year. In this framework, between 2020 and 2030, it is expected that more than 1.800 offshore wind turbines will require a decision regarding their end-of-life scenarios, which means: refurbishment, repowering or decommissioning.

2. RESULTS AND DISCUSSION

The wind energy is considered a clean source, however, environmental impacts are verified during the life cycle of wind projects, namely in manufacturing, transportation, installation, maintenance and in the EoL [5]. The life cycle assessment (LCA) methodology allows to identify and quantify the potential environmental impacts of a given product or process during its entire life cycle, [6]. Most LCAs emphasize that 78% of the environmental impacts are concentrated in the manufacturing [7].

Regarding the emissions of greenhouse gases (GHG) the construction/installation respond for 67%, followed by the turbine manufacturing (30%) and operation and maintenance (3%) [6].

For ref. [8] some aspects associated with the EoL are not clear, and are partially explored or even omitted in the LCAs. Moreover, the associated environmental impacts are not fully covered regarding the possible scenarios in the EoL. In this setting, waste management is a huge concern in the EoL, as part of the LCAs neglects the possibilities for recycling the components [10]. In this context, for ref [11] the recyclability rate of the wind turbines is 85% to 90% and their recycling processes are well-established [1]. However, the wind blades are a unique challenge due to the materials used in their manufacture, namely, the composite materials to improve their performance [12]. According to ref. [13] the recycling/disposal rate of blades are up to 95%, and the main commercial technique adopted to recycle the produced composite materials is the cement co-processing, which may result in a reduction up to 16 % of the CO output [12]. Another possibility is the replacement of virgin raw materials for new turbine manufacturing. Despite the existence of other available alternatives for the treatment of composite materials, they require advances and industrialisation [11].

As stated in ref. [5], reviewed LCAs of offshore wind farms identified 21 environmental impacts. Most of the studies emphasyse climate change as a considerable impact, which includes the emission of greenhouse gases (CO_2; CH_4 and N_2O, some authors also include SF_6; HFC and PFC). For ref. [1] the environmental impacts may be divided into the following categories: CO_2 emissions; climate change; cumulative energy demand; resource

requirements, abiotic depletion; acidification; stratospheric ozone depletion; human toxicity; particulate matter formation, dust; ecotoxicity; photochemical oxidation (smog); nutrient enrichment, eutrophication; solid waste generation; land use, land transformation; human health endpoint; natural environment endpoint; natural resources endpoint; single score endpoint; non-toxic emissions; toxic emissions.

The EoL may be analysed through a reverse logistics chain [12], and their environmental impacts may be based on the impacts of the installation phase. Therefore, environmental studies for new wind farms projects identified some environmental impacts related to changes in the landscape during the their installation. Thus, these possible impacts should be considered, once they may occur during the EoL associated activities, as well as, specific impacts for each scenario of the EoL.

3. CONCLUSION

Wind energy is considered a "green" source, however, when its entire life cycle is analysed it may be observed relevant environmental impacts, as such: emissions, waste generation and pollution. Thus, based on LCAs, most of these impacts are concentrated on the manufacturing stage, namely due to the material consumption, especially steel for towers. Moreover, the extraction of raw materials, installation and decommissioning have also significant impacts. However, there is a lack of knowledge regarding the EoL and the associated environmental aspects, advantages and disadvantages of the possible scenarios: decommissioning, refurbish and repowering. Furthermore, the decision respecting to the future of turbine components in the EoL, disposal; recycle, remanufacture or reused should consider the contribution of each process in the total embodied energy, costs, available techniques and the socio-environmental impacts. Even, some authors consider that the EoL as a reverse process of installation, and the environmental impacts of installation may be considered the opposite in the EoL, the particularities of the scenarios and the onshore and offshore wind farms will influence the impacts.

Therefore, for future works, the environmental impacts related to the end-of-life of wind farms will be more detailed for each scenario, Furthermore, the lack of environmental regulatory legislation and standardization for these scenarios will also be explored in future research.

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Integrated Life Cycle Assessment of A South European House Addressing Different Design, Construction Solutions, Operational Patterns, and Heating Systems

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ABSTRACT

Building industry and buildings are responsible for a considerable share of energy consumption, material resource use, and waste generation. To understand the overall influence of different building construction and operational parameters, life cycle assessment (LCA) has been applied to study buildings under different scenarios. This study aims to comparatively assess the relevance of alternative designs, building envelopes and operational conditions in the life cycle energy of a south European single-family house located in Portugal. Alternative building conditions are parametrically evaluated: location, orientation, building shape, windows placement and sizing, insulation level, exterior wall construction, operational pattern, ventilation level, heating system, and end-of-life scenarios. Non-renewable primary energy (NRPE) results are presented for the total life cycle of the house. Afterward, the house embodied energy is presented per building component to assess how significant the assumed building components are in terms of initial and recurrent embodied impacts, and different circular economy end-of-life scenarios are analysed to assess their potential benefits. As buildings are typically unique, complex and difficult to compare with each other, the results of this paper will contribute for future comparison purposes, in order to foster LCA studies devoted to Mediterranean houses.

Keywords: End-of-life, LCA, Life cycle, Mediterranean house, Parametric study, Primary energy.

1. INTRODUCTION

Life cycle assessment (LCA) can be used to quantify the environmental burdens of buildings and/or building options during several phases of their life cycle (LC) and support overall improvements: from material extraction, processing, building construction and use, till their end-of-life (EoL). In the last years, priority has been given to reduce buildings' operation energy demand. However, this trend is shifting, since reducing the operational impact, may boost the relative impacts of construction and EoL phases. On the other hand, the massive volume of Construction and Demolition Waste (C&DW) calls for the need of converting building EoL materials into more sustainable innovative value-added products and a more circular economy approach.

The main goal of this study is to compare the impact of alternative designs, building envelopes and operational conditions in the LC energy of a south European single-family house located in Portugal. For that purpose, some data published by the authors (devoted to the same house) and scattered in the literature was compiled, comparatively analysed and discussed in this article [1]–[4]. Indeed, the alternative parameters were evaluated: location, building orientation, building shape, window placement and sizing, insulation level, exterior wall typology, operational pattern, ventilation level, heating system, and end-of-life scenario. Afterward, the house embodied energy is presented per building component to assess how significant the assumed building components are in terms of initial and recurrent embodied impact and the potential benefits of different circular economy end-of-life scenarios are evaluated.

2. MATERIALS AND METHODS

A detached south European house was taken as case study, based on previous research [1]–[4]. The building, which follows the Portuguese household building stock characteristics, is occupied by a 4-people family. Fig. 1 shows the east and west (front) facades the house. Following the life cycle assessment (LCA) methodology (ISO 14040/14044), attributional LCA studies have been performed, for the following functional unit: a single-family house building with 133 m^2 of living area and a 50-year life span. Aiming to comparatively analyse the LC influence of building options at different levels, the parameters considered in this parametric study are based on previous research and include: eight building orientations, two windows placement, four window sizes or window-to-wall ratio, three building shapes (compact base case, one-floor terraced house, and a two floor less compact house) [4], three exterior wall constructions (double hollow brick masonry, lightweight concrete block masonry, and wooden wall), five insulation thickness (0, 3, 6, 9 and 12 cm), six insulation materials [3], three different operational patterns, six locations [5], four heating systems (resistance heaters, heat pump, natural gas condensing boiler and wood pellets boiler) and three electricity generation mix scenarios [2]. All the information required for the LC inventory, embodied energy of production, transport, construction (A1-A5), maintenance (B3-B4), and model simplifications are presented in refs. [1]–[4]. Lastly, to assess the EoL stage impact, three

EoL scenarios for C&DW were modelled: EoL1 (landfill); EoL 2 (material recycling for secondary construction works replacing gravel and backfilling materials); EoL 3 (material recycling to substitute both gravel/backfilling materials (50%) and cement powders (50%), and window and door elements recovery and reuse).

3. RESULTS AND DISCUSSION

Assuming the base case (0.6 ac/h and 6 cm XPS insulation), a lower ventilation level (air-tight building: 0.3 ac/h), especially during winter, has more influence to reduce the operational NRPE, than a higher thermal insulation thickness. High ventilation levels (for instance due to users) can easily undo the thermal insulation benefit. The results suggest that simple design options (window sizing, orientation, and building shape) are as significant as the envelope construction options and therefore should be simultaneously addressed. LC results are also very sensitive to operational conditions: different forms to inhabit a house (operational patterns), energy systems, and their supply chain. In countries with mild climatic conditions and culturally low operational patterns, it is important to plan for plausible operational scenarios addressing the user behavior variability. Regarding EoL, results showm that, recycling may avoids the extraction of primary materials (such as gravel and backfilling material), offsetting significant primary energy (i.e., a net reduction of 16% of A1-A5 in EoL 2 and 64% in EoL 3).

4. CONCLUSION

This study comparatively assessed the impact of alternative design options, building envelope solutions and operational conditions in the LC energy of a south European single-family house located in Portugal. It is concluded that in mild Mediterranean climate, the embodied energy of construction elements (e.g. concrete structure, slabs, brick exterior and interior walls) may represent most of LC NRPE of houses. The results suggest that design options are as significant as the envelope construction options and therefore should be simultaneously addressed. C&DW represent massive waste flows. The EoL scenarios assessed showed that new circular economy solutions, namely focused in dismantling and reuse building components (e.g., doors and windows) and to produce secondary aggregates and powders from C&DW to replace burdensome primary materials (e.g. cement) can promote material resource efficiency and reduce the embodied energy levels of future built environment and construction works.

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E129   **17:30-17:36**

8-Stroke Low Heat Rejection Engine

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ABSTRACT

In a combustion engine, 25% of the energy present in the fuel is wasted as heat; this heat is dissipated to avoid overheating and prevent damages. This article presented a simulation work developed to study an internal combustion engine with a low heat rejection index. The engine is based on a 4-stroke cycle, but it reduces engine heat losses by extracting the heat absorbed by the walls during combustion and gas expansion; this reduces the need to dissipate heat through the cooling system. The engine can obtain more of the heat energy produced by the fuel than in conventional machines. This engine also works at higher temperatures than usual engines, thus promoting better combustion and emissions. Theoretical foundation and results obtained from a computational simulation are presented in this work.

Keywords: Angular-velocity; Crank-angle; Cylinder-pressure; Inertia; Instantaneous-velocity; Torque;

1. INTRODUCTION

Internal combustion engines are machines characterized by their ability to convert the energy contained in the fuel into mechanical energy delivered to the mechanical transmission, our electric generator system.

Throughout the energy conversion process, the fresh air on Diesel engines or air/fuel mixture on Otto engines is compressed to improve combustion and remove the maximum efficiency of the fuel in the mixture.

During the compression time, on Otto engine the pressure retained inside the cylinder can increase from the atmospheric pressure to a pressure inside the cylinder 20 times higher and temperatures quickly go from 288 K to 1050 K. These pressure-increasing capabilities are due to the compression ratio of the engine and the temperature of the cylinder walls temperature [1].

In an internal combustion engine, the energy resulting from fuel combustion in the engine is divided into 40% to exhaust gas enthalpy, 25% heat transfer, 10% mechanical losses, and only 25% is positive work obtained on crankshaft [2].

This work has as aim reduce the 25% of heat that is lost in heat transfer essentially for cooling system that which represents heat fluxes to the chamber walls in order of 10MW/m2 during the combustion stroke [1].

2. CONCEPT

Internal combustion engine sees the increase in the temperature limited by the building materials of the engine itself, which leads to the need to dissipate the excess heat absorbed by the engine through the cooling system.

This heat dissipation lowers the temperature of the engine walls, which not only translates into less heat convection in the direction of the walls for the mixture but also at the moment after combustion, the convection occurs in the opposite direction, removing energy from the expansion, which will be dissipated in the engine's cooling system.

There is also another phenomenon associated with the low temperature of the cylinder walls; this is the extinction of the flame front when it comes into contact with the cylinder walls, which is at a much lower temperature than that of the flame front. This phenomenon results in incomplete combustion of the fuel [3].

In this sense, several works are carried out in order to reduce heat losses by internal combustion engines using ceramic materials in the construction of these; the introduction of this type of material allows reaching temperatures inside the cylinder 5 times higher than the temperatures currently reached in the engines, which is transmitted in an improved efficiency that can be up to 12% higher [4,5].

The 8-stroke cycle is based on the 4-stroke cycle with the original crank road system, but with the use of what we call the 8-stroke cycle, it is possible to use better the heat produced by combustion. The use of this heat occurs with the suppression of the engine's cooling system; after suppressing it, it is necessary to adjust the engine temperature; this is where the engine concept 8-stroke comes in. The operation of the 8-stroke engine can be divided into two distinct phases, a first phase in which the engine follows the 4-strokes cycle in a regular way, in a second phase, the engine performs the same 4-strokes, but this does not admit fuel in the admission stroke, admitting only fresh air; the entry of this fresh air will allow significant convection of the cylinder walls to the air due to the significant temperature difference between the walls and the air trapped on the cylinder, this

convection will allow not only to lower the temperature of the walls, acting as a cooling system that as previously adapted to dissipate less heat but also to increase the temperature of the air and consequently its pressure, which in the second expansion contribute with positive work.
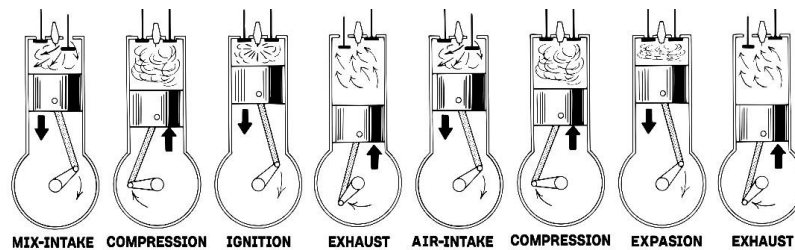
Fig. 1. 8-stroke working diagram.

3. RESULSTS DISCUSSION AND CONCLUSION

In order to prove the 8 stroke concept and the gains obtained with the introduction of these cycles, computational modeling was carried out; this modeling consists of two programs capable of simulating the 4-stroke combustion engine and the 8-stroke combustion engine.

The results obtained are in accordance with the concept introduced; through the simulation, it is possible to observe that the total heat loss decreases with the increase in the temperature of the walls, which would be expected due to the more significant gradient between the walls and the admitted air that will promote the heat flux.
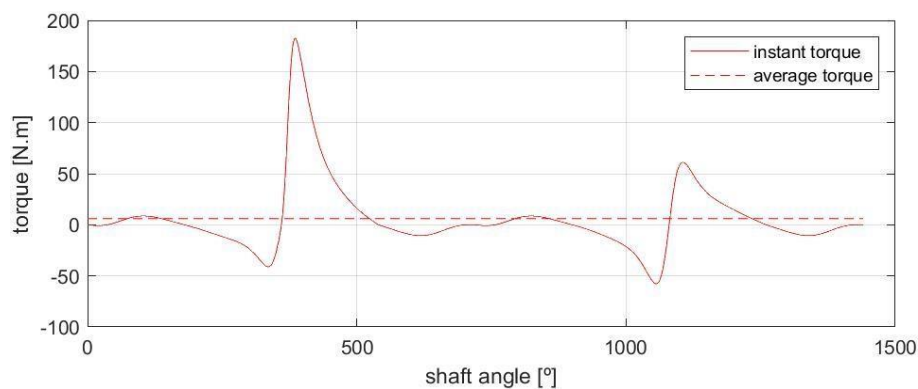
Fig. 2. Torque along crankshaft angle for 8 stroke cycle

Through the graph of the torque of the 8-stroke cycle, it is possible to observe the second expansion where it is visible that the torque produced is greater than that necessary for air compression, which proves that there is heat reabsorption by the air and consequently an increased pressure.After this works it is possible to see that without this type of coating with temperatures easily supported by usual materials, it is possible to reduce the heat losses of the engine by only 5% instead of the initial 20% and, consequently, increase the efficiency.

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A Biochemical Methane Potential of Pig Slurry

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ABSTRACT

This study assesses the methane production potential for the Anaerobic Digestion, using pig slurry as substrate at 8 % TS for two different Substrate to Inoculum Ratios, 0.65 and 1. The experimental and theoretical methane production, the Specific Biogas Production, the Specific Methane Production, and the average methane content were determined for both experiments and adjusted to Standard Temperature (273.15 K) and Pressure (1 atm). The experimental values were then compared with the theoretical prediction. The results show that the experience conducted with a SIR of 1 produced more volume of biogas, with higher methane content than the one with the lower SIR. With a SIR of 1.0, it was achieved a SMP of 0.568 NL CH_4/g VS with an average methane content of 83%, with a Technical Digestion Time of 12 days. By comparing the experimental BMP with the estimated value of 0.623 NL CH_4/g VS, it was possible to conclude that the estimated value presented a deviation of just 2.96 % during the assay with a SIR of 1.

Keywords: Anaerobic digestion; Biochemical methane potential; Circular economy; Methane production; Pig slurry; Theoretical methane prediction.

1. INTRODUCTION

Anaerobic Digestion (AD) is the most common wastewater treatment applied to manure management. AD converts organic matter into energy and reduces pollutant gas emissions. With this procedure, it is also possible to convert the agriculture and organic by-products into fertilizer, fuel, or electricity, finding a place in the circular economy and reducing the environmental impact [1].

Biochemical Methane Potential (BMP) measures the sample biodegradability. Therefore, these assays are employed to understand and analyze parameters such as pH, agitation, temperature, inoculum substrate ratio, among others, and how they impact the maximum methane production for a given substrate [2]. For the BMP tests, a substrate is mixed with an anaerobic bacteria culture, generally from an active digester. This mixture is incubated under mesophilic conditions and continuously mixed over consecutive days until the achieved methane production is lower than 1% [3]. During the incubation period, the volume of biogas produced is measured as well as the methane content. Theoretical methods for predicting the BMP are fast and straightforward to implement. For this, it is assumed that the substrate is completely degraded [4]. Additionally, it is necessary to address that the accuracy of this method relies on the biodegradable fraction of the substrate composition. The Specific Biogas Production (SBP) and the Specific Methane Production (SMP) are tools used to evaluate the BMP assay. The first is described as the volume of biogas produced per VS mass fed to the reactor and the second one is the volume of methane produced per VS mass fed to the reactor. When the SBP and the SMP have similar values, the biogas produced has a higher methane concentration. The analysis of the SMP curve of any BMP essay should describe a similar behavior of other SMP curves for different substrates [5]. The purpose of this study is to establish the best SIR conditions for pig slurry AD.

2. MATERIALS AND METHODS

The substrate used in this study was Pig Manure (PM), collected from a pig farm placed in the central region of Portugal. Anaerobic sludge from the anaerobic digester of a municipal wastewater treatment plant was used as inoculum. The experimental procedure was conducted in the AD Reactor located at Instituto Superior de Engenharia de Coimbra. The substrate and inoculum analytical analysis were performed according to the Standard Methods [6]. The Methane content was evaluated using the Absorption of CO_2 in the alkaline liquid method proposed by Abdel-Hadi (2008). The measured biogas and methane volumes were adjusted to Standard Temperature (273.15 K) and Pressure (1 atm). The elementary molecular analysis was conducted on the equipment Fisons Instruments, model EA1108. In this study, BMP was determined by employing experimental data and theoretical prediction, with Elemental Composition, Chemical Composition, and Chemical Oxygen Demand of biomass being applied to estimate the theoretical BMP of the substrate.

3. RESULTS AND DISCUSSION

For the first BMP assay (BMP1), the SIR was set at 0.65 for a working reactor volume of 8.6 L. In the second BMP assay (BMP2), a SIR of 1 and a working volume of 14.25 L were used. The temperature was maintained at 36 ± 1ºC and the stirring at 8 rpm. On day one, BMP1 biogas production reached a maximum output of 1.60 NL representing 1.39 NL CH_4. From this point forward, the biogas production decreased until day 10, with biogas production ceasing with the experiment being stopped on day 20. Regarding the BMP2, the biogas production started slower than for BMP1, reaching the maximum biogas production on day 4 with 1.99 NL with a CH_4 of 1.75 NL. After day four, biogas production decreased until day 18, producing just about the same volume every day until day 24. On day 25, the biogas production stops, and the experiment was terminated on day 30.

Comparing the results of both tests, BMP2 produced better results than BMP1. For the first assay, the SBP was 0.410 NL/g VS and the SMP of 0.329 NL CH_4/g VS. The average methane content during the assay was $79.0 \pm 3.2\%$. In BMP2, it was possible to achieve an SBP of 0.675 NL/g VS, and SMP of 0.568 NL CH_4/g VS. The average methane content during this assay was 82.8 ± 3.2 %. Therefore, the percentage of methane produced on BMP2 was, on average, 3.8 % higher since the ratio of substrate to inoculum was higher than in BMP1. For the BMP2, the TDT was reached between days 12 and 16, when 77.9 % and 91 % of the total biogas production was achieved. In the first experiment, the TDT is between days 5 and 7, when 76.6 % and 89.6 % of the total biogas is produced.

The prediction of theoretical maximum methane potential allows to conclude that the BMP2 consumes higher amounts of the substrate when compared with BMP1. Therefore, using a SIR of 1, the performance of the AD will be optimized, and the maximum methane that it is possible to achieve from this substrate will be attained.

4. CONCLUSION

The BMP2, in which a higher SIR was used (1.0), produced better results than BMP1 (SIR 0.65). It was registered an increase of 60.6 % for the SBP, and the SMP improved by about 62.7%, with the average methane content increasing from 79.0 to 82.8 %.

The technical digestion time was found to be 5-7 days for the first assay and 12-16 days for the second one. These numbers can be a reference of HRT for future work with similar conditions. The results obtained in BMP2 were much closer to the theoretical predictions of BMP, indicating that with a SIR of 1.0 the amount of substrate added to the digester was enough to achieve a methane production closer to the theoretically attainable value.

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A Proposed Roadmap for Delivering Zero Carbon Fishery Ports

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ABSTRACT

Seaports are facing increased pressures to reduce their carbon footprint, while increasing their energy efficiency and global competitiveness. Moreover, energy consumption in seaports is continuously monitored to manage the increasing energy costs, which is reflected in the increased fuel demand. As the fishing industry is one of the most energy intensive activity of seaports, studies have reported that the global human consumption of fish increased dramatically from 1950 to 2012. This paper will develop and propose a roadmap to convert fishing ports into carbon-free ports through a number of techniques and methodologies involving analysis of energy consumption in the port and buildings and sustainability informed decision making. The overall objective of the net zero port is to reduce energy dependence from national grid by taking advantage of the electricity produced locally from solar energy. The developed roadmap will contribute to the emergence of carbon-free fishery ports ecosystem that implement sustainable energy practices including assessement of the quality of the energy used in the fishery port with informed practices for promoting carbon-free societies.

Keywords: Digitalisation; Energy audit; Renewable Energy; Simulation; Zero Carbon Port

1. INTRODUCTION

Many countries economies are based on trade through maritime transport, as about 80 % of the total global trade volume crosses through the seas (1). The main role played by maritime trade in the shipping and shipping operations in addressing society's demands for basic and secondary commodities is essential to realise (2). However, Maritime activities in recent years have contributed to adverse environmental effects, leading to an increase in the percentage of carbon emissions in ports and coastal cities directly affected by the increase in population numbers and economic growth in developed countries and the rise in supply and demand The fishing industry is one of the main activities of seaports with a proportion of fish processed world-wide increasing from 20 million tons to more than 136 million tons, which adds pressure for fish processing industries to change its energy practices around fish processing operations (3, 4). This study proposes a roadmap for decarbonizing fishery ports by proposing a micro-grid approach that optimizes energy production and consumption based on various energy demand patterns. The methodology has been applied in the Milford Haven Port using smart grid technologies to reduce the costs and carbon impact of electricity systems. The proposed roadmap plan as shown in Figure 1, consists of five stages from energy auditing, developing energy simulation models, micro-grid model, energy sharing with local community to real time decision-making.

2. KEY ROADMAP STAGES FOR NEARLY ZERO CARBON FISHERY PORTS

The development and implementation of a net zero roadmap aims to convert fishing ports into carbon-free ports through several techniques and methodologies. The process begins by conducting an audit of the fishery port's energy systems to understand the parameters of consumption at the port level. The second stage involves the development of a simulation model for energy analysis as to understand the energy consumption patterns and reduce time necessary in a real-life investigation of the energy usage. Energy analysis will inform the development of a micro-grid model used to determine the capability of the site to optimize the local energy demand. The fourth step identifies a process of expanding toward an energy community around the fishery port and to enhance the potential of the micro-grid to meet the energy needs of the port and the surrounding assetts by taking advantage of the port-owned renewable energy sources. After the completion of the analysis including the micro-grid system and identification of an optimum for the energy network to achieve local energy sustainability at the port level, the control systems within the network are developed and optimized. These strategies can significantly improve the efficiency of the energy systems and optimize the utilization of locally produced solar energy.
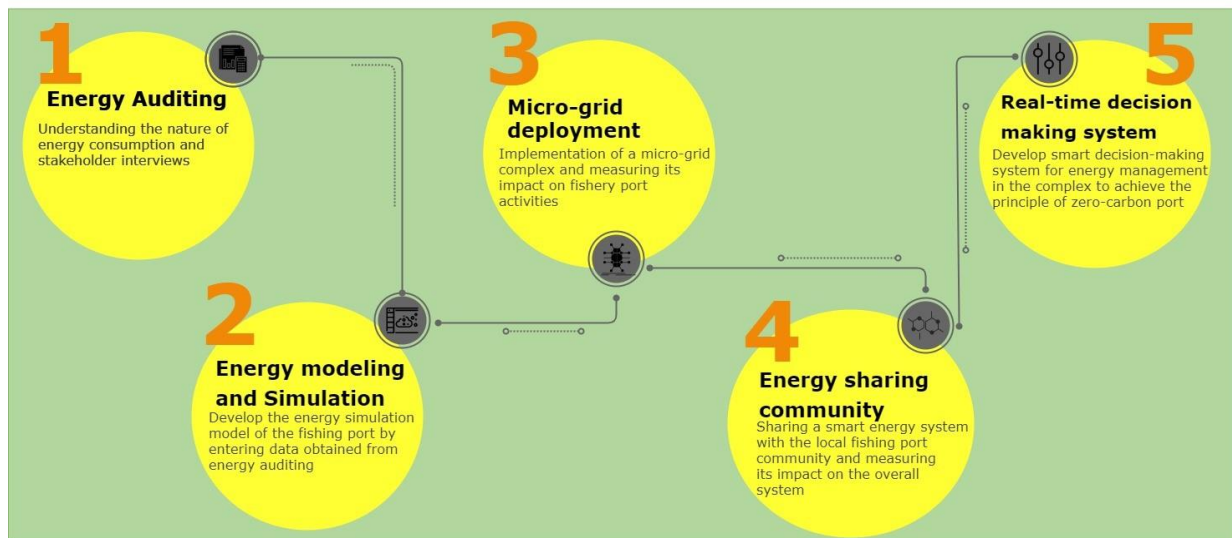
Figure 3: Proposed roadmap for delivering a zero-carbon fishery port with an energy community.

The digitalization of industries as facilitated by recent ICT developments can increase the competitiveness, quality and innovation of industrial services and deliver a higher order of efficiency for the entire lifecycle of the industrial sector. The proposed smart port concept can promote the adoption of smart technologies such as Machine Learning (ML), Internet of Things (IoT) and Blockchain and lead to the development of a fishery port digital twin. Such digital twins contain digital replicas of physical assets and have the ability to orchestrate various resources, services and operations identified at the port level using near real-time simulation and optimization algorithms. The zero-carbon vision for ports represents a step forward in the process of industrial transformation with potential to unlock energy services and enable transactions in a circular and sharing economy context.

3. CONCLUSION

The proposed roadmap aims to facilitate the transformation of fishery ports into smarter, greener, sustainable, and less environmentally damaging ports. The identified roadmap stages require an understanding of the nature of energy consumption at the fishery port level by adopting smart energy technologies such as smart grid and distributed generation. The proposed roadmap aims to support the decarbonization of ports with inclusion of renewable energy resources and smart energy management systems. We argue that carbon-free ports need to prioritize the quality of the energy used in the fishery port and the surrounding community while enhancing access to sustainable clean energy and a carbon-free society.

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Examining in Mibel Market the Effect of Quantities Offered by Hydraulic, Renewable, Non-Renewable Sources and Thermal Technologies on Electricity Prices through An Adrl Approach

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ABSTRACT

The aim of this article is to analyze and empirically validate the differential effects in the daily schedules of the induced electricity prices by selling bids for three different technologies, namely Hydraulic, Thermal and Renewable Energy Sources, in hourly values, by daily observations for the year of 2018. For achieving this objective, we employ an autoregressive distributed lag (ARDL) model bound testing approach. The results of the ADRL-ECM method, which also reports the long run analysis, show that (a) the Renewable and Thermal technologies positively and significantly affect the electricity price for Endesa and Hidroelétrica del Cantábrico Generators and (b) the Hydraulic technology impacts negatively the electricity price, both at a 1% level of significance. Other important results that must be highlighted in the in long–run are the ones reported by the Renewable sources that show, with a 1% level of significance, a negative impact on the electricity price, for the Generators Iberdrola, E. ON Energy, Union Fenosa and EDP Energy of Portugal. However, in the short run, the results report a positive effect, at 1% level of significance, between the quantities traded by Hydraulic and Thermal technologies on the electricity price for Endesa, Iberdrola, Hidroelétrica del Cantábrico and EDP Energy of Portugal.

Keywords: Electricity Price, Iberian Electricity Market, Hidraulic Technology, Quantities Offered, Renewable Energy Sources, Thermal technology..

1. INTRODUCTION

The MIBEL market of electricity is composed by certain important characteristics such as volatility and connection to seasonal cycles. For instance, the wholesale market pricing presents a slight degree of non-constant volatility and a strong connection to the seasonal cycle. The mean reversion level, which is connected to the seasonal cycle, is mainly affected by the process by which prices return to the initial seasonal level, after fluctuations have occurred [1]. Traditional and new technology influences the offers in wholesale market by electricity generators/producers. For example, although hydro electrical power plants can be started and stopped in order to adapt to outputs levels almost instantaneously, thermal plants are quite inflexible as start-up and shut-down costs are higher than those of hydro electrical power plants [2,3]. Moreover, while hydro electrical plants are intrinsically dynamic, thermal plants are intrinsically static as coal or gas consumed in a given period does not affect electricity production in subsequence periods [2]. If the characteristics of structured MIBEL market, where the market players are supposed to coordinate strategically among themselves, help players to immediately detect price divergences then, according Zalzar et al. [4], the low interconnection capacity in Spain and Portugal with the electricity markets from France and Germany may be contributing to the convergence of electricity prices on the day-ahead and intraday markets. According to Macedo et al. [5], in the MIBEL market, the penetration of Renewable Energy Sources (RES) has resulted in a decrease of the equilibrium wholesale price. Several authors [6,7,8], among others, explain the behavior of the decreasing electricity prices, which can consequently create repercussions for generators of conventional Hidraulic and Thermal electricity power plants, while for Renewable energy sources stakeholders and investors, could be an reducing electricity price value [9]. Accordingly, the main objective of this research is to analyze and validate the differential effects in the daily schedules of the induced electricity prices by selling bids for technology in the year of 2018.

2. MATERIALS AND METHODS

For achieving the main objective of this analysis, we employ an ARDL model bound testing approach. To run the ARDL analysis, we then need to satisfy the assumption that is normally related with the employment of the ARDL bounds testing approach of cointegration, meaning that each variable must be integrated in order zero or order one, hence I(0) or I(1). Unlike other papers found in literature, this study tests for structural breaks when examining the short-run and long-run relationships between electricity wholesale price and quantities offered by hydraulic, thermal and renewable energy technology sources, by daily observations for the year of 2018.

3. RESULTS AND DISCUSSION

The results of the ADRL are also shown in table 4, for Endesa, Iberdrola, Hidroelétrica del Cantábrico and EDP Generators, showing a positive effect at 1% level of significance, between the quantities traded by Hydraulic and Thermal technologies on the electricity price, in the short run. On other side, the special regime technology (renewable sources) shows a negative impact on the electricity price, with a level of significance of 1%. However, when the E. ON Energy Generator is considered, all three technologies evaluated show a positive and significant effect on the electricity price. In the long-run analysis, the results for Endesa and Hidroelétrica del Cantábrico show a positive and significant effect for the Renewable and Thermal technologies on the electricity price; while the Hydraulic technology shows a negative impact on the electricity price, both with a 1% level of significance. Other important results that must be highlighted in the in long-run are the results reported by the Renewable technology for the companies Iberdrola, E. ON Energy, Union Fenosa and EDP, which show with a level of significance of 1% a negative statistical impact on the electricity price.

4. CONCLUSION

The aim of this paper was to analyze and evaluate quantitatively the relationship between quantities offers by hydraulic, thermal and special regime with renewable technological sources in the MIBEL market during all hourly day of 2018 year. Considering the importance of our results using the ADRL techniques, and the expected signals and estimates for explaning the relationship between wholesale electricity price and quantities offered by type of technologies, in this specific electricity market (MIBEL), is is possible to understand how the integration of the special technologies as renewable energy sources in alignment with others traditional technologies, such as hydraulic and thermal, affects the price dynamics of these daily market, both in the short-and long-run analysis. For a deeper understanding of the empirical evidence of our results, and in accordance with commitment to some policies, see the EU Directive 2009/28/EC on the promotion of the use of electricity to produce energy from renewable sources.

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Session 8A - Sustainable Buildings
08:30-09:30 @ Meeting ID: 948 1336 4454

E038	8:30-8:45

Lessons Learned from PCM Embedded Radiant Chilled Ceiling Experiments in Melbourne

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ABSTRACT

Buildings are responsible for over a third of energy consumption worldwide, particularly for the increasing demand of air-conditioners in response to the more extreme heat around the globe. It is imperative to move towards more energy-efficient space cooling alternatives. The integration of phase change material (PCM) with a radiant chilled ceiling (RCC) is a promising technology due to its benefits regarding energy efficiency and indoor environmental quality. This article presents a field study conducted on a newly-developed PCM embedded radiant chilled ceiling (PCM-RCC) installed in a stand-alone cabin located in Melbourne. The study evaluates the thermal and energy performance of the system through investigation of the transient thermal behaviour of PCM panels in charging-discharging cycles, the indoor comfort conditions, and the electricity peak demand. It was observed that the proposed PCM-RCC can provide satisfactory comfort conditions and contribute to load shifting if a refined operating strategy is applied. The efficiency of PCM recharge overnight depends on several factors that need to be carefully considered in design. The challenges related to the implementation of optimal operating dynamic schedules in response to the thermal behaviour of PCM-RCC, and accurate weather forecasting should be addressed to realise the full potential of this technology.

Keywords: Chilled Ceiling; Energy Efficiency; Experiment; Phase Change Material (PCM); Radiant Cooling; Thermal Comfort

1. INTRODUCTION

2020 was recently ranked as the world's second-hottest year on record, closely behind 2016 [1]. The global climate continues to warm due to the extra heat-trapping greenhouse gas emissions caused by human activities and the upsurge in global energy consumption [2]. As the world keeps getting warmer, a range of changes on the human's routine life is come through. Focusing on the IAQ-related impacts, the more extreme heat affects the occupants' comfort level and stimulates unprecedented demand for space cooling. As the data indicate, buildings account for more than a third of final energy consumption worldwide, particularly due to the increasing demand for air-conditioners (ACs). 1.6 billion ACs are already installed worldwide and it could jump to around 5 billion units by 2050, becoming one of the main drivers of global energy demand [3]. To put this "cold crunch" on a sustainable path, more energy-efficient cooling technologies together with energy demand flexibility strategies are greatly appreciated. The PCM embedded radiant chilled ceiling (PCM-RCC), owing to its potentials in energy savings, peak load shifting, and thermal comfort establishment, has been introduced as a sustainable cooling technology [4,5].

In this study, the operation and thermal-energy performance of a newly-developed PCM-RCC system were experimentally evaluated in a real-scale condition. The research aimed to figure out 1) the transient thermal behaviour of PCM panels and the heat transfer rates in both charge and discharge cycles, 2) the indoor comfort level provided by the system, and 3) the amount of energy consumed for PCM recharge overnight.

2. MATERIALS AND METHODS

In PCM-RCC, PCM absorbs the indoor sensible heat during the daytime and starts melting. Overnight, the chilled water circulating through the panels rejects the PCM heat and force it to solidify.

Here, the experiments were performed on a stand-alone test cabin equipped with a PCM-RCC system (Fig. 4, left), in which shape-stabilised organic PCM boards with the phase change range of 15–20 ˚C and latent heat capacity of 900 kJ/m^2 were utilised (Fig. 4, right). The cabin was also equipped with multiple sensors to measure various parameters required for PCM-RCC performance evaluation. All measured data were then imported to the developed data portal for visualisation and further analyses.

Fig. 4 The test cabin at the University of Melbourne (left), and PCM ceiling panels with capillary tubes (right)

3. RESULTS AND DISCUSSION

Based on the measured data, after a 6-hour night-time recharge cycle on the first day, the panel temperature reached about 15 °C. The positive values of heat flux during the daytime confirms that the ceiling panels gradually absorbed the indoor heat while PCM was melting. Closely before 17:00, the melting phase of PCM in panels located near the façade was almost ended. For panels along the south wall, PCM remained active until around 20:00. The heat transfer rate was then decreased with a steeper slope.

Due to this accumulated heat in the cabin at the end of the first day, it was predicted that with the same night-time schedule, the fully-recharged panels cannot be achieved the next morning. Hence, a longer recharge cycle was set for the second and third days. An operating strategy for peak design conditions was also defined to preserve more cooling capacity for the peak demand period.

According to ISO 7730:2005 and also assuming the occupancy hours of 9:00–17:00, it was observed that the installed PCM-RCC can maintain indoor comfort mostly within Class C (24.5 ± 2.5 °C). The measured relative humidity during the occupancy hours was 54 ± 5% for all three days, which is in the range of what ASHRAE 62-2001 recommends for a comfortable range. Also, the vertical temperature between 0.1 m and 1.7 m was always found lower than 2 °C, as ISO 7730 defines within Class A.

Regarding the total energy consumption, the system utilised about 70% of the daily energy usage outside of the peak period (15:00–21:00 weekdays in Victoria). PCM-RCC ability in peak load shifting can be further improved if a more refined, flexible control strategy is employed.

4. CONCLUSION

The system showed satisfactory performance in terms of thermal energy storage to meet the peak cooling demand during the daytime. Typically, 6–8 hours of recharge cycle seems to be sufficient if no over-heating occurs before midnight. The low heat transfer rate of water capillary tubes and the lack of full thermal contact between PCM and the tubes are identified as the main issues of the current panel design. Overall, an optimal operating and control strategy in response to the transient thermal behaviour of PCM, the indoor environment, and the weather condition should be implemented to realise the full potential of this technology.

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E013   **8:45-9:00**

Hybrid Nanogrids Development to Improve Residential Reliability and Resiliency Supply: Testing and Implementation

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ABSTRACT

Nanogrids would become a relevant concept during the COVID-19 pandemic since everyone has to do all their activities at home. This paper proposes a new topology of hybrid nanogrids called "Dual Power Nanogrids" to improve the reliability and resiliency supply in residential sector. In this system, the voltage is divided into two parts, first is the AC voltage which is supplied through an inverter 230 VAC to feed the motor / inductive loads, and the second one is DC voltage through a DC-DC converter with an output voltage of 230 VDC to supply the SMPS (switch load power supply). The PLC-IoT is embedded to the system to anticipate fault conditions. At the DC side, the voltage remains stable at the 230 VDC during dynamic loads condition. During transition from DC to AC, the system could recover the voltage stability in 2 seconds. Furthermore, during the serial failure at the DC-DC converter and utility grid supply, the voltage is stable, and the load still run properly. The role of battery is strategic as a last source against the various disturbance. The Dual Power nanogrid could guarantee the power reliability and resiliency when the blackout occurred in the utility grid.

Keywo rds: Nanogrids; Battery; Household Appliances; DC-DC Converter; power outage; resilience

1. INTRODUCTION

The Nanogrids system utilize the distributed generators that allow house to produce electricity independently. This is useful for reducing utility grid electricity bills when electricity demand increases, especially in the conditions of the COVID-19 pandemic since everyone must carry out their activities at home to avoid their spread [1]. The electrical power systems are not only considering the reliability but also resilience. Resilience is a hot topic discussed considering natural disasters that often cause damage to the power system [2]. Microgrids that have a variety of local generators such as photovoltaic, microturbine, diesel generator sets, or energy storage are considered capable of recovering faster when outages occur. Nanogrid, which is a small scale microgrid, can be more resistant to extreme conditions so that it can increase the resilience ability of the power system [3].

In this paper, a new concept of a hybrid nanogrid called Dual Power Nanogrids which uses AC and DC power sources to supply the loadThe DC source is considered as the main source in supplying the load while the AC source becomes a back-up when the DC source got outage.

This nanogrid is expected to improve the reliability and resiliency supply in residential by relying on the local generation. The reinforcement system to enhance the resiliency is not only being proposed by this nanogrid but also the strategy to cope with the extreme event by equipping them with the intelligent system based on PLC-IoT.

2. MATERIALS AND METHODS

The experiment tried to test the performance of dual power nanogrid resiliency under the power outage scenario as seen in figure 10. The SMPS load (electric stove) is supplied through DCON as the main priority source (number 1-red line), then the DCON has a fault which leads the PLC to order the utility grid to supply the power to the electric stove immediately (number 2-blue line). Furthermore, the utility grid gets the power outage that make the load is automatically taken over by the bidirectional inverter that connected to the battery (number 3-orange line).

3. RESULTS AND DISCUSSION

When the DC-DC converter (DCON) has a fault, that makes the DC voltage and its power drops to zero (see figure 6a and 6c). Then the PLC immediately shift the contactor to change the voltage from DC to AC which is delivered by the utility grid. However, the load has power outage because the system changes to operate under AC voltage. This occurs due to the difference's characteristics between the DC and AC. The load can be reenergized by the utility grid voltage within 2 seconds after a power outage.

In the next scenario, the utility grid has a fault that not possible to supply the load at 90th seconds, then the bidirectional inverter automatically replaced the utility grid role. As seen in figure 12b, the voltage down to 203 VAC or around 7.7% voltage drop, the power consumption also decreased to 787 W (see figure 6d). The voltage drop in this experiment is not a crucial problem because it is still in the limit. The load still operated even there was a change of operation from the utility grid to the bidirectional inverter.

4. CONCLUSION

The proposed Dual Power Nanogrids is proven for two years of operation to supply the AC and SMPS load. The advantage of a 230 VDC voltage system can reduce the electricity conversion stages through AC voltage as implemented in inverters. The output voltage of the DC-DC converter is proven to be applied for household appliances that generally operate at DC voltage so that this system can be more efficient than an AC system. The intelligent PLC-IoT system can anticipate the system to face the fault conditions. Two power outage scenarios are addressed to test the system resilience. The voltage remains constant or stable at the 230 VDC during dynamic loads condition. The Dual Power Nanogrid could recover the system stability when the utility grid got blackout. Through the tests carried out, Dual Power Nanogrid can restore system stability when the utility grid got blackout in 2 seconds. Though the drop voltage reached 7.7% during a fault, the system is still running properly and stable. In this system, the role of the battery is very strategic as the last source against the various kinds of disturbances. The Dual Power nanogrid could ensure the voltage stability, particularly for the SMPS loads, and guarantee power reliability and resiliency when the blackout occurred in the utility grid, especially during COVID-19 pandemic where all human activity are centered in residential sector (house).

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Energy Efficiency and De-Carbonization Improvements Using Court-Yarded Clustered Housing with Compressed Earth Blocks' Envelope

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ABSTRACT

Representing more than half of the Egyptian cities' land use, housing is a major contributor to energy consumption and carbon emissions. What can be called; the 5th generation of Egyptian sustainable urban settlements is evaluated in this research. The potential of new housing typology arranged around courtyards with earth construction envelope to improve energy efficiency and reduce carbon footprints. For a south-east oriented apartments, the energy performance simulation of conventional detached and clustered attached housing with different envelope materials are compared. Results show that the clustered housing paradigm, accompanied with the Compressed Earth Blocks (CEB) envelope, reduced cooling loads during summer by 15.6%, annual energy consumption by 8.5% and 11.6% of carbon emissions compared to the conventional case of detached housing and Solid Cement Blocks (SCB) envelope. The study demonstrates the significance of employing such passive design strategies on improving sustainability measures, along with spotting a light on the character of such urban housing typology as another coin side.

Keywords: Compressed Earth Blocks; Court-Yarded Clusters; Sustainable Housing; 5th Generation of Egyptian Cities.

1. INTRODUCTION

While obtaining the major impact of energy consumption and he resulting greenhouse gas emissions in Egypt [1], the building sector itself represents a large potential for reducing energy demand. Most of the inhabited locations in Egypt experience either a hot-humid or a hot-arid climate with a high solar energy potential. Urban communities' projects that are planned to be constructed during the next decades should, nonetheless, be compatible with the characteristics of their climatic regions. However, customary design and planning practices were applied on most of the current housing projects. Adaptation for future climatic conditions that alleviates urban canyon temperature [2] and diminishes energy consumption [3] is "not a welfare mode of sustainability or a prosperous idea of architecture design" [4]. Adaptation strategies are not limited to vegetation solutions such as trees [5], green roofs [6] and walls, but also comprise the urban fabric composition in a micro-local climate scale [7]. Hence, this research, formulates a comprehensive vision (Urban-Building-Materials-Renewables) to generate a new era of energy efficient buildings in Egypt. Since the microclimatic effects of urban canopy layer significantly influence indoor environments, the major proportion of energy consumption is passively reduced through clustered urban form design [8], while the remaining energy demand is met by a renewable energy system.

2. MATERIALS AND METHODS

A comparative analysis of different housing typologies and building materials in an urban settlement case study of nearly 4000 residential units in Atfih, Egypt (29.38°N, 31.35°E) was carried out through energy-based simulations using Design Builder software. The meteorological inputs for simulations at the case study location were obtained from an interpolated weather file for Atfih was generated from the nearest weather stations via Meteonorm software [9]. The building case studies represent a conventional design example that is currently used for new cities in Egypt (Case I) and a conceptual passive design of a courtyard cluster (Case II). The material construction alternatives for the buildings' envelope were the commonly used solid cement bricks (SCB) and compressed earth blocks (CEB) of lower thermal conductivity and lower production cost and embedded energy than the SCB.

3. RESULTS AND DISCUSSION

The case that uses passive design strategies provides the best energy performance among all cases that provides an average reduction by 15.6% in cooling loads and 11.6% in CO_2 production compared with the basecase during the summer months. Furthermore, utilizing a combination of passive design measures, lead to a considerable annual reduction in energy consumption and carbon emissions by about 8.5% from the base case. Finally, by monthly segmenting energy costs according to tarrifs in Egypt, the design case resulted in an annual reduction of 1107 Egyptian Pounds (EGP) for each unit, and nearly 4.43 million EGP per annum for the urban settlement case study of 4000 residential units.

4. CONCLUSION

This research aims to highlight the advantages of utilizing a combination of passive design applications on both scales of single building and urban design that tends to reduce energy consumption and CO_2 emissions. This supports the newly suggested urban housing design paradigm that connects urban planning, urban and architectural design, affordable construction materials and renewable energy systems, to regulate the sustainability measures of what can be called; the 5th generation of urban settlements in Egypt. Design Builder simulations held with an interpolated weather data file of the case study location of Atfih, Egypt. The simulations outputs manifest the significance of passive design strategies on improving sustainability measures. Opting for the court-yarded clustered design and CEB wall material resulted in cooling energy conservation of 15.6% during summer, and reduced the annual overall energy consumption and carbon emissions by 8.5% from the conventional design. In addition, developing an urban pattern for a sustainable design paradigm for housing in hot regions rather than the parcel model that generates high-rise dot patterns reinforces the character of housing typologies in such regions.

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Residential Building Rehabilitation in Porto Historic Center: Case Study Analysis by Using A Simulation Model

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ABSTRACT

Nowadays, rehabilitation in historic centers can become a challenge due to the restrictions concerning the requirements for the building envelope. Portugal has conducted studies to define the maximum U values $[W/(m^2 \cdot K)]$ for single building components, based on the indoor temperature. Despite the relative humidity being crucial for thermal comfort, the current Portuguese scheme for energy certification of buildings does not consider it. Additionally, it is essential to know that most of the dwellings in Portugal are in a fleet-float regime due to cultural habits and energy poverty. Therefore, increasing the insulation thickness of exterior walls might not have a relevant impact on the indoor temperature. There is even the risk of harming the authenticity of the built heritage. Using a calibrated dynamic simulation model developed with TRNSYS software, we found that, in winter, the effect of external wall insulation on the indoor temperature is tiny. Results suggest that maximum U values $[W/(m^2 \cdot K)]$ for exterior walls might be over-defined. Further studies of cost-optimal levels should be conducted with calibrated models in a free-float regime to define the maximum U values $[W/(m^2 \cdot K)]$ of external walls for this type of buildings.

Keywords: Dynamic simulation; Indoor temperature; Historic centers; Rehabilitation; Residential buildings

1. INTRODUCTION

The main objectives of this paper are to study the variation of the indoor temperature caused by the application of thermal insulation on the exterior walls of a recently retrofitted building located in the historic center of Porto. For that purpose, a calibrated dynamic simulation model was developed with TRNSYS software in a free-float regime. The final goal is to evaluate if the minimum requirements for the U values $[W/(m^2 \cdot K)]$ of exterior walls for historic or ancient buildings are adequately defined.

2. MATERIALS AND METHODS

Using TRNSYS software and SKETCHUP 3D plugin, the dynamic simulation model (Fig. 2) was developed using 13 thermal zones and considering a loss reduction factor of 0.6 to adjoining buildings [1]. The construction materials used in the simulation were based on the publication ITE 50 [2] published by National Civil Engineering Laboratory (LNEC) and Order N.º 15793-K/2013 [4]. Regarding the climatic data used for these simulations, it was decided to use the database provided by Directorate-General for Geology and Energy (DGEG) [3]. As no mention of relative humidity is made in the Portuguese scheme for energy certification of buildings, the model was calibrated based on the temperature. We took the guidelines of ASHRAE 14-2014, as well as the document Concepts and Options for Determining Energy and Water Savings, Volume I of the International Performance Measurement and Verification Protocol (IPMVP) [4].

3. RESULTS AND DISCUSSION

With the calibrated model, we have carried out simulations to assess the impact of thermal insulation on building external walls, on the indoor temperature. It should be noted here that the exterior walls to be insulated represent about 17% of the total area of the building envelope. The first simulation (base) considered the occupied building on a free-float regime and respected the heritage constructive solutions. The second and third simulations were like the first one. Still, it was considered the application of 2 cm and 8 cm, respectively, of expanded agglomerate cork, vapor barrier, and 1.3 cm gypsum board on the inner face of the external walls. The second simulation (PextI2cm) is following Decree-Law Nº 95/2019 [5], the most recent Portuguese legislation respecting residential buildings rehabilitation, in compliance with the thermal transmittance maximum values (U-value) allowed by Ministerial Order Nº 297/2019 [6]. PextI8cm, the third simulation, is based on Decree-Law Nº 118/2013 [7] and

requirements for new buildings or interventions in building components defined by Ministerial Order Nº 379-A/2015 [8]. Simulation results indicate that external wall insulation has a low impact on indoor temperatures. First, it appears that the placement of insulation on the inside face of the external walls reduces the number of hours with lower temperatures and increases the hours with higher temperatures. However, the change is not significant, even when the insulation thickness is increased from 2 cm to 8 cm. In contrast, applying this material on the inner side of the external walls causes spaces to overheat in summer with differences between 19% and 36% and between 30% and 61%, in relation to the situation without any insulation second and third simulation, respectively.

4. CONCLUSION

Indoor temperatures were compared only in occupied periods from November to February. Results seem to indicate that the reduction in the number of hours with temperatures below 16 °C is noteworthy. The application of thermal insulation in the external walls, in this type of buildings, for purely legislative reasons, is highly discussable due to the reduced impact associated with it. Furthermore, there is a growing risk of overheating in summer due to the number of hours with temperatures above 27 °C increasing. Incompatible energy efficiency requirements cannot so condition the Portuguese State responsibility to safeguard Historic Centers. Under a free-float regime, in this type of buildings, thermal insulation on external walls has a reduced impact on indoor temperatures. Still, it harms preserving the authenticity of the built heritage.Future developments should consider reviewing the maximum U values $[W/(m^2{\cdot}K)]$ of external walls for this type of buildings.

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Session 7B - Education for Sustainable Development
09:00-09:30 @ Meeting ID: 979 7648 1988

Qualitative Mapping of Barriers to The Renewables' Development Against Energy Literacy Dimensions: A Case Study of Pakistan

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ABSTRACT

The development of renewable energy (RE) has been recognized as a promising way for solving the energy security problems in future. However, there are various barriers that hinder the development of RE. If the decision-makers are clear to all the barriers, the proper strategies could be planned to address through the targeted index of energy literacy. Energy literacy is one of the most important aspects of the 4th sustainable development goal (SDG) for achieving energy security (SDG-7). This work aims to focus on identifying the importance of energy literacy for addressing the barriers hindering RE development. For this purpose, the barriers to RE development in Pakistan are identified from the literature and categorized in macro-environmental aspects. These barriers are mapped with dimensions and sub-dimensions of energy literacy by conducting focus group meetings with energy and out-comes based education (OBE) theory experts. The analysis of qualitative mapping elaborates that the affective dimension of energy literacy has the highest importance in addressing most of the confronting barriers. It is enlightened that energy literacy can play a pivotal role in achieving the sustainable future by addressing the barriers constructively.

Keywords: Barriers; Eenergy literacy; Qualitative mapping; Renewable energy; Sustainability.

1. INTRODUCTION

The 'sustainability' has a key linkage with SDG-7. The successful achievement of the SDG-7, subjected to sustainable energy transition by increasing renewables' share in the energy mix, is impeded by the number of barriers confronted by the consumers of the society [1]. The solution of any certain type of barrier is also associated with confronting entity such as human [2]. To deliver the understanding about the energy aspects with the aim of addressing the barriers, it is important to identify the corresponding perspective(s) of humans. The answer can be drawn through energy literacy (an aspect of SDG-4) dimensions [3]. Energy literacy can be defined in terms of three aspects [4]: *knowledge*, *attitude*, and *behavior*. There is no well-defined scale for measuring the energy literacy. However certain studies reported that energy literacy is more concerned with the behavior and attitude of the people [5].

Insight of the barriers to the development of renewables, different policy implications have been proposed to address them. To achieve the objectives of SDG-7 and make the globe sustainable, humans' participation in a right way is of vital importance. To address these barriers constructively, it is necessary to define them in terms of energy literacy dimensions so that policy solutions could be implemented accordingly. There is no such work available in the literature highlighting the humans' nature perspectives in terms of energy literacy dimensions for addressing the barriers. The unique contribution of this work is: qualitative linkage between SDG-4 and SDG-7 perspectives, the mapping of barriers to the development of renewables with energy literacy dimensions identifying the required sub-dimension(s) among cognitive, affective, or conative domains.

2. MATERIALS AND METHODS

The current work mainly consists of three phases. In the 1st phase, twenty-three barriers to the RE development in Pakistan are identified through literature review, interviews and author's own deliberation, and categorized under macro-environmental framework (PESTEL) including political, economic, social, technical, environmental, and legal aspects. In the 2nd phase, three dimensions (affective, cognitive, and conative) and eight sub-dimensions of energy literacy are defined from literature in the light of out-comes based education (OBE) theory [3]. In the 3rd phase, the qualitative mapping of barriers is completed by connecting the barriers with the sub-dimensions of energy literacy. In order to illustrate the proposed methodology, Pakistan has been studied based on the focus group meetings with four officials having expertise in energy and OBE domains. Experts were asked to choose sub-dimensions of energy literacy through which the corresponding barriers could be addressed constructively. The final mapping is done based on the frequency distribution method in which each barrier is

mapped with the sub-dimension(s) that is (are) suggested by two or more experts.

3. RESULTS AND DISCUSSION

The barriers hindering the RE development in Pakistan are mapped with the dimensions of energy literacy subjectively. The analysis of qualitative mapping in terms of energy literacy dimensions and sub-dimensions, portrayed in Fig.1, elaborates that the affective domain is the most important one linked with the maximum number of barriers, and the cognitive domain has 2nd highest number of linkages. While the conative domain has the minimum number of linkages. Among the sub-dimensions, attitude is the most important perspective of human nature needed to target for addressing 10 out of the 23 barriers. While the 'soft skills' is recognized as the least important sub-dimension of energy literacy.
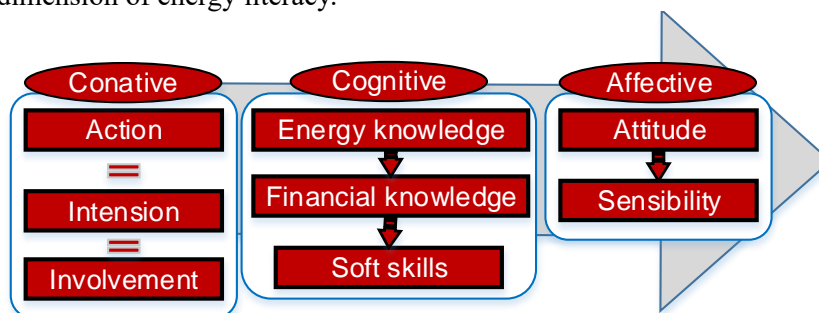
Fig. 1. Importance prioritization of energy literacy dimensions

4. CONCLUSION

An effort is made to inter-link the barriers of RE development and the energy literacy dimensions in the context of Pakistan. The main outcomes are:

- 'Affective' is the most important energy literacy dimension mapped with thirteen barriers.
- It is also found that 50% of the barriers require the involvement of more than one sub-dimensions of energy literacy to get addressed constructively.

This new idea of mapping the barriers of RE development (SDG-7 perspective) with the energy literacy dimensions (SDG-4 perspective) can be promoted to other countries, especially in the developing world. So that the contextual nature of barriers could be analyzed in a systematic way, and could be targeted for addressing the barriers hindering sustainable development

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Clustering and Exploring University Students' Knowledge and Attitude towards Energy Sustainability

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ABSTRACT

The study aimed to examine whether the Indian university students, who are considered as the future work force of the nation, could be categorized into subgroups based on their attitude towards energy and to determine the energy knowledge of each subgroup. Hierarchical Cluster analysis was used to segment the surveyed population into four distinct groups, or "personas", each with varying levels of engagement and differing perceptions of energy. Four clusters were identified: "Agents of change", "Mindful wanderer", "Big talker", and "Indifferent onlooker". The energy knowledge of each persona was analyzed for core energy topics and the analysis of correlation test explained that there was a significant positive relationship between energy knowledge and energy attitude. The study also tries to discuss what implications the empirical findings on subgroups or personas have for the development of energy education curriculum at various educational levels..

Keywords: Attitude; Behaviour; Clustering; Energy; Knowledge; Sustainability.

1. INTRODUCTION

Sustainable development has become an integrating concept embracing economic, social, and environmental issues. It is a pattern of economic growth in which resource use aims to meet human needs while preserving the environment. Among the various resources, which constitute the backbone of a country, energy is considered as the key for relieving poverty, improving human welfare, and raising living standards [International Atomic Energy Agency, 2007]. Energy sustainability is related with the provision of adequate, reliable, and affordable energy, in conformity with social and environmental requirements [Grigoroudis, 2019]. One solution, towards reducing the overall energy consumption, is to motivate people to decrease energy waste. Communities and countries across the world are faced with the challenge of meeting rising energy demands in environmentally and economically responsible ways.

2. MATERIALS AND METHODS

The sample for the study comprised of youth pursuing under-graduation in colleges affiliated to University of Kerala. The National Energy Literacy Survey Questionnaire developed and launched by National Energy Foundation, USA was modified and culturally adapted to use in India. The questionnaire was based on a framework of five core energy topics. It included questions related to knowledge, attitude, and behaviour. The final survey instrument included questions divided into 4 categories: demographics, behaviour, knowledge, and attitudes.

3. RESULTS AND DISCUSSION

Cluster analysis was conducted to identify similarities and differences between individuals and combine similar individuals into clusters. By applying the method of hierarchical cluster analysis with the Ward method, the pattern of the respondents' answers was explored. Squared Euclidean distance was selected as similarity-difference measure in calculation of distance between the variables. The cluster groups with four different personas each with varying levels of engagement and differing perceptions of energy were named as agents of change, mindful wanderer, big talker, and indifferent onlooker. The analysis of the data related to energy knowledge of the four cluster groups with respect to the five core energy topics discussed are presented graphically. discussion. Agents of change, having the positive attitude towards energy received the highest core regarding energy content knowledge (59.6). The corresponding decrease in the value of content knowledge for mindful Wanderer (50.6), Bi Talker (44.8) and Indifferent Onlooker (46.9) reveals the relation between energy knowledge and energy attitude.

4. CONCLUSION

The results of this study reveal that students with a higher score of energy knowledge shows a more optimistic energy attitude and vice versa. These two factors present a significantly positive correlation. The research results emphasize the importance of not overlooking knowledge as a means of improving the prospects for informed decision-making in both existing and new contexts. It also suggests that greater efforts are needed to link formal

learning with daily life to enhance attitude and awareness of how individuals use energy in everyday practices and illustrate how changing behaviour affect energy use.

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Session 1B - Energy Efficiency
09:45-11:00 @ Meeting ID: 948 1336 4454

E021   **9:45-10:00**

Investigation of the Effects of the Jet Nozzle Geometry and Location on The Performance of Supersonic Fluid Ejectors

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ABSTRACT

Supersonic Ejectors (SE) can be used to replace mechanical compressors in several industrial applications. In this paper, Computational Fluid Dynamics (CFD) has been used to investigate the effects of different geometrical parameters and operating conditions on the ejector performance. The numerical simulations were validated against experimental measurements in terms of entrainment ratio and pressure distribution. The effects of the supersonic nozzle location and its dimensions have been investigated with respect to pressure distribution. The flow dynamics was also investigated for various geometry parameters with the purpose of identifying the mechanisms leading to higher ejector performance. The main conclusion is that under a given set of operating regimes, different geometric parameters should be simultaneously considered for an optimal performance of a supersonic ejector.

Keywords: Supersonic ejector; jet nozzle; entrainment ratio; fluid mixing

1. INTRODUCTION

Supersonic ejectors are simple mechanical devices with no moving parts which convert the pressure energy of a motive fluid to kinetic energy to create suction and therefore circulate a secondary fluid in a thermal or cogeneration cycle.

Foa (1955) in [1] proposed "pressure exchange" ejectors in which the energy exchange between the primary and secondary flows takes place through the work of normal stresses in the fluid flow. It should be noted that most of the pressure exchange ejectors suffer from severe sealing and bearing problems as mentioned by Hong et al. (2004) in [2].

Zhu et al. (2009) in [3] studied the effect of different geometry parameters such as location of the nozzle exit plane (NXP), diameter of the supersonic nozzle throat and its exit diameter, and the expansion angle of the jet in the mixing section using CFD simulations. They found that the optimum NXP and the jet expansion angle increase when the primary flow pressure rises. Further fluid dynamic analysis was needed in order to find the optimal geometry for a specific primary pressure.

As demonstrated in [4] and [5] (El Hassan et al, 2019, 2020) investigated the flow dynamics inside single and binary fluid ejectors using CFD simulations. The numerical prediction of the entrainment ratio and the pressure distribution showed a good agreement with the experimental results. El Hassan et al (2020) in [6] also found that the molecular mass and specific heat ratio can significantly affect the entrainment ratio of the ejector and consequently the COP of an ejector-based refrigeration system. In this paper experimental and computational investigations were done to enhance ejector performance.

2. MATERIALS AND METHODS

The compressible steady state form of the flow field was solved in a two-dimensional axisymmetric plane and the averaged Navier-Stokes equations for variable density flows (Favre averaged) are used. Commercial CFD package ANSYS FLUENT 19 was used to solve the governing equations. The SST k-ω turbulence model was used since this model showed a closer agreement with the experimental results as compared to the other models. Similar agreement can be found in the literature regarding the SST k-ω turbulence model ([4]-[7]).

The experimental setup consists of gas bottles with pressure regulators, needle valves, two 7.5 kW circulation heaters with PID controllers, custom made ejector, buffer tank at the end of ejector, water sealed vacuum pump, heat exchanger, silencer/separator, 10 thermocouples and 4 pressure transducers, pressure manifold along the ejector's body and data acquisition system. The configurable ejector used in this study consisted of four main

parts: nozzle, mixing chamber, throat and the diffuser. All parts were replaceable to reduce experimental costs and the nozzle could be moved inside the ejector.

3. RESULTS AND DISCUSSION

The pressure distribution along the ejector wall and the Mach number distribution are presented in this section. The influence of the ejector geometry and NXP is discussed. The static pressure distribution and the mass entrainment ratio were compared between numerical simulations and experimental results. The results are overall in good agreement and thus the CFD modelling is validated.

In case 1, a recirculation zone starts to form at the end of the mixing chamber. The sharp jump in the pressure distribution at the wall shows that the flow decelerates around a circulation region.

The presence of the recirculation region can lead to a flow blockage characterized by an increase in the pressure inside the ejector throat and thus dramatically decrease the entrainment rate and the ejector performance.

In case 2, although the numerical prediction of the pressure distribution in the throat area in slightly deviates from the experimental results, the mass entrainment ratios are in a very good agreement.

In case 3, the supersonic core is not developed enough to cover the throat. Such ejector configuration usually provides a low entrainment ratio since the secondary flow decelerates before reaching the throat.

In case 4, showed a similar pattern to the ones shown in case 2, but the width of the supersonic core in case 2 is still growing and keeps close to the wall when entering the diffuser. This leads to a sharp decrease in pressiure distribution at the beginning of the diffuser.

4. CONCLUSION

Experimental and numerical investigations were presented in this paper to study the influence of the supersonic nozzle diameter and its location on the ejector performance. Based on the results, the following conclusion were drawn:

- The numerical prediction of the pressure distribution along the ejector walls showed a good agreement with the experimental results.
- under the same operation conditions, a smaller nozzle diameter leads to a less developed supersonic jet and a reduced mixing between the primary and the secondary flows.
- The location of the supersonic nozzle exit (NXP) should be properly chosen for an optimal mixing inside the ejector.
- a nozzle with a 2 mm diameter the flow presented a separation from the ejector wall for NXP = -35 mm whereas the supersonic jet core extended inside the ejector diffuser for NXP = 0 and 35 mm.

Therefore, in order to optimize the ejector performance, both the nozzle dimensions and the location of the nozzle exit should be properly defined for a given set of operating regimes.

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E030   **10:00-10:15**

Energy Saving Potentials of An Efficient Recycling Process of Different Aluminum Rejects

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ABSTRACT

In addition to the efficient and fully comprehensive use of all available resources, energy optimization is also an important part of the global efforts to reduce emissions. In connection with the energy-efficient production of aluminum products, it is therefore necessary to use recycling processes that are as energy- and resource-efficient as possible. One example of such a process is a friction-induced and continuous recycling process related to the Conform process which is currently the subject of intense research work at the LUF as an intermediate stage on the way to a direct part production from scrap. The energy saving potential of processing chips of the wrought alloy EN-AW-6060 has been determined in previous investigations to be 50% compared to the melting metallurgical process. Further studies presented in this paper will investigate the feasibility of recycling other aluminum alloys as well as other shaped aluminum products. This validation of the feasibility for these very different fields of application represents the basis for a broad application of the process. In a final analysis, the friction-induced recycling process and the primary and secondary production of semi-finished aluminum products are compared in terms of the energy required.

Keywords: aluminum; energy efficiency; friction-induced; recycling;

1. INTRODUCTION

A variety of different aluminum alloys are used in the transport sector for the production of cars and trucks, in the construction sector for facades and doors, as a packaging material, but also as a construction material in industry [1]. Depending on their intended use, all these products sooner or later reach the end of their life and have to be disposed of. Not only at the end of the life cycle, but also during the creation phase of the products, waste is produced in the form of production scrap, which is also called new scrap. An example of this is the high chip removal rate up to 95 % in the machining of aluminum components in the aerospace industry, which produces new scrap in the form of aluminum chips. Considering the conventional recycling process, these scraps are collected, processed and then recycled by smelting metallurgy and reprocessed into new products. Due to the still high energy consumption of this process, alternative methods for recycling production scrap have been increasingly investigated in recent years [2]. An experimental setup for friction-induced recycling of aluminum chips has been created at the University's Department of Forming and Machining Technology (LUF) [3]. The setup has adapted the original process principle of the Conform process to the recycling of aluminum components.

2. MATERIALS AND METHODS

The use of external heating elements such as heating cartridges in the friction induced recycling process is not necessary due to the fact, that the heat is generated by the friction between the aluminum and the surrounding tool. This should be done at the beginning of the process during the start-up phase by adding a small amount of aluminum chips. Depending on the rotational speed used, a stationary state is established after a few minutes, which can be described on the basis of a constant external temperature of the tool as well as a constant torque of the gear motor.

In the investigations carried out, both aluminum chips of different alloys and also conventional aluminum foil from the supermarket are used. For this purpose, the almost pure aluminum EN-AW-1350, the heat-treatable wrought alloy EN-AW-6060, the high-strength alloy EN-AW-7075 and the frequently used cast alloy AlSi10Mg are used. The chips have all been produced in a conventional milling process without using cooling lubricants. All the materials described are extruded in independent tests at a constant rotational speed of 11 rpm. The wires produced are investigated in terms of appearance and die filling as well as the mechanical properties of hardness and tensile strength.

3. RESULTS AND DISCUSSION

The results show a feasibility or processability of all four investigated alloys with the friction induced recycling process. The high-strength alloy EN-AW-7075, which is frequently used in the aerospace industry, the almost pure aluminum EN-AW-1350, the alloy EN-AW-6060, which is used in the automotive industry and architecture, and the casting alloy AlSi10Mg can all be processed. This shows the wide range of applications of the friction-induced recycling process. As expected, the nearly pure aluminum EN-AW-1350 shows the lowest 0.2% yield

strength stress but also tensile strength. With respect to the 0.2% yield strength, no major difference can be determined of the wrought alloy EN-AW-6060 as well as the cast alloy AlSI10Mg. On the other hand, the tensile strength of the cast alloy is about 27% higher compared to the wrought alloy. As expected, the alloy EN-AW-7075, which is also widely used in the aerospace industry as a high-strength structural material, exhibits the highest values in terms of both the 0.2% yield strength and the tensile strength.

For the processing of the aluminum foil the friction-induced recycling process is initially started by filling aluminum chips of the alloy EN-AW-6060 in the wheel and heating the die system. This step is necessary because the model machine used has no external heat supply in the form of cartridge heaters or similar, but is heated by the frictional heat generated in the process. The folded aluminum foil is placed in the groove of the wheel as soon as the stationary state is reached (the torque to be applied and the tool temperature are almost constant). Following the one-time insertion of the foil, the further material is drawn in independently. The result of the now running extrusion process is a completely solid and, with respect to the surface, markless wire, which is continuously extruded from the shaping opening.

The central aspect of the current investigations in the field of production technology is the energy and resource-related increase in efficiency. Approximately 155.9 MJ of energy is required to produce one kilogram of primary aluminum, with half of the electrical energy coming from hydroelectric and coal-fired power plant [4]. The conventional recycling process for secondary aluminum production is significantly more efficient and requires approx. 17.7 MJ to produce one kilogram of aluminum from scrap [5]. In addition to the provision of energy, other influencing factors such as the degradation of bauxite for primary production or the salt slag produced in the conventional recycling process must be considered in the overall balance as well as the extrusion processes for the production of a defined profile geometry. Compared to these two processes, the direct friction-induced recycling process represents a constructively simple and energetically improved alternative in the form of a solid-state process. Considering the low rotational speed of 6 rpm, 8.68 MJ of electrical energy must be expended to produce one kilogram of wire with a diameter of 5 mm [3]. The increased energy requirement at the rotational speed of 11 rpm results in a slightly higher energy requirement of 9.86 MJ/kg. However, one advantage of this increased rotational speed is the higher output rate and thus productivity.

4. CONCLUSION

The friction-induced recycling process of aluminum chips offers the energy- and resource-efficient possibility of direct recycling for the production of user-specific semi-finished product geometries. In this research, four different aluminum alloys have been investigated for workability with the recycling process. All four alloys can be processed into a wire with a full cross-section and homogeneous mechanical properties. The feasibility of recycling aluminum in the form of a very thin aluminum foil has also been successfully validated. The areas of application of the friction-induced recycling process can therefore be seen in the future not only in the field of processing production scrap.

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Energy And Material Efficiency Strategies Enabled By Metal Additive Manufacturing – A Review For The Aeronautic And Aerospace Sectors

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ABSTRACT

Conventional manufacturing of aeronautic and aerospace parts requires substantial amount of resources (energy and materials) and generates high quantities of waste. Metal additive manufacturing (MAM) has the potential to reduce resource consumption, which is particularly important for energy-intensive materials such as titanium. The manufacturing and aviation sectors are responsible for significant energy use and carbon dioxide emissions. We undertake a systematic literature review of MAM processes for the aerospace/aeronautic sector focusing on energy and material efficiency. Relevant literature was classified and discussed based on the life cycle stages at which resource efficiency strategies for MAM were identified: 1) product design; 2) material development and sourcing; 3) processes development, control, and optimization; 4) end-of-life extension and circular economy. Results highlight the key factors required to optimize MAM and the relevance of assessing its environmental impact compared to conventional manufacturing. Material and energy efficiency vary significantly between different MAM processes due to the several factors directly linked to the process but also in the supply chain, e.g. electricity mix or material sourcing. Further research could explore new trends in technological development for circularity or multi-material MAM.

Keywords: 3D print; additive manufacturing; carbon emissions, resource efficiency; sustainability.

1. INTRODUCTION

Additive manufacturing (AM) is a disruptive manufacturing technology that enables the production of new complex geometric parts, if not possible, or challenging, by conventional manufacturing (CM). Metal Additive Manufacturing (MAM) especially attracted attention of high demanding sectors, including aeronautic and aerospace. Compared with CM subtractive processes, MAM may significantly reduce the materials used and the emission and waste generated. Metal industry, including mining and manufacturing, is responsible for 12% global carbon dioxide (CO_2) emissions. Aviation accounts for 9% of CO_2 emissions of all transport means, and commercial flights have been increasing till 2019, resulting in 918 million tons of CO_2 emissions in 2019. This study aims to present an overview of current energy and material efficiency strategies enabled by MAM for aerospace and the aeronautic sectors, while identifying the key aspects influencing potential MAM benefits at different levels. Through a systematic review of studies focusing on MAM processes for the aerospace and aeronautic, reported benefits for energy and material efficiency were identified. Studies were grouped and discussed based on the following stages: i) MAM product design; ii) MAM material development and sourcing; iii) MAM processes development, control and optimization; iv) MAM end-of-life extension and circular economy.

2. MATERIALS AND METHODS

A literature search was performed focusing on sustainability studies that intersect with the MAM field. The initial search yielded 108 items. The list of papers was narrowed down through a sequence of filters and the results were assessed according to a set of key categories. The items were filtered to consider only those that directly address resource efficiency and/or sustainability analysis (36 papers). A scoping review was undertaken to identify the key categories and levels at which strategies were applied in the MAM for the aeronautics/aerospace sector, based on the categories proposed by [1] (13 papers). The information was used to outline the most common strategies applied towards a holistic resource efficiency approach in MAM, and the gaps/ for their the development and implementation.

3. RESULTS AND DISCUSSION

The reviewed literature is divide in the stages at which resource efficiency strategies are applied:

- **MAM product design:** MAM enables components' re-design for their specific function, eliminating redundant material trough complex geometries thus allowing new topology-optimized parts to be

developed. Key framworks of resource efficiency design of MAM include: bio-inspired product design (e.g. biomimicry); integrating design for AM factors (e.g. raw material quality, process parameters, part functionality); lightweight design reducing fuel consumption; and sustainability assessment trough life cycle assessment (LCA) and life cycle costing (LCC).

- **MAM materials – development and sourcing:** This was the stage with less development in terms of resource efficiency. Metal powder production still need further study, to better understand their embodied energy requirements. Another potential strategy is the use of MAM as an on-site manufacturing technology and exploiting new extra-terrestrial materials for space exploration.

- **MAM processes analysis, control and optimization:** Enery and material strategies depend heqvily on the type of process used. For example, Power Bed Fision (PBF) and Laser Metal Deposition (LMD) allow more complex geometries and have been more studied than wire-fed processes [2]. However, Direct Energy Deposition (DED) and wire processes have higher production volumes and deposition rates than PBF, being more cost effective for large parts [3]. Results also showed that the preferable solution (lower impact per part) depends on the number of parts required. Development of LCA and LCC allows to understand the impact of MAM processes to better inform technology selection and adoption. One of the barriers to MAM implementation is the lack of process monitoring and control systems. Furthermore, due to higher energy efficiency in MAM processes, the contribution of embodied energy and impacts of AM machine significantly increase.

- **MAM End-of-life and circular economy:** MAM has the potential to extend the components life through DED custom-made repairing, remanufacturing, or on-demand production of spare components. Combining LMD with machining was proven to successfully repair high-value components such as turbine blades, avoiding the production a new component. More research is needed to assess new circular economy strategies, to recycle metals into functional MAM material.

4. CONCLUSION

Energy and material efficiency strategies at MAM product design level can transform manufacturing in aeronautic/aerospace, significantly reducing resource consumption and costs. Thus, studies regarding the selection of design, planning and qualification parameters are highly valuable and more research is requiered. New material development strategies are also important to increase the number of MAM applications. Studies accounting for the embodied impacts of MAM powders and wires are highly important to select alternatives with lower embodied impact, namely through energy efficient processes and a higher incorporation of recycled metals. As different MAM technologies are available, it is important to understand which specific manufacturing technology is preferable, to avoid problem shifting. LCA studies have identified critical factors to consider, which should be taken into account when selecting MAM technologies. Overall, more studies having a broad life cycle perspective are needed to assess not only MAM technologies but also the embodied impact from materials, the required post-treatments, and components' use stage.

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E135   10:30-10:45

Increasing Energy Efficiency with a Smart Farm - an Economic Evaluation

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ABSTRACT

Rural farms are typically energy-intensive facilities with relatively low energy efficiency. In this sector, the introduction of renewable energies and integrated resource management technologies has been slower than in the domestic and industrial sector. The introduction of renewable energy sources was an important step in the past, but they are currently insufficient, as they do not allow for adequate energy management. The development of new solutions with integrated energy control is especially attractive for these installations as they present the least limitations in terms of space and adaptation to new technologies.

This work describes a solution that was developed and implemented in a farm located in central Portugal. The results show that 83.2% reduction in energy from the grid can be achieved, with 5527 kg CO_2 savings, and the return on investment (of €32,434) is about 8 years. However, this period can be shortened if evolutionary options are taken, such as upgrading to electric driven agricultural equipment.

Keywords: Photovoltaic, Renewable Energy, Sustainable Communities, Sustainable farms.

1. INTRODUCTION

The SDGs [1] set specific targets for the next 15 years, ensuring a balance between the three dimensions of sustainable development - economic, social and environmental, while focusing on a healthy planet. In this context, the main objectives of the present work were both to develop a system able to reduce energy consumption in a rural farm, using a photovoltaic (PV) system, and to develop a specific automation oriented to manage a set of existing devices within the infrastructure and equipment applied in agricultural use. This paper will also analyze environmental impacts, both positive and negative, and perform an economic analysis of the project's viability. This work brings an original contribution, as it presents a developed system for a rural farm that responds to some specific SDGs: SDG 6 – Clean water and sanitation; SDG 7 – Affordable and clean energy; SDG 9 – Industry, innovation, and infrastructure; SDG 11 – Sustainable cities and communities. In fact, solutions that have been exploited and implemented for *smart farms* are frequently based in infrastructures that were developed for industry and therefore more expensive than the ones that certainly will take place when verifying the massification of its use [2].

2. MATERIALS AND METHODS

The dimensioned photovoltaic system consists of 6 solar trackers with 18 photovoltaic modules each and has 24 OPzS 2V batteries each. It should be noted that the system has a Multicluster MC-Box6.3 control box to interface and control the loads, and there is also control and monitoring through a PLC with a supervision application.

3. RESULTS AND DISCUSSION

The implemented photovoltaic system will always be in service and only in exceptional cases, for example in the absence of battery charge, does the DC/AC converter switch and allow the electricity to come from the national electricity grid. The costs associated with supplying electricity from the grid were quite significant. One of the invoices is shown for a non-significant month of electricity consumption from the network, in this case in March. Annually, the user had costs of about €5,000, which is quite high. The contracted power is 20.7 kVA.

The expected benefit of installing the photovoltaic system was to reduce the costs of purchasing electricity from the National electricity grid. The calculation of the gross revenue is made through the product of the electric energy produced and the value of the remuneration for the purchase, considering the value of 0.1258 €/kWh for the first year. However, this value is not the same every year, as the cost of purchasing power from the grid will have a predictable average increase of 5.8% per year, as a result of inflation, over the lifetime of the project. The Operation and Maintenance (O&M) cost of all components remains fixed at a defined value for all years. It was considered that all equipment used in the photovoltaic system has a lifetime equal to the operating time of the system. It should be noted that the possible negotiation of insurance for the installation of the photovoltaic system was not considered.

The project's net revenue was calculated by the difference between the gross revenue and the facility's O&M costs. In order to allow for a comparative analysis, it was decided to consider the value of the initial investment without VAT and a discount rate of 7%. In short, the considered values were as follows:

Photovoltaic System cost	€32,434.00 (VAT excluded)
Estimated annual production	27.000 kWh
Operation and Maintenance cost	€324.34/year (VAT excluded)
Electricity price growth	5.8%
Percentage of energy produced	83.24%

With the data obtained, it was concluded that the investment capital is recovered, which is why the project is economically viable. It could also be concluded that, with the application of a rate of 7%, a positive NPV (VAL=49,960 €) is obtained with an Internal Rate of Return (IRR) of 6% and a Payback Time of 8 years. In short, it is a viable project and there is no doubt that this will be the future in self-consumption with energy storage in smart farms.

A technical comparison was made between the developed solution against some solutions available in the literature [3,4,5], concluding that our solution is more expensive but allows the incorporation, later on, of other energy sources such as the one resulting from a mini hydro generator.

Additionally, the electric energy produced by the present solution from the photovoltaic system avoids an anual emission of 5527 kg of CO_2.

4. CONCLUSION

As the implemented System A is framed in the so-called energy efficiency, it has in fact contributed to a significant improvement in the rural farm owner's monthly energy bill, thus making housing more efficient, ecological and automated. With an investment cost of 32,434.00 €, energy savings in CO_2 of 5527 kg CO_2 and 83.24% reduction in the energy consumption from the grid, the system has a payback time of 8 years. The development of technologies based on electronics is consistently low in prices at the same time that it has high potentialities. So, in the future, the use of technologies oriented for the smart farms will be more affordable and, therefore, with much more attractive payback. In addition, the completion of the following phases of the project, i.e., inclusion of a mini-hydro generator and change to electric agricultural machines it is expected that will lead to an increase in the competitiveness of smart farm products.

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E093   **10:45-11:00**

New Lifing Criterion for Land-Based Gas Turbines in Flexible Operation Mode

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ABSTRACT

Under the ongoing global energy transition, gas turbines are increasingly experiencing new modes of operation. In the recent years, primarily in Europe and similarly in various parts of the world, renewable energies are gaining momentum to support more environmentally friendly energy policies. Renewable Energy Sources (RES), such as wind and solar are intermittent by nature and a rise in their contribution is associated with grid instabilities. As a result, reliable energy sources such as fossil fuel-based plants are required to fill flexible back-up or reserve power, capable to rapidly response in case of RES downtime. This introduces new operating conditions, characterized by very high start/stop cycles (almost daily) and load cycling operations, beyond those foreseen under the classic base-load or cyclic operations. The present criteria used for establishing the inspection intervals and components' lives, are put in place based on the assumptions that the gas turbine will operate at base load for the most part, with some exposure to cyclic operations. This paper identifies the most critical gaps in the present criteria, particularly due to increased thermal instability or sustained transient under the flexible operation requirements.

Keywords: Creep-fatigue interaction, flexible operation, lifing criterion, peaking machine, thermal stability.

1. INTRODUCTION

The European Commission's EUCO30 scenario foresees a share for the Renewable Energy Sources (RES) in power generation close to 50% by 2030 and about 65% by 2050. Other scenarios project the RES's share even higher, beyond 80% of the total energy sources as demonstrated [1].

The RES's rise is generally proportional to the increased need for higher power system flexibility, which at the moment is largely provided by fossil fuel based-plants (i.e., gas and/or steam turbines). The transition to sustainable energy sources necessitates gas turbines to dispatch energy in minutes to balance the electric system loads over the course of the day and across seasons, while maintaining grid reliability. This is in comparison to 15- and 30-minutes start to full power capabilities for advanced simple and combined power plants, respectively. The impact of these changes on the industrial heavy duty is different than with aero engines for example, since the latter are subjected to variable speed to control the load changes. Studies on the correlation between the changes in the rotating speed and stresses in aero-engines components exposed to flexible mode operation are more frequent. [5] and [6] are good references of that, addressing the effects of flexible operation on the degradation mechanisms of aeroderivative engines. They investigated the effects of the new requirements (peak, partial, full loading, and fast ramp-up rates) on the turbine operating temperature, particularly the turbine inlet or entry temperature (TIT). This is since, the metal temperature distribution and gradients are the most important parameters determining the expander blades' lives among other critical components operating in the hot section [2]. This article focuses on the flexible operations' effects on the heavy-duty GT only. It describes the present lifing criterion and reveals critical gaps in fulfilling the new requirements associated with these changes.

2. MATERIALS AND METHODS

The results presented in this paper are largely based on field observations and first-hand experience in gas turbine components repairs, in addition to analysis of publications on this topic.
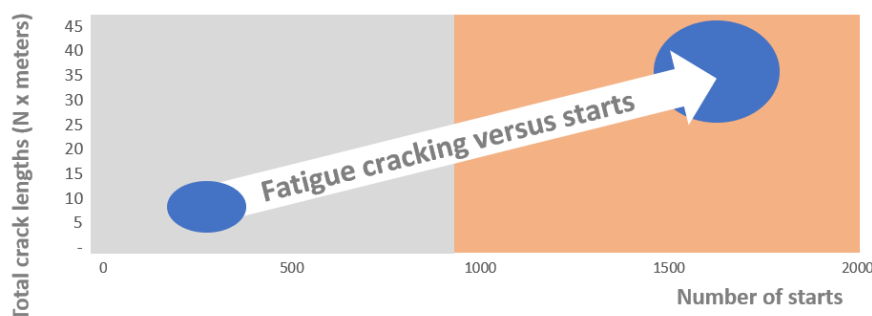
Figure 1: Impact of fatigue mechanism on cracking.

The correlation shown in Fig. 1 reflects the strong relationship between the number of starts and total crack

lengths in a first stage expander nozzle set. This is an example of the flexible operation's implication on the components, promoting extensive cracking due to thermal transients. The extent of cracking (i.e., length, depth, etc.) is an important factor in the restoration of degraded components within the required properties and economic feasibility. Therefore, unaccounted thermal transients due to frequent starts and load changes promote excessive cracking and potentially premature end of service.

3. RESULTS AND DISCUSSION

After examining the present lifing criterion [3] largely used in the gas turbine maintenance industry, two important gaps are noted;

First, in case of the starts-based criterion, the new thermal characteristics are not fully captured, for example the time interval at a specific load, leading to excessive cracking. Studies on the interaction of thermal mechanical fatigue (TMF) due to energy demand variation reveals major weaknesses in accounting for actual stresses. This is since the existing TMF lifing methodologies are extrapolated from a generation of more simplistic isothermal data, obtained from high temperature fatigue or creep tests. Such data represents a linear damage accumulation approach, which fails to fully capture the complex interactions between the different damage mechanisms [4].

Second, the hours-based criterion (or creep driven) is found to be conservative, especially with the rise in part load regimes. The effects of partial loads, particularly pertaining to the metal temperature's impact on the first stage expander blade's life is reported [2]. Beagle et al showed that 300 hours operation at 70% load can be equal to one hour operation at base load. This is established through correlation of load and metal temperature, and is applicable in case the load changes are due to variation in the turbine inlet temperature alone (not via the exit variable guide vane -EGV).

4. CONCLUSION

The ongoing energy transformation, particularly concerning the rise in renewable sources will continue to drive the need for flexible operations in fossil fuel-based plants. The most important gaps and challenges are identified in the present lifing criteria and summarized; i) the present inspection and lifing criteria do not reflect the novel factors associated with flexible operations; ii) in case of the starts-based criterion, the new thermal characteristics are not fully captured, leading to excessive cracking; iii) on the contrary, the hours-based criterion (or creep driven) is found to be conservative, especially with the rise in part load regimes; iv) in case of the equivalent operating hours criterion, the individual effects from starts and load levels are diffused into the equation, adding another layer of complication.

It is proposed to revise both criteria (hour/start based and equivalent operating hours) to adapt them to the new requirements associated with the flexible mode operation, adequately representing the frequent starts, continuous load changes, part and peak loads.

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11:15-12:15 @ Meeting ID: 948 1336 4454

Methodology for the Decision-Making Process in Social District Heating Implementation

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ABSTRACT
District heating is a centralized energetic system, capable of providing heat to different structures. This technology helps achieving energetic efficiency with a high fuel flexibility, enabling the use of various renewable sources, which will lead to a lower pollution potential. Beside the environmental perspective, these systems show a great ability concerning the social context. Benefits such as, tackling fuel poverty, increasing employment and population in areas suffering from desertification, along with forest fire prevention, lead to the social perspective as the primary motivation for the implementation of these systems, creating the concept of Social District Heating (SDH). Therefore, this paper developed a decision support tool to prioritize locations in the most need of an SHD, with the necessary features to include this technology in its area. A methodology intended to assess quantitative and qualitative variables is presented, step by step, evaluating each location relatively to community aspects, background context and council power criteria. The results presented enhance more than one location, however one appears as the most appropriate for the SDH implementation.

Keywords: Social District Heating, Forest waste - biomass, Decision support tool, Pairwise comparison.

1. INTRODUCTION
District Heating (DH) consists in a central facility designed for heat production, with a pipe network that is responsible for its distribution for the different structures and services [1]. The growing popularity of this systems is a result of its sustainable characteristics, ensuring a low pollution potential, due to energetic efficiency and possibility of renewable sources usage [2].

Social District Heating (SDH) is an unused term that depicts the social role in a DH system. Benefits concerning the social perspective include job opportunities increase through wood residues related activities [3], along with fuel poverty mitigation and stimulation of the local economy. Forest fires prevention is another significant advantage, given their serious consequences to the environment, society and economics. The coordination of DH system activities with a correct forest management by collecting forest residues, to be used as a fuel, is considered an effective tool to prevent fires [4].

A decisive phase that influences the systems functioning throughout its life is the planning stage, however the lack of tools to support the selection of an appropriate location to implement the SDH system is a considerable limitation. From the existing methods, GIS (Geographic Information System) is the most frequently used by enhancing opportunity zones and prioritizing the most suited locations to implement a heat system project, Scotland Heat Map being one example [5]. Another tool, Leeds Heat Planning Tool, is a quantitative technique that by calculations determines locations scores [6]. However, the idealized tool in this study requires the social component as an important criterion and the evaluation of the locations according to its rural context, and neither fulfills both conditions, along with the need of processing quantitative and qualitative criteria. The implementation studied concerns a DH system fed by wood forest residues.

Therefore, a new tool that meets the project goals for the system to be studied, framing the social role directly, among other important aspects, was developed. For this reason, in this work was developed a methodology to prioritize locations to implement an SDH system using as an energy source wood forest residues.

2. MATERIALS AND METHODS
The developed methodly is divided in four steps:
1. Definition of macrovariables and variables responsible for evaluating the locations in study. Three macro variables were established: community, background and council power and each one is divided into other variables.
2. Information gathering related to the variables defined, to apply the methodology.
3. A methodological analysis comprising the various procedures, including: normalization to convert all variables' values into the same range, pairwise comparison assigning a weight to each variable, ranking of

the location through an equation involving the weights and variables normalized and a sensitivity analysis altering these weights.

4. Checklist to analyse the qualitative criteria, complementing the previous assessment.

The application of this methodology in a real context is conducted in Viseu, a district located in the centre of Portugal. Viseu has been suffering from population desertification, primarily, due to lack of employment opportunities, requiring this type of projects. Also, the centre of Portugal is the second region in the country with higher biomass availability, this aligned to the fact that the region lost a considerable amount of biomass makes it is essential to implement forest management activities to protect the forest and prevent forest fires deflagration. Intermunicipal community of Viseu Dão Lafões, an organization where Viseu is inserted, has its mission, perspective and values defined aligned with the objectives of the implementation of the SDH system by providing a sustainable growth with an economic and social cohesion (Comunidade Intermunicipal Viseu Dão Lafões). Consequently, the support from this organisation towards the system implementation is almost guaranteed.

3. RESULTS AND DISCUSSION

The weights assigned by applying pairwise comparison range from 3,6% to 16,4%. In the values of the weights lie the only difference between the first calculation and the calculation of sensitivity analysis, since in the second the weights attributed were 10% to all of the variables (obtained dividing 100% by the number of variables).

Regarding the ranking tool, three counties holding the highest scores were identified. When comparing these with the ones from the sensitivity analysis, the disparity is evident, indicating that the modification of the weights has an influence when selecting the most appropriate location to implement an SDH system, requiring thorough attention and precaution when defining them.

The complementation achieved by applying the checklist reinforces one location of the three identified in the quantitative procedure, furthermore it is possible to also identify another promising location.

4. CONCLUSION

The developed tool was applied to a real case in Portugal, considering quantitative and qualitative criteria. The quantitative approach involved normalization, application of pairwise comparison, ranking and a sensitivity analysis. Combining both approaches, results obtained presented a location with high scores in both procedures, and identified another promising one.

Future work will consider the surveys to the different councils that will be carried out, in order to collect all the necessary information to finalize the evaluation process and, therefore, select the final location. Once the location is decided, the exact same methodology should be applied to other community areas to select which one will benefit from the implementation of the SDH system.

The developed methodology takes a step towards a well-organized and thoroughly considered system implementation allowing the inclusion of different variables with different natures.

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| E102 | 11:30-11:45 |

Selection of Features in Reinforcement Learning Applied to Energy Consumption Forecast in Buildings According to Different Contexts

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ABSTRACT

The management of buildings responsible for the energy storage and control can be optimized with the support of forecasting techniques. These are essential on the finding of load consumption patterns being these last involved in decisions that analyze which forecasting technique results has more accurate predictions in each context. This paper considers two forecasting methods known as artificial neural network and k-nearest neighbor involved in the prediction of consumption of a building composed by devices recording consumption and sensors data. The forecasts are performed in five minutes periods with the forecasting technique taken into account as a potential to improve the accuracy of predictions. The decision making considers the Multi-armed Bandit in reinforcement learning context to find the best suitable algorithm in each five minutes period thus improving the predictions accuracy in forecasting. The reinforcement learning has been tested in upper confidence bound and greedy algorithms with several exploration alternatives. In the case-study, three contexts have been analyzed.

Keywords: Energy Management, Learning, Load Forecast, Multi-armed Bandit

1. INTRODUCTION

The energy management can be optimized with demand response programs focusing on the adjustment of the demand for the power with the supply. This can be achieved with consumption patterns anticipations according to prediction activities. The errors obtained from these tasks indicate the predictions accuracy which relies on several factors including algorithms applications, the available sensors, different learning parameters and the structures applied for train and test data [1]. Reinforcement learning may be useful in understanding which forecasting algorithm provides more accurate results in different contexts. The multi-armed bandit algorithm is an indicated choice due to its advantage in confidence analysis and several decisions [2]. Several applications are expert on forecasting and learning approaches considering electricity consumption in buildings. However there is evidence lack to use learning approaches to select the most reliable forecasting algorithm in an office building that monitors and records electricity consumption which is the main goal of this paper. This paper uses the multi armed bandit learning algorithm in order to identify the most reliable forecasting algorithm in different contexts.

2. MATERIALS AND METHODS

The reinforcement learning approach considers several steps in order to select the more accurate forecasting algorithm in different short periods. Data collected from sensors devices is readpted to a data structure operational by reinforcement learning activities and organized as a time series to support forecasting tasks. The next step considers energy consumption forecasts for short periods according to two different algorithms, Artificial Neural Networks and K-Nearest Neighbours. The following step considers reinforcement learning in order to evaluate which of the two algorithms is more appropriated in each context. This decision making considers the allocated period and a reward criterion. This calculation is added to an average reward which looks for the reward progress in an accumulated amount of periods. A preliminary application shown in [2] selects rooms of a building where it is intended to improve the accumulated rewards by selecting rooms with better user preferences. Following the reinforcement learning for the period in question, several parameterizations involved in this learning are updated including the exploration and exploitation rates and the learning methods. The exploration rate researches previously unexplored territory for the forecasting algorithms selection while the exploitation rate explores the knowledge involved in a particular forecasting algorithm selection.

The energy consumption is described by weekly profiles separated in five minutes periods. The forecasting week considers the 18 to 24 November 2019. Three different scenarios are considered being these classified as "morning", "afternoon" and "night". Morning takes sequences of five minutes in periods between 9AM and 12PM, afternoon keeps a sequence of periods from 1PM to 6PM and night provides a sequence of periods from 8PM to 9AM. Morning presents a total of 312 observations while afternoon presents a total of 360 and night presents a total of 984 observations. The goal is to check more accurately the consumption progress according to the different aspects featuring sequences of five minutes.

3. RESULTS AND DISCUSSION

The five minutes decisions classify the different contexts according to two alternatives, K-Nearest Neighbour and Artificial Neural Network classified respectively as 0 and 1. Reinforcement learning classifies as 0 or 1 respectively if the selected forecasting algorithm corresponds to the one with higher or lower forecasting error. The average of rewards define an accumulated reward divided by the sequences of five minutes that have passed. The upper confidence bound and greedy methods are two methods analyzed for the reinforcement learning approach. On the upper confidence bound method, morning and afternoon scenarios start with a right forecasting selection for the first five minutes. Afterwards, morning converges in a short sequence of five minutes to reward ranges between 0.1 and 0.2 increasing nearly afterwards to rewards between 0.4 and 0.5. Afternoon instead converges directly to reward between 0.5 and 0.6. Night starts with a wrong forecasting algorithm prediction for the first five minutes. This converges in a short sequence of five minutes to rewards between 0.5 and 0.8 decreasing the range nearly afterwards to 0.5 and 0.6. The greedy method has a similar behavior to upper confidence bound on the three scenarios with the exception that morning converges like afternoon directly to a high reward. Moreover while in upper confidence bound the exploitation rates show similar behavior, the greedy method tends to have different average reward behaviors for the different five minutes periods. The confidence bound displays a trust in particular forecasting algorithms in general. The observations provided by all possible configurations is that K-Nearest Neighbours is much more reliable than Artificial Neural Networks. Despite this, the confidence of the latter is high enough to state that in some particular five minutes contexts, Artificial Neural Networks is still the most convenient option.

4. CONCLUSION

This paper discusses the forecasting method that looks more adequate in each five minutes context concerning the decisions: k-nearest neighbors and artificial neural networks. Trial and test studies consider alternate configurations including the exploration, exploitation, period and learning method are considered for a more detailed analysis. The confidence bound graphs show that KNN is clearly the most trustable forecasting algorithm despite the confidence bound for ANN showing that this is not true on specific five minutes periods. The average rewards shows good decision making for the morning, afternoon and night scenarios where confidence bound looks to consist on a more powerful learning method than greedy. However greedy shows to be a less exhausting method that sometimes results in not making few mistakes that result in high average rewards decreases.

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Examining The Long Term Relationships Between Energy Commodities Prices Carbon Prices And Electricity Prices Using Markov Switching Regression

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ABSTRACT

The present work aims to quantitatively measure the relationships between the price of energy commodities, coal, natural gas, fuel oil, carbon prices and the price of wholesale electricity in Iberian Electricity Market, using 2018 daily data. To examine these relationships we considered both techniques, Markov-Switching Dynamic Regression and Markov-Switching Autoregressive Regression, and proposed two equations with electricity price and coal price as dependent variables. According to the parameters estimated in the model, coal and gas affect the price of electricity moderately at times in the day that are highly recessive. During the 2018 daily periods analyzed, the relative changes in gas and coal prices led to a loss of competitiveness of natural gas, increased by the moderate evolution of carbon prices and therefore the price of coal fell sharply in the recent past. The evolution of time varying transition probabilities and of the energy commodities prices variables is very informative. It is clear that the transition probabilities of remaining in the same state vary throughout our sample of energy commodities prices and wholesale electricity price.

Keywords: CO2 Prices; Commodities Prices; Electricity Prices; Iberiann Electricity Market (MIBEL); Markov-Switching.

1. INTRODUCTION

The wholesale electricity market, encompasses a set of transactions arising from the participation of market generators in the sessions, where the daily market is the platform in which most transactions take place. During the daily period of analysis 2018, the relative changes in gas and coal prices led to a loss of competitiveness of natural gas increased by the moderate evolution of CO2 prices and therefore the price of coal fell sharply in the recent past. The relations between carbon and the future energy market were study in France, Germany, UK and the Nordic countries by [1] in Phase II of the EU ETS (European Union emission trading scheme) (2008-2012). The results show a two-way causal relationship between carbon and future electricity prices for the Nordic countries and the European Energy Exchange. For the French market, there is evidence of a one-way causality starting from electricity to carbon prices, while the opposite ratio has been noted in the UK. A similar result found by [2]. The research proposed by [3] investigated the European market during phases I (2005-2007), II (2008-2012) and III (2013-2016). The Granger causality approach points to a two-way relationship during phase I and that in phase II it becomes unidirectional starting from electricity to carbon [3], the authors inferred there would be a weakening of the influence of the carbon market in the electricity market [3].Within this framework, we research the relationship between the price of CO2 and the prices of wholesale electricity prices, and fuel fossil prices in the Iberian Electricity Market (MIBEL), using time series with day observations. The aim of this study is examining the price relationships between the prices of spot electricity, fossil fuels and carbon emissions prices, important for the implementation of an eco-energy oriented policy that addresses environmental implications. So, for this aim, we employ the Markov-Switching regression (MSR) models, developed by [4] and [5]. A jump in electricity prices can then be considered as a change to another regime, showed by [6] and [7].

2. MATERIALS AND METHODS

The price of coal is the API2, the natural gas is the TTF, the Fuel is the CIF NWE 1% S and CO2 emission allowances is the BlueNext emissions market. The time series of these prices relate to daily data for the year of 2018 period and the dataset includes 366 observations. Unlike revisited literature typically based on univariate models, we employ multivariate models that allow appropriately to capture the possible endogenous relations, including the short-term dynamics and long-term adjustments between the price of CO2, spot electricity prices and oil, natural gas and fuel oil prices. This approach also allows us to investigate the magnitude and persistence of the effects of innovations in the prices of these energy commodities on the price of CO2. Therefore, it seems important to allow for interactions of series prices of commodities, electricity price and CO2 price. In our methodology for validate our proposed model, we used Markov-Switching regression (MSR) models developed

by [4], and following the study developed by [5]. This estimation involves multiple equations that can be characterize the time behaviour of series of prices in different regimes and this model capture more complex dynamic patterns.

3. RESULTS AND DISCUSSION

The results of Markov-switching dynamic regression show for coal price and gas price significant impact on electricity price, while the price of fuel is not significantly on price of electricity. With regard to the autoregressive structures of the model, four lags were need to capture the dynamics of electricity prices in wholesale Iberian market. For the remaining of the sample, Electricity prices are characterize as a high state. In order to assess whether the energy commodities and CO2 price contribute to predict probabilities and inquire, by looking at the temporal evolution of the time varying transition probabilities whether changes in regime seem to be triggered by changes in the energy commodities prices and CO2 Price. According, the parameters estimated in our econometric approach, suggest that during expansion daily states, coal and gas shocks have positive effect that tend to last for a limited period of days. During highly recessionary daily states, coal and gas prices affect the electricity price system only moderately.

4. CONCLUSION

The research findings allow us to get a better understanding on the nature of the price relationships between spot electricity, oil, gas and fuel and CO2 prices in the integrated MIBEL market. We extend the model developed by [4], by allowing time varying transition probabilities (TVTP), that probabilities would depend on the dynamics of energy commodities prices and Carbon prices to interpret the probabilities of switching from one state to another state of electricity price. We hope our empirical analysis, and specifically the econometric results, on the one hand using a Markov-switching model, to contribute to the literature showing that the relationship between electricity price and commodities energy prices may also be non-linear in the short-run; and on the other hand, these same results to help and inform policy makers about possible price adjustments and the nature of those relationships proposed and estimated.

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Global Model of Urban Traffic Noise Dependence on Energy Paper

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ABSTRACT

Traffic noise, as energy phenomena, depends on the energy source used. The key components of noise are rolling, aerodynamic and engine noise, with over 95% of source energy coming from engine power supply. The relationship between noise and energy spent to produce it was studied before. However, by then, limited to car noise. The upcoming developments conducted to the current paper that presents a global model including bus, truck and motorbike, based on a new concept of speed and energy that support the continued knowledge and the major developments that have now been considered. New on-site data was collected on cars and original data was collected on bus, trucks and motorbikes. An innovative approach was used to build a noise model based on Monte Carlo simulation of vehicles mix that correlates speed and energy consumption, using research data. Results allow concluding that conventional urban traffic management strategy contributes to increase energy consumption (rather than reducing noise) at a rate of almost 0.045 $kgCO_2$ vehicle/km/day. This means that in an average European town the reduction of urban maximum speed from 50 to 30 km/h does not reduce noise but increases carbon footprint in 1.17 $tonCO_2$ per day.

Keywords: Carbon footprint, Monte Carlo simulation, Traffic energy, Urban noise.

1. INTRODUCTION

The management of urban mobility usually focuses on the issue of maximizing destination source flows [1]. Scientific contributions in this area are usually based on proposals for optimizing the road network, transport offers and the organization of populations, but sustainability has recently overlapped with all these studies and has become the main guiding vector of research [2]. It is not enough to optimize routes, they have to be sustainable and for this, the demand for new energy sources is at the heart of scientific development [3], but in the immediate way the control of the speed factor [4] seems to be one of the options with greater effectiveness although not always lower speed means greater energy savings and much less noise. The contribution of this work is directed towards the management of urban traffic from a perspective of noise and energy with speed as a variable.

The exposure of urban space users to noise is one of the greatest phenomena of urban pollution [5] and its association with energy consumption has not been made. Combining these two aspects is the objective of this work by proposing a new evaluation parameter and for this purpose a unit of quantification was developed that relates the relationship of energy reduction consumed with noise reduction– ESdB – Energy Savings per deciBel. The following research question is therefore proposed:

- *How does the average traffic speed reduction affect the parameter ESdB ?*

To develop this problem, the following procedures were made:

- Initially, the work developed since 2018 was resumed in the context of which it was possible to identify the relationship of noise consumption with the variation of speed for light vehicles.
- Similar design studies have been developed for other urban vehicles, buses, lorries and motorcycles;
- Since the composition of urban traffic only in average terms can be identified for the different types of vehicles, the probabilistic percentage distribution of each type of vehicle was identified;
- As it concerns to the sound emission of each vehicle, in the same manner, rather than the average value, was carried out its probabilistic distribution;
- The Monte Carlo method methodology was mathematically developed to be possible to carry out simulations that would allow understanding the relationship of the speed variation with the parameter ESdB.

2. MATERIALS AND METHODS

The back ground research was developed by the author's team NI&DEA since 2019 and partially presented in [6] .The proposed relationship between noise and energy is based on CNOSSOS noise model that in short could be synthetized as a way to calculate noise emission based on speed, and traffic flow related to its sound power. The parameter ESdB is proposed as the amount of energy saved by noise variation as speed increases.

3. RESULTS AND DISCUSSION

Monte Carlo simulation allows considering the uncertainty span of data needed to state the relationship between

traffic noise and energy, otherwise the gap between theoretical and real data will always be a barrier for conclusions. Figure 1 presents the comparative graph for theoretical and practical data from a case study.
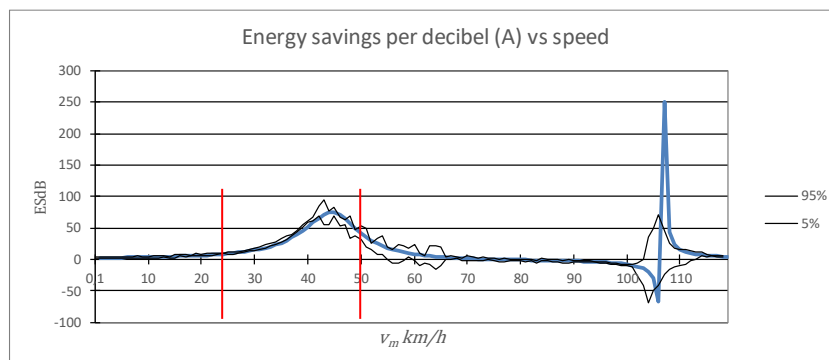
Fig. 3. ESdB parameter variation with velocity considering the randomness of data

4. CONCLUSION

The relationship between urban noise and energy is a challenging domain because a multiplicity of factors do influence it. Urban noise management has origins manly in traffic noise, no linearity exists between the velocity of vehicles, and noise neither exists with the spent energy. To avoid this randomness scenario, a numerical model based on a new parameter ESdB was developed using Monte Carlo simulation. The use of this model allows to conclude that decisions on urban noise should consider both noise and related energy savings. Relative to previous research, this new model is able to consider all the different vehicles with random fuel consumption and noise emission complemented with the unsystematic mix of traffic. The previous linear average data approach give place with this work to random numerically analyzed data.

FUNDING

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13:45-14:45 @ Meeting ID: 948 1336 4454

E080	13:45-14:00

Performance of Silver, Alumina & Graphene Oxide Nanofluid Over the Microporous Surface in Nucleate Pool Boiling

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ABSTRACT

The effect of nanofluid over the microporous surface still needs to explore in several phase change heat transfer applications. The objective of the study examines the performance of nanofluid over microporous surfaces in NBHT. The study analyzed three different; carbon (Graphene oxide), metallic (silver) and ceramic (Alumina) nanofluid for nucleate pool boiling heat transfer (NBHT). The literature reported enhanced performance of nanofluids over the plane surface is verified in the study before proceeding to the detailed analysis over the microporous surface. Three different concentrations of 0.01%, 0.001%, and 0.0001% were tested for each type of nanofluid. For plane surface, the critical heat flux (CHF) has been increased to 1047, 1046, 1800 [kW/m^2] for Ag and Alumina and GO nanofluid from 800 [kW/m^2] for deionized water. The average increase in heat transfer coefficient (HTC) is 2.34, 1.47, and 2.06 times for Ag and Alumina and GO nanofluid, respectively. Graphene oxide (GO) nanofluid resulted in the highest performance for the plane surface; however, it resulted in the extra GO layer's deposition and wholly covered the microporous surface, severely affecting the performance. For GO nanofluid of 0.001% over M surface, CHF and HTC values decreased to 0.38 and 0.17 times.

Keywords: Critical Heat Flux; Energy Efficiency; High Power Electronics; Micro-nano surfaces; Nanofluids; Thermal Management.

1. INTRODUCTION

The recent innovations and developments in two-phase heat transfer techniques are the result of this trend [1]–[3]. Both microporous surfaces and nanofluids are reported in the literature with enhanced phase change heat transfer. However, the effect of nanofluid over the microporous surface still needs to explore. The objective of the study examines the performance of nanofluid over microporous surfaces in NBHT. A detailed analysis is performed using nanofluids with diverse nature such as metallic, ceramic, and carbon-based nanofluid. The literature reported enhanced performance of nanofluids over the plane surface is verified in the study before proceeding to the detailed analysis over the microporous surface.

2. MATERIALS AND METHODS

The detailed synthesis technique for microporous surfaces and nanofluids, and the experimental procedure, validation of the user testing setup, and data calculation and uncertainties can be found in the group's previous publications [4], [5].

3. RESULTS AND DISCUSSION

Compared to metal nanoparticles and ceramic nanofluid, the deposition concentration for GO nanoparticles is observed to be higher. The SEM analysis of the testing sample after the experiments, Figure 5, shows a deposited layer of GO on microstructure, which completely covered the tested samples' microspores. As stated earlier, the microporous surface (M) helps in separating the flow of bubbles and liquid by providing separate pathways for their flow. It is believed that the deposition of nanoparticles has severely affected these vapor and fluid channels and decreased heat transfer efficiency in terms of HTC and maximum ability of heat transfer in terms of CHF. Compared to Ag and alumina, GO nanofluid resulted in a comparatively higher effect even at a lower concentration. The superheat value has been increased for higher concentrations of 0.001% and 0.01%.

All the nanofluids resulted in enhanced performance for the P surface. However, both CHF and HTC values have been affected over the M surface. GO nanofluid resulted in the highest performance over P surface, with 2.25 and 2.06 times improvement in CHF and HTC. However, its performance over the microporous surface is more significantly lower. Compared to AG and alumina, GO nanofluid increased deposition and made an external layer on the surface. Even for the lowest concentration of 0.0001%, the effect is apparent and increased with increased concentration. For 0.001% GO nanofluid, the CHF and HTC are 0.38 and 0.17 times the original M surface.
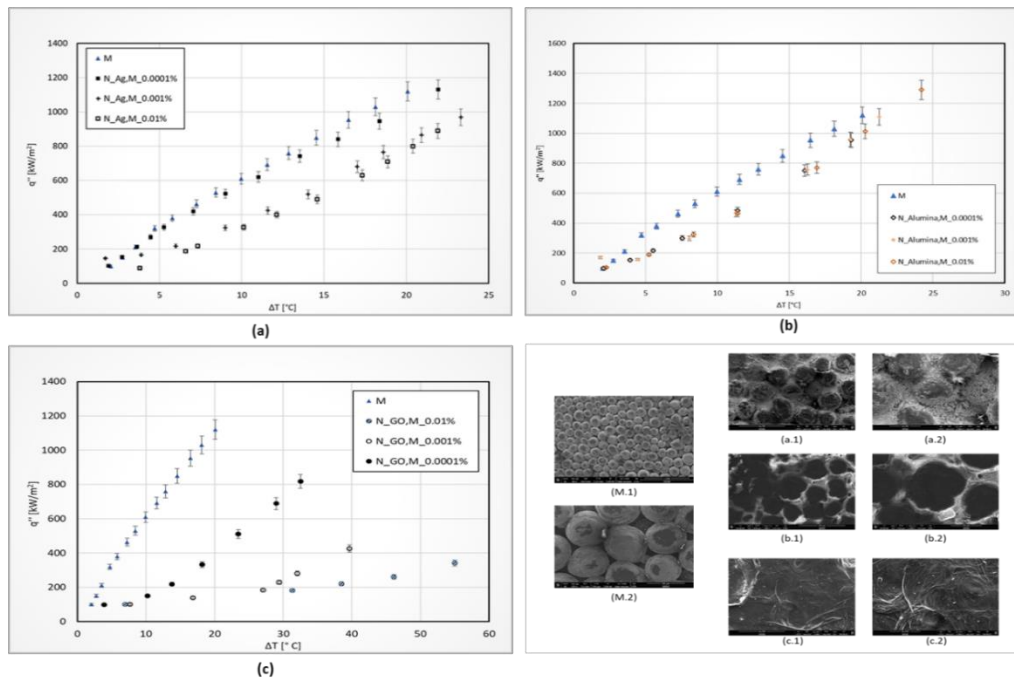
Figure 5. NBHT curve for nanofluid as working fluid over microporous (M) surface: (a) Ag nanofluid, (b) ceramic nanofluid, (c) GO nanofluid.. Morphology of microporous surface before and after nanofluid based NBHT experiments: (M.1) and (M.2) represents microporous surface before experiments: (a.1) and (a.2) represents M surface after Ag nanofluid experiment, (b.1) and (b.2) represents M surface after alumina nanofluid experiment, (c.1) and (c.2) represents M surface after GO nanofluid experiments.

4. CONCLUSION

The nanofluid resulted in deposition over the microporous surface, which affects the porosity. GO nanofluid resulted in a thick layer over the microsurface, which completely covered the microchannels and resulted in the lowest performance. Compared to metals nanofluid, ceramic particles were observed to deposit in less quantity due to lower density, resulting in a lower effect on CHF and HTC values. For higher concentration, the deposition of the particles almost covered the pores over the micro-porous surface, and hence an increase in concentration resulted in lower HTC and CHF values.

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Design of a 1.5 MW Supercritical CO₂ Power Group for a Waste Heat Recovery System

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ABSTRACT

Supercritical carbon dioxide closed and semi-closed power cycles have been receiving increasing attention mainly due to their promising performance, compactness and expected operational flexibility. The paper deals with the layout arrangement and machinery design of a 1.5 MW power group for a supercritical carbon dioxide recuperated cycle for waste heat recovery systems. All the power-group components were preliminary designed using 1-D and 2-D models. Furthermore, they were modelled and optimized using the commercial CFD tool Ansys-CFX.

Keywords: Heavy industry, Recuperated Brayton cycle, Supercritical CO2 systems, Turbomachinery design, Waste heat-to-Power

1. INTRODUCTION

Supercritical Carbon Dioxide (sCO2) closed and semi-closed power cycles are expected to have many appealing aspects: high performance and compactness, good operational flexibility, reduced water and footprint consumption. Their application to waste heat recovery could help in reaching the energy saving challenging targets set by EU.

This study aims to arrange a suitable layout for a power group for a 1-2 MW sCO₂ recuperated Brayton cycle for WHR in the industrial sector. It considers the most relevant components' constraints and features as well as the system part-load flexibility. All the machines (compressor and expanders) have been designed from a 0-D to a 3-D level and analyzed at the nominal point.

2. MATERIALS AND METHODS

The sCO2 reference recuperated cycle was preliminary set to achieve a good trade-off between power maximization and minimization of the estimated pay-back period [1]. It is made of a compressor, an expander (E1) on the same shaft of the compressor, and a power turbine (E2) aerodynamically connected with the expander E1 and assembled together with the electric generator on a second shaft. Such a configuration was considered the most proper to assure good operational flexibility at part-load, fast start-up and shut-down.

The free-standing shaft speed was fixed at 30000 rpm to compact the compressor designing as one-stage centrifugal component. To avoid a bi-phasic flow at the inlet section and transonic flow at the impeller exit section, the inlet pressure was fixed at 180 bar. It was the starting point for the design of the power group.

Once the general layout was selected, the machines were designed following an iterative procedure. First, each component and sub-component was preliminary designed using 1-D and 2-D models according to what was reported in the literature [2].

After checking all the relevant global parameters, a detailed design was carried out through 3-D CFD methods. The commercial software ANSYS-CFX was adopted for the fluid dynamic numerical analyses. For each sub-component (impeller/rotor, diffuser/nozzle), an H-O-H 3D mesh was realized. The appropriate refinement of structured meshes was defined by preliminary grid independence analyses. Overall mesh quality parameters (maximum and minimum face angles, edge length ratio, element volume size) were checked to provide good accuracy and a reasonable convergence time. Steady-state 3D viscous flow simulations were set up using a high-resolution advection scheme to discretize Navier-Stokes equations. An SST (Shear Stress Transport) model was selected as turbulence model for the compressor analysis, while a k-ε model was applied for both turbines. To describe the working fluid, the real gas cubic equation Aungier-Redlich-Kwong Model was selected for all the machines except for the compressor, which works with CO2 close to the critical state. For this component, a more accurate model was adopted to evaluate the working fluid thermodynamic properties. Such a model is based on the NIST Real Gas Properties (RGP) database and considers both the liquid and the vapour phase in a biphasic mixture.

3. RESULTS AND DISCUSSION

Based on the starting cycle specifications, a single-stage radial compressor was designed. Therefore, the initial

3D geometry, made of a shrouded impeller and a bladed diffuser was iteratively modified to reduce stalls and stagnation zones detected mainly in the impeller elbow close to the hub and blade pressure side and in the diffuser at the suction side.

Moreover, the inlet pressure was increased to avoid a bi-phasic flow at the inlet section, and the overall pressure ratio was reduced to limit the relative Mach number at the impeller exit section.

The design of the expander E1 was arranged to balance the compressor power demand. The machine is made of a shrouded centripetal rotor with a vaneless nozzle. The CFD analysis of the machine at nominal conditions has not highlighted severe fluid dynamic issues.

The turbine E2 was designed on the basis of the remaining pressure ratio. As the expander E1, it is made of a shrouded radial rotor and a vaneless nozzle.

To complete the design of the power group, leakage flows through cover disks and casing which deeply affect volumetric and windage losses were taken into consideration for each component. Since no specific correlations have been developed yet for sCO2 turbomachines, the numerical formulas reported in [2] for leakage and disk friction losses were adopted for a preliminary evaluation of the most relevant secondary losses.

In Table 1, the main thermodynamic data and the achieved performance are reported for each designed machine of the power group.

Table 1. Overall nominal performance from CFD analyses

	Compressor	Turbine 1	Turbine 2
Total inlet pressure [bar]	180	287	238
Total inlet temperature [°C]	30	374	354
Total exit pressure [bar]	292	240	182
Total exit temperature [°C]	41	355	324
Speed [rpm]	30000	30000	30000
Adiabatic efficiency* [%]	93.8	94	96
Internal Power* [kW]	575	809	1311

*without volumetric and leakage losses

4. CONCLUSION

The paper presents the layout arrangement, and the machinery design results of a power-group for a 1.5 MW supercritical CO2 recuperated system. Due to the specific features of the sCO2 reference cycle and the plant capacity, a dual-shaft layout made of a free-standing group and a power turbine was conceived for the power group to provide good performance in nominal and off-design operational conditions. In the end, the system respects all the main mechanical and aerodynamic constraints. Once the compressor was designed and analyzed at nominal conditions using 3D quasi-steady CFD methods, the expanders E1 and E2 were designed accordingly. All the components do not seem to show any severe issue at the design point.

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E107   **14:15-14:30**

Electrical Energy Storage Using a Supercritical CO_2 Heat Pump

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ABSTRACT

This work proposes a new Pumped Thermal Energy Storage (PTES) configuration that works with supercritical CO_2 as the working fluid and molten salts as the thermal storage fluid. The net work generated by this novel proposal is 12.46 MW in the load and 10 MW in the discharge, reaching an efficiency of 80.26%. In addition, a techno-economic optimization is carried out to quantify the discounted cost per unit of energy discharged from this storage technology with a value of 0.116 €/kWh.   Which places this technology as a strong candidate to be the energy solution of the future due to its low wear per duty cycle, easy power scalability, and presents a lower initial cost than other technologies with low LCOS.

Keywords: Brayton cycle; heat pump; renewable energy; supercritical CO2; thermal storage.

1. INTRODUCTION

The energy market's future raises a new situation. A reasonable amount of the generation plants is not manageable, which means their supply depends on external factors, mainly climatic ones. The global energy market has been changing progressively in recent years. This situation can be explained with different facts, being the most outstanding ones the growing concern for the environment and the climate change, the increase of fossil fuels cost and their depletion, and the development of new renewable technologies that are increasingly more competitive.

The research aims to obtain a validated design of a PTES system with a standardized low storage cost, "Levelized Cost of Storage" or "LCOS," that also allows achieving high storage performances. The key parameter to analyze is the cost updated per kWh stored over the lifetime of the LCOS system. A thermo-economic optimization of the system will be performed to find the minimum LCOS, keeping the system's efficiency consistently above 65%. An analysis will be carried out in terms of overall efficiency, scalability, lifecycle analysis, and costs, quantifying the economic potential of the solution. The results of these analyzes are compared with other energy storage solutions, taking as reference the initial analysis of [1].

2. MATERIALS AND METHODS

A PTES system absorbs electricity from the grid and transforms it into thermal energy using a heat pump. The thermal energy is stored and later used to power a heat engine, producing electricity. The system uses a reversible cycle based on supercritical CO_2 to work as both a heat pump and a heat engine. When this stored energy is needed, there is a switch in the flow direction to turn the heat pump into a heat engine [2]. This state means that the PTES has two different working ways: the charge and the discharge cycle (see Fig. 1).
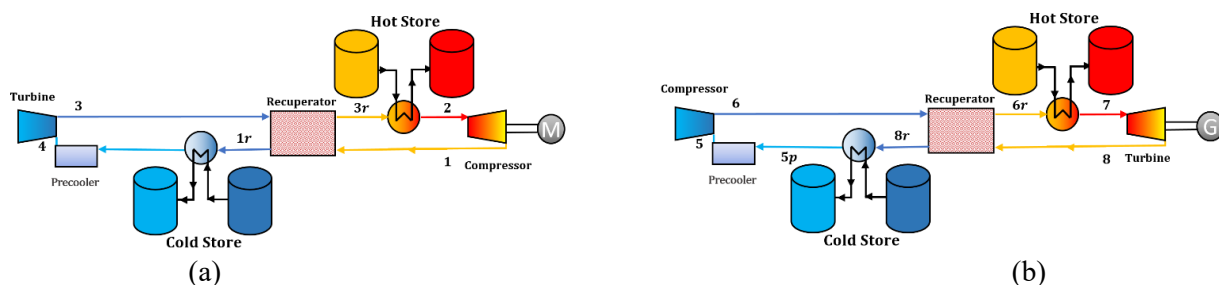
Figure 1. Proposed PTES. (a) Charge cycle and (b) Discharge cycle

In order to obtain the best cycle in terms of efficiency and cost, there have been simulated and analyzed more than 200.000 cases. First, the thermodynamic cycle operation range of the variables was set. Then all these combinations were simulated using the EES (*Engineering Equation Solver)* program to obtain their efficiency and equipment sizes.

3. RESULTS AND DISCUSSION

Cost calculation estimates have been based on different papers [3, 4] about PTES systems and s-CO$_2$ Brayton cycles. The optimal plan presents an LCOS of 0,116 $\frac{€}{kWh}$, it is of high interest to compare the designed PTES systems with other energy storage solutions [1] and [5], whose LCOS are shown in Fig 2.
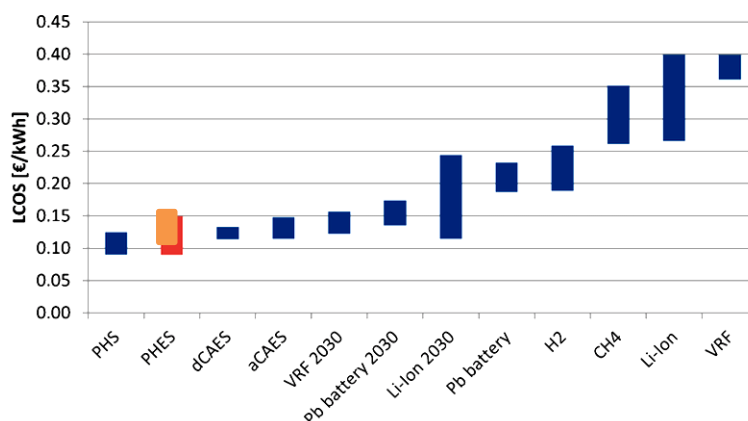
Figure 2. PTES. Costs in operation according to the storage technology.

As it can be seen, this value places the PTES of this research as one of the most cost-efficient technologies. The mark is surpassed by the best PHS (Pumped-storage hydroelectricity) and PHES (Pumped Heat Electrical Storage) cases. The initial cost is much higher for both technologies, and the geographical conditions are particular and rare.

4. CONCLUSION

This work aimed to determine if PTES systems, specifically those working with SCO$_2$, were competitive enough among energy storage solutions. First, the ability of this technology to be installed almost anywhere means a clear advantage over the best cost-efficient alternatives so far. Also, its performance is not diminished after a long sequence of cycles, unlike chemical batteries. However, not only the technology by itself is favorable, but the 80.26% of efficiency and 0,116 $\frac{€}{kWh}$ results make this technology a strong candidate to be the energy solution of the future. This system has differential factors compared to its competitors: Absence of geographical conditions, low wear per work cycle, lower initial cost than other low LCOS technologies and allows easy power scaling.

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Techno-economic Comparison of Diabatic CAES with Artificial Air Reservoir and Battery Energy Storage Systems

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ABSTRACT

In the present paper, Diabatic Compressed Air Energy Storage (D-CAES) based systems are compared with Na-S and Li-Ion Battery Energy Storage (BES) systems on the basis of the Levelized Cost of Storage (LCOS) method. Analyses have been carried out by varying key parameters such as the installed power, the charge/discharge time periods, the price of electricity and the fuel cost. Results show that the adoption of D-CAES systems can lead to a better economic performance in respect to mature and emerging BES technologies. Sodium-Sulfur (Na-S) battery based systems show a better economic performance in comparison with Lithium-ion (Li-ion) based ones. It has been noticed as D-CAES economic performance improves by increasing the size of the system both in terms of installed power and storage capacity. D-CAES solutions can achieve a LCOS lower than that shown by Na-S batteries, provided that the size of the system and the price of electricity are large enough.

Keywords: Battery Energy Storage (BES), Compressed Air Energy Storage (CAES), Electric Energy Storage (EES), Levelized Cost of Storage (LCOS).

1. INTRODUCTION

In the last decade, the production of electricity from non-programmable Renewable Energy Sources (RES) - such as sun and wind - has rapidly increased worldwide. Such a growth has resulted in a relevant reduction of CO_2 emissions and in a remarkable improvement of the sustainability of the overall energy system. On the other hand, the intermittency of RES availability and the uncertainty in estimating along the time the amount of producible electricity pose significant problems in terms of safe and reliable electric grid operations. Electric Energy Storage (EES) can give a relevant contribution in mitigating the above issues and, therefore, further promote the use of RES for electricity production.

Therefore, this study is aimed at assessing the techno-economic of medium scale storage plants (5-20 MW) suitably located on the electric grid with an energy storage capacity of tens/hundreds of megawatt-hours. In order to ensure the actual feasibility of the storage systems, only BES and CAES mature technologies are considered: Sodium-Sulfur (Na-S) batteries, Lithium-ion (Li-ion) batteries,) and diabatic CAES (D-CAES) plants equipped with artificial storage tanks. Techno-economic performance of the above storage concepts are compared on the basis of the Levelized Cost of Storage (LCOS) method

The techno-economic performance of systems under comparison has been evaluated by varying the absorbed power and the storage capacity. The influence of other key quantities such as the electricity and fuel prices is also investigated.

2. MATERIALS AND METHODS

The D-CAES thermodynamic performance is evaluated by a computational model developed by the Authors described in detail in [1]. Process quantities (i. e. pressures, temperatures, mass flows, etc.) are then used to size the main plant components. Sizes of components constitute the input to evaluate investment and operational costs required to calculate the LCOS. The plant investment cost has been estimated by adopting an individual cost factor method.

BES systems, unlike CAES plants, because of their modular design can be scaled to any capacity to serve utility-scale applications. Therefore, a simpler tecnho-economic model based on few global design quantities and performance indicators can be succesfully adopted. BES investment cost is evaluated by introducing two coefficients accounting for installed power and storage capacity respectively, according to [2]
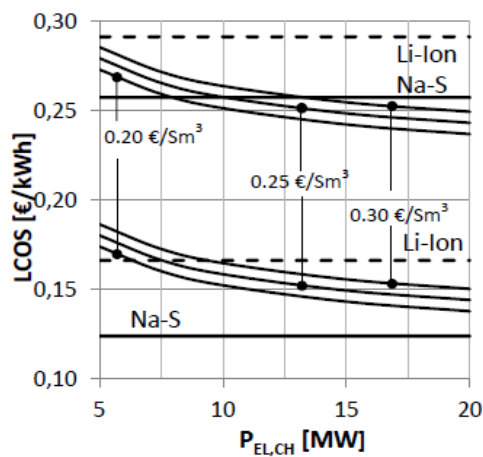
Fig 1. LCOS by varying the rated charging power $P_{EL.CH}$.   Case t_{CH} = t_{DS}=6h.
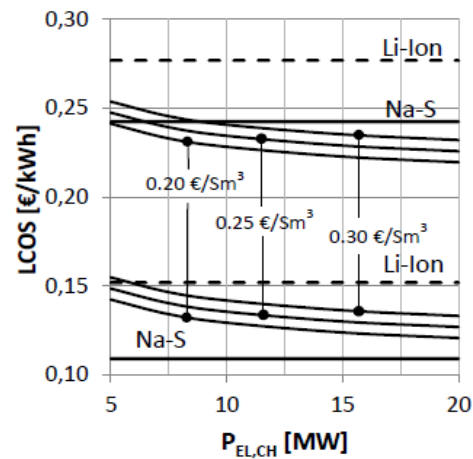
Fig 2. LCOS by varying the rated charging power $P_{EL,CH}$. Case t_{CH} = t_{DS}=10h.

3. RESULTS AND DISCUSSION

Results are summarized in Figs. 1 and 2, where the LCOS achieved by the different EES systems under comparison is plotted against the rated design power absorbed during the charging phase $P_{EL,CH}$. Figures refer to systems sized for charging time periods t_{CH} of 6 and 10 hours, respectively. A discharge time period t_{DS} equal to t_{CH} is assumed. Curves plotted in the upper part of both figures refer to an electricity price of 0.1 €/kWh, while curves in the lower region of the graph concern with a free provision of electricity.

In any case, it can be noticed as the LCOS of BES systems does not vary by varying the rated charging power. D-CAES levelized cost shows instead a decreasing trend by increasing $P_{EL,CH}$.

With reference to Fig. 1 (t_{CH}=t_{DS}=6h), in case of electricity price of 0.1 €/kWh, the LCOS of D-CAES is always lower than that of Li-Ion. D-CAES shows the ability to achieve an LCOS even lower than that of Na-S based systems (i. e. 0.257 €/kWh). As an example, for a fuel cost of 0.2 €/Sm³, the levelized cost of D-CAES is smaller than that of Na-S if $P_{EL,CH}$ is higher than 7.5 MW. A $P_{EL,CH}$ value of some 13 MW is required to break even if the fuel cost is raised to 0.3 €/Sm³.

The same trends are observed in case of cost free electricity (lower part of Fig. 1). Na-S based systems show the best LCOS. D-CAES achieves a better performance in respect to Li-ion batteries for values of $P_{EL,CH}$ higher than 6 MW if the fuel cost is set at 0.2 €/Sm³, and higher than 10 MW if the fuel cost is increased to 0.3 €/Sm³.

Fig. 2 refers to storage systems sized for a charge/discharge periods of 10 hours. LCOS values found for all EES systems under consideration are, all things being equal, lower than those shown in Fig. 1. In case of electricity price equal to 0.1 €/kWh, D-CAES prevails over Na-S if the installed power is greater than 8 MW, whatever the fuel cost. Interesting values around 0.22-0.23 €/kWh are achieved for rated design power in the order of 15-20 MW. In case of cost free electricity supply, LCOS of D-CAES varies between the Li-ion (0.15 €/kWh) and the Na-S (0.11 €/kWh) ones.

4. CONCLUSION

D-CAES design solutions are compared with Na-S and Li-Ion Battery Energy Storage (BES) systems on the basis of the Levelized Cost of Storage (LCOS) method. Analyses have been carried out by varying key parameters such as the installed power, the charge/discharge time periods, the price of electricity and the fuel cost. Results show that the adoption of D-CAES systems can lead to a better economic performance in respect to mature BES technologies. It has been noticed as D-CAES economic performance improves by increasing the size of the system both in terms of installed power and storage capacity. D-CAES solutions can achieve a LCOS lower than that shown by Na-S batteries, provided that the size of the system and the price of electricity are large enough.

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Session 6B - Life Cycle Analysis Methodologies
15:00-16:15 @ Meeting ID: 948 1336 4454

E069   **15:00-15:15**

Life Cycle Environmental Impacts of Water Use in Building: A Case Study in Qatar

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ABSTRACT

Water use in buildings accounts for a large share in global freshwater consumption where research on the impacts of water use received relatively little attention. This study attempted to quantify the environmental impacts of life-cycle water use in a multi-family residential building in Doha (Qatar) through life cycle assessment (LCA). Building modelling was based on Building Information Modelling (BIM) tool. The LCA score indicated much higher impacts in the raw water treatment stage in Doha, which involves energy-intensive thermal desalination where the water use stage resulted nearly half of the impact as the raw water treatment. The annual total emission was 59440 kg CO_2 for the overall life cycle of water use in the modelled building. This study will be beneficial to both water authorities and building research communities in establishing more sustainable water use policies for specific regions/countries.

Keywords: Environmental impact, Life cycle assessment, Residential buildings, Urban water cycle, Water consumption in buildings

1. INTRODUCTION

Buildings are considered as one of the highest consumers of fresh water. At the same time, the use of water in buildings creates a wide range of environmental impacts [1]. Although several studies are being performed in water research area, however, overall impact analysis of water use in buildings through LCA are rarely reported. Those that have typically are associated with buildings located in the United States, Europe or Australia, while there are no studies concentrated in top water-stressed countries where desalination plays a key role in water supply. In this paper, we have examined water use impacts for a modelled residential unit in Doha, Qatar. The LCA results provided relative contribution of each water use stages in order to focus on the major contributing stages that demand more attention and research.

2. MATERIALS AND METHODS

The Case Study Building
Building Information Modeling (BIM) was used to model a representative case study residential building. Next, Autodesk Green Building Studio (GBS) was employed to determine baseline annual energy and water requirements for the modelled building.

Building Characteristics
The case study building was designed as a multi-family residential building (number of residents: 30) up to the third floor. The floor area of the model building was 1189 m^2. The design of the building followed all suitable codes and regulations of Qatar.

Water and energy requirements
Further analysis of the building model using GBS provided the annual water and energy consumption by category. Energy calculations followed the requirements of ASHRAE 90.1-2010 and water use calculations were based on the American Water Works Association (AWWA) Research Foundation 2000 Residential/Commercial and Institutional End Uses of Water report and the 2000 Uniform Plumbing Code of the International Association of Plumbing and Mechanical Officials (IAPMO).

Water Use Stages
Domestic water undergoes several transitions before reaching households for direct use, and again after use when it is discharged from the buildings. Five water use stages were identified to analyze the complete water use scenario for residential buildings: water treatment, water transportation, water use by households, wastewater transport, and wastewater treatment.

LCA Framework

The goal of this study was to quantify the life cycle impacts of water use in residential buildings. Hence, the functional unit was 3130 m^3 of high-quality potable water used annually per residential unit, calculated as the basic water requirement by GBS.

3. RESULTS AND DISCUSSION

Figure 6 represents the water use impacts in terms of CO_2 emissions for modelled building. Grouping the total emission of different water use stages clarifies that largest impact is due to the raw water treatment stage. As mentioned earlier, the treatment of raw water in Doha is completely dependent on MSF thermal desalination, which consumes a large amount of energy (fossil fuel) for operation. The use of steam for supplying thermal energy, and electricity use for pumping in the desalination process were the main contributors to the CO_2 emission compared to small contributions from chemical use in pre- and post-treatment. The second highest impact generated from building use stage, contributing nearly half of the impact as water treatment stage. The impact of raw water treatment and water-use within the buildings in terms of CO_2 emissions are 38,070 and 18,249 kg CO_2 per year, respectively. For the wastewater treatment stage, the CO_2 emission was 2,044 kg CO_2 which is much less compared to the previously discussed two stages. The CO_2 emissions for transportation of potable water was found 907 kg whereas for the wastewater transportation, it was found to have a value of 170 kg CO_2 per annum.
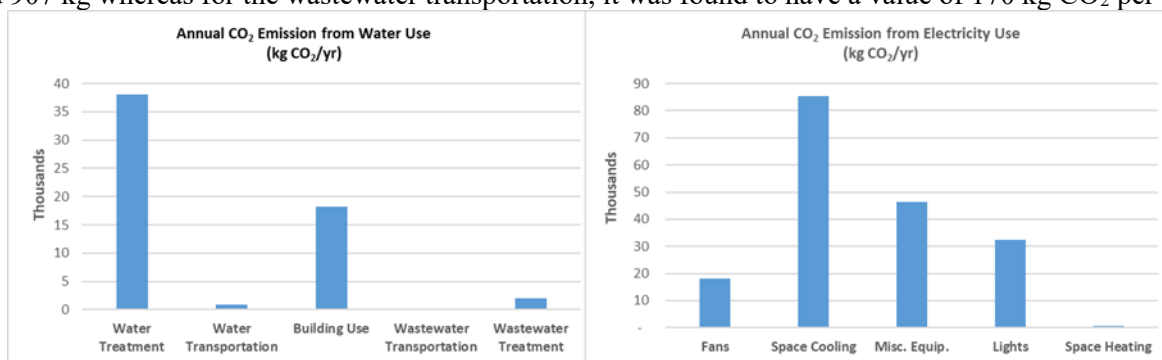
Figure 6: Annual CO_2 emission from water-use stages and electricity use in the case study buildings. The left part of the figure clearly shows that the main impact generated from the raw water treatment stage for Doha. Right part of the figure represents the CO_2 emission potential for case study building for annual electricity use.

According to the specifications of the electricity grid mix for Qatar, the annual CO_2 emissions for electricity use in modelled building was investigated (Figure 6). Calculation of the CO_2 release from the annual electricity (basic required) use revealed that building in Doha was responsible for 111,314 kg where the total CO_2 release for overall water use stages was 59,440 kg CO_2 over an year.

4. CONCLUSION

This comprehensive LCA analysis creates the baseline, based on the quantitative scores, to settle more specific water policy and guidelines for buildings. Moreover, the results highlight the value in existing national research strategies at improving desalination efficiency which will have a carry on effect on significantly reducing building water use impacts.

For a complete water use impact assessment for buildings in future studies, embodied water should be included along with operational water. Embodied water use can be significant compared to the life cycle operational water use [2]. Therefore, the impact assessment for water use will provide a more comprehensive result if both construction and the operational phase is considered. Furthermore, we limited the study to residential units. However, there are several other building types that require complete impact assessment for water use. Therefore, this study can open the door to several other research opportunities, including embodied water, different types of buildings, and more locations, to assess the total impact of water use over a building's life cyclework.

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Environmental Performance Comparison of Active Living Wall and Commercial Air Purifier: Life Cycle Assessment Study

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ABSTRACT

A wide variety of particulate matters, gaseous contaminants, mold and pollen are found as air pollutants in building environments which can have significant impact on human health and wellbeing. To address the indoor air quality issues, several ways have been adopted so fur such as source minimization, dilution, use of air cleaning devices as well as vertical greening systems. The application of sustainability for these air cleaning methods has become an important challenge today. Hence, this study presents a comparison of two different indoor air cleaning methods including commercial air purifier (CAP) and active living walls (ALW) through life cycle assessment (LCA). Results of this LCA study showed potential reduction of environmental impact in case of using ALW for indoor spaces compared to commercially available air purifier. Although the impacts of the CAP production are comparatively lower to the ALW system in this study, however, the overall impacts are much significant when looking at the entire product life cycle. This preliminary study aims to benefit the building professional through our framework of estimating the environmental cost of two different indoor air purification methods.

Keywords: Active living wall; Commercial air purifier; Indoor air quality; Life cycle assessment.

1. INTRODUCTION

Compared to the other parts of the world, in Middle Eastern countries people tend to spend their time longer than average in indoor spaces as a result of harsh weather such as higher ambient temperature and humidity [1], [2]. In such condition, coupled with the ambient air pollution level, IAQ has become a great concern in this region. Along with the indoor portable air purifiers, building professionals are showing high interest for different indoor vertical greening systems, such as active living wall (ALW), for combating indoor air pollutants which also adds aesthetic benefits for the occupants [3], [4]. However, still there is very limited research results about the life cycle performance of these different indoor air purification methods from environmental perspective.Hence, this study aims to assess the environmental impacts of a specific ALW system and a commercially available indoor air purifier through life cycle assessment (LCA) and finally compares the impacts of the two systems.

2. MATERIALS AND METHODS

The LCA study is based on a ALW and CAP system which are located in a small office room inside an educational institute (University located in Doha, Qatar).

Description of ALW and CAP

ALW system is an innovative improved form of vertical greening systems which allows a forced air flow through the plants rooting zone and substrates to improve the removal capacity of indoor air pollutants. This advanced greening technology has the potential to reduce both gaseous pollutants and particulate matters through adsorption and absorption process as well as has the ability to reduce indoor temperature and increase in humidity. The ALW system used for this study is a felt based system where several felt layers have been used as substrate, supported by a PVC foam plate. Pre-grown plants have been selected and inserted into the pockets of felt layers. Automated irrigation system helps to supply the required water and nutrients while the axial fan on the top of the system ensures the sufficient airflow through the plants rhizosphere zone. On the other hand, HEPA filter is considered as one of the most effective filters for particulate matters which is one of the main concerns in this region. In this study, a commercial HEPA filter has been used with a three stage filtering process including pre-filter, HEPA filter and finally carbon filter for VOC/odor removal.

Basic Approach to LCA

In this study, LCA has been used to evaluate the environmental burdens of ALW and CAP systems. LCA tool GaBi has been used to assess the environmental impacts.

3. RESULTS AND DISCUSSION

Results of this study showed potential reduction of environmental impact in case of using ALW for indoor spaces compared to commercially available air purifier. Although the impacts of the CAP production are comparatively

lower to the ALW system in this study, however, the overall impacts are much significant when looking at the entire product life cycle. The total CO_2 emissions for the one year life cycle of ALW and CAP systems were found 820 and 1440 kg, respectively.

The highest impacts in each category are due to the use phase, except for human toxicity category. In this impact category, the production of steel based products are found mainly responsible for higher impact in the case of ALW while for CAP, the production of outside aluminum (Al) cabinet is the major factor for higher impact. For ALW system, production of irrigation supporting tank, axial fan, and irrigation pump resulted 63%, 19%, and 6% impacts, respectively, where for CAP system, Al cabinet alone was found to have 90% impact in human toxicity category. For the rest of the categories, the highest percentage of impact lies in use phase which is due to the use of electricity. In the case of ALW system, the impacts from electricity use are 81%, 55%, 85%, and 82%, respectively, for the climate change category, terrestrial acidification, fossil depletion, and marine eutrophication category. In each impact category, ALW system was found to have less environmental impact. For climate change, ALW system resulted 848 kg CO2 equiv. where the number was 1491 kg CO2 equiv.for CAP system. Terrestrial acidification causes due to the deposition of inorganic elements (i.e. sulphates) in the soil which ultimately changes the acidity of the deposition area. In this study, the impacts resulted for ALW and CAP systems are found 1.92 and 2.58, respectively, for terrestrial acidification category. Fossil fuel depletion category estimates the damage to natural resources due to fossil fuel extraction. In this comparative study, ALW resulted 45% lower than the CAP system in fossil depletion category where ALW resulted nearly 43% lower than the CAP system in marine eutrophication category. However, for human toxicity category both ALW and CAP systems resulted in similar range, 33.5 and 34.9 kg 1,4-DB eq., respectively.

4. CONCLUSION

One of the most important findings of this LCA study is that the use phase played a major role in the life cycle of both type of air purification methods where most of the impacts were due to the use of electricity. The impact of water use was found very minimum compared to electricity in case of ALW system. Hence, this study suggest to use renewable energy to a certain possible extent in combination with the usual electricity supply from grid. Again from the raw materials viewpoint in ALW system, as stainless steel has been found as a dominant factor for environmental burden, several other suitable materials can be used to replace the stainless steel such as hard wood, recycled plastic or even coated steel that can survive in ALW environment. Similarly, for CAP system recycled plastic can be the sustainable alternative for Al based outside cabinet.

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E064	15:30-15:45

The Carbon Footprint of a Furniture Industry Facility: Evaluation of the Impact Progress over 2013-2019

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ABSTRACT

The increasing social and political pressure on the development of more sustainable industries has led to an increase in the importance given by organisations to their products' impact on the ecosystems. Carbon Footprint is a valuable tool in the assessment of those impacts. This study used Scope 1, 2 and 3 emissions were considered to estimate the carbon emissions of a furniture industry plant and evaluate the evolution of those emissions in the 2013-2019 period.. It was found that the main contributor to the studied plant carbon emissions is electricity consumption. In the scope of this work, it was possible to notice positive progress in the greenhouse gas emissions over that time, mainly throughout 2017-2019, as a result of an important investment in solar energy.

Keywords: Carbon Footprint; Direct and Indirect Emissions; Electricity Consumption; Furniture; Global Warming Potential; Greenhouse Gases

1. INTRODUCTION

Over the last decades, greenhouse gas (GHG) emissions from anthropogenic sources have been appointed as the primary cause of climate change. This way, accurate estimation of GHG emissions is essential to provide valid data to policymaking procedures [1]. The carbon footprint (CF) is a vital tool to assess the anthropogenic activity's environmental impact [2]. CF presents the total amount of GHG, usually in carbon dioxide equivalent (CO_2 eq), emitted during a specific period or over the product life cycle [3]. Quantification of CF requires a detailed analysis of the process inputs and outputs and demands the specification of organisational and operational boundaries to determine the considered activities [4].

This study pretends to estimate the carbon footprint resulting from a furniture industry plant activity over the 2013 to 2019 period and to evaluate the evolution of the environmental impacts of the studied facility. The case study is an industrial plant from a multinational company located in the northern part of Portugal. There are limited Portuguese perspectives on the carbon footprint of furniture factories, thus, this paper addresses a gap in the literature and adds to informed practice in this sector. Therefore, the principal contribution from the presented case study is to address how sustainable solutions can reduce the carbon footprint generated inside the proposed boundaries of the production facility.

2. METHODOLOGY

According to the Intergovernmental Panel on Climate Change (IPCC), CO_2 emissions might be estimated by "combining the information on the extent to which a human activity takes place (called *activity data* or *AD*) with coefficients which quantify the emissions or removals per unit activity", as it is translated by Eq.1.

$$Emissions\ (CO_2\ eq) = AD \times EF \tag{1}$$

AD can relate, for example, to electricity consumption, travelled distance or the amount of produced waste. The emission coefficients or factors (EF) can be provided by different sources, namely the Department for Environment, Food and Rural Affairs (DEFRA), IPCC and GHG Protocol. GHG Protocol Corporate Standard states that GHG emissions can be categorised into three scopes. Scope 1 accounts for GHG emissions from sources owned or controlled by the company (direct emissions). Scope 2 relates to the emissions from the generation of purchased electricity. Scope 3 is an optional reporting category as it accounts for emissions that are a consequence of the company's activities but whose sources are not owned or controlled by the organisation. For Scope 1 emissions, the GHG emissions from fixed sources, fugitive emissions, and company-owned vehicles, including forklift trucks, have been considered. Scope 2 only accounts for the emissions generated from purchased public electricity and for Scope 3 are considered the emissions from materials and waste transport,

waste disposal, and employees commuting to and from work.

In this study, the carbon footprint estimation is divided according to those scopes. CF quantification was performed applying Eq.1. However, some of the considered activities have specificities that require an adjustment of Eq. 1 to allow the CF estimation.

3. RESULTS AND DISCUSSION

Scope 1 emissions decreased from 2013 to 2019, with fixed sources being the main contributor.The fugitive emissions have a low impact on the CF. The contribution of company-owned vehicles presents a significant reduction in 2019 due to the transition to electric forklift trucks, which are now accounted for in Scope 2. Despite a consistent increase in electricity consumption between 2013-2018, the corresponding CF oscillates within the studied period because the electricity EF varies over time. Additionally, in 2018, the electricity consumed in the facilities began to be partly self-produced, resorting to solar panels. This study results show that the installation of a photovoltaic plant had a clear impact on reducing electricity consumption related emissions. The reduction of electric consumption in 2019 is greatly attributed to replacing the illumination system with LED lights.Nevertheless, it is not possible to conclude if the change performed on the illumination system was sufficient to compensate for the transition to electric forklift trucks impact on the factory energy consumption. Scope 3 emissions increased between 2013 and 2014 and decreased in 2015. This decline can be explained by a production reduction that occurred in 2015 and resulted in a reduction of supplied raw materials and utility necessities, leading to a decrease in waste production. The main contributor to Scope 3 is the raw material transport, whilst water consumption and treatment are minor contributors to the CF. The importance of these emissions can be worrying because this emissions typology refers to the activities that are most difficult to be reduced by company controlled decisions. Green procurement policies can significantly affect these emissions resulting in smaller quantities of waste and toxic disposable substances. A decrease in the total CF is noticeable since 2017, with most being attributed to the reduction to electricity consumption related emissions.

4. CONCLUSION

The carbon footprint evaluation allows identifying the main contributors to carbon emissions that result from industrial activity, providing valuable data for a conscious decision-making process. Studying CF evolution permits the ascertainment of the impact of the measures on GHG emissions, becoming a powerful tool to evaluate the efficiency of the decisions taken by the organisations to increase the environmental sustainability of their activity. From this study, it is possible to conclude that the carbon emissions related to the considered furniture industrial plant activity had a positive evolution over the last three years of the studied period, revealing the success of the various measures introduced by the company to reduce the carbon footprint of its activity. With the presented data, it is clear that the introduction of solar panels and the replacement of conventional illumination with LED contributed to a significant reduction in the specific energy consumption of the plant. The former, coupled with the introduction of electric forklifts and reduced waste transportation, greatly diminished the CF by the end of 2019. Lastly, the main contributor to GHG emissions is electric energy consumption, which has experienced a decrease in the two last years of the studied period due to the energy rationalisation measures introduced and to the consumption of self-produced electricity.

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Life Cycle Energy and Carbon Analysis of A Road-Safety Barrier Produced Using Recycled Tire Rubber

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ABSTRACT

Increasing end-of-life material recovery and its application in new products is essential to reduce resource consumption. This paper assesses the cradle-to-gate life cycle energy and carbon dioxide (CO_2) emissions of a new road safety barrier product to analyze the potential life cycle benefit of incorporating recycled materials. Three alternative products were compared: a conventional product (A) produced with conventional virgin synthetic rubber and polypropylene (PP) and two alternatives under development: B (using recycled end-of-life tire rubber granulate (TRG) and PP), and C (using TRG and recycled polypropylene). The results show that the incorporation of recycled TRG has a positive effect in primary energy and carbon emissions. Product B presents less 38% CO_2 emissions and 47% non-renewable primary energy than product A. The combination of TRG and recycled polypropylene (C), presents even more benefits: less 69% CO_2 and 86% non-renewable primary energy than A. To conclude, recycled materials incorporation should be strongly encouraged since it has a great potential to reduce current carbon emissions and primary energy of products.

Keywords: Circular economy; LCA; primary energy; recycling; secondary material; tire rubber.

1. INTRODUCTION

Circular economy requires to re-think current industrial production systems and take consistent actions to increase products reuse, repair, material recovery, recycling to eliminate wastes. With the global rise of road transport, on average a billion of tires reach their end-of-life (EoL) yearly, requiring appropriate disposal [1], or material recovery solutions. Managing safely the EoL of tires is currently a global challenge. The EoL tires can valued though different recovery routes, such as energy recovery, in energy intensive industries and material recovery, of crumb rubber or Tire Rubber Granulates (TRG), textile fibers, steels and oils, which can be used to replace valuable raw materials. In the past years some attempts to incorporate EoL Tire material recovered were found mainly in construction industry: TRG has been incorporated in asfaltic pavements, playgrounds, filling layers. Life Cycle Assessment (LCA) has been used to compare the potential environmental impact of alternative EoL scenarios for tires. For instance, comparing TRG material recycling in asphalt pavements with energy recovery in cement kilns, material recovery presented lower environmental impact than the energy recovery route [2,3]. Anchustegui, and Pasakopoulos (2019) used a LCA to assess the environmental impact of the four most common EoL tire routes in Sweden (from cradle-to-grave), and highlighted that TRG material recovery is interesting route from an environmental point of view, but further LCA research is needed on other products incorporating TRG. In fact LCA studies of molded products incorporating TRG are still scarce and the uptake of tire secondary material by molding industry is still low.

The goal of this paper is to assess the potential life cycle primary energy and carbon dioxide (CO_2) emissions associated with a new road-safety barrier product, using LCA. The road-safety barrier was developed to be installed around metallic poles of guardrails. Following circular economy principles, this product, requiring elastomeric properties, has been designed to be produced from a blend of recycled EoL Tire Rubber Granulate (TRG) and a thermoplastic matrix of polypropylene (PP). The study also also aims to assess the potential life cycle benefit of incorporating recycled materials (TRG and recycled polypropylene, RPP) when compared with a blend of conventional materials (synthetic rubber and PP) and identify preliminary hotspots for improvement.

2. MATERIALS AND METHODS

The LCA methodology (ISO 14040/14044) was used to evaluate the potential life cycle energy and CO_2 emissions associated to a new road-safety barrier product, in a preliminary stage of its development. A cradle-to-gate LCA was followed to assess the influence of incorporating different blends of virgen and recycled materials and three equivalent product alternative were compared:

A) A base case conventional, using a blend of non-recycled materials: synthetic rubber (SR) and PP;

B) A blend with recycled TRG (55% w) and conventional PP (45% w);

C) A blend using TRG and recycled polypropylene (RPP).

Having an alveolar geometry and being produced by extrusion the product had a rubber-thermoplastic matrix dry weight ratio of 55/45.

3. RESULTS AND DISCUSSION

Results show that the primary energy associated with this product development is mostly non-renewable, this is mainly because the materials used (PP and SR) are primarily derived from petroleum hydrocarbons, thus, being fossil-fuel based. A significant non-renewable primary energy reduction (over 46%) is achieved with the incorporation of recycled TRG (in B) when compared with the conventional product (A), and an 82% was achieved if both conventional materials are replaced by recycled materials TRG and RPP (C). The CO_2 emissions trend among scenarios is strongly related to their non-renewable energy consumption. Whereas the conventional product alternative (A) was responsible for around 48 kg CO_2 eq. emissions, alternative B reduced potential emissions by 38%, and the alternative C reduce emissions by 68.5%.

4. CONCLUSION

This study used LCA to analyse the life cycle primary energy and carbon emissions associated with a new road-safety barrier product in a preliminary stage of product development. The goal was to inform decision regarding the environmental benefits of incorporating recycled materials such as TRG and recycled PP in comparison to a conventional material blend of synthetic rubber and PP.

The study showed that from a life cycle primary energy and CO_2 emission point of view, the use of TRG is preferable when compared to synthetic rubbers' use, allowing to reduce the non-renewable primary energy of the product by over 46% and its carbon emission by 38%. The combined use of two recycled materials (TRG and RPP) achieved a substantially higher reduction. Thus, the use of recycled materials should be urgently encouraged, for instance in moulded products like this, where esthetical requirements are not as stringent as in other products.

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Circular Economy of Expanded Polystyrene (EPS) Container Production: Environmental Benefits of Household Waste Recycling Considering Renewable Energies

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ABSTRACT

Plastic industry is ubiquitous worldwide, and the generation of "plastic waste" has been steadily increasing to the point of being considered a high impact pollutant. The expanded polystyrene (EPS) plastic industry aware of the issue is interested on trying recycling post-consumer material. Through a recent study made in an alliance between the private sector and the academy, the feasibility of the EPS "mechanical" recycling was proven; therefore, a possible solution through a circular economy model. The aim of the present paper was to investigate the potential environmental impacts avoided by the circular economy scenario previously developed, through a life cycle assessment (LCA) performed for the city of Guayaquil, where 64% of all the plastic manufacturing industries in the country are located. The entire life cycle of 1.00 kg of 5x5 inch. food containers were assessed from the production stage until its end-of-life stage: focusing on three different valorization paths, circular economy closed-loop (container-to-container) proposal with electricity share of 2019 and another with the 2027 future one, and traditional linear economy (container-to-landfill). Results showed that the scenario C that considers the recycling of post-consumer EPS waste and the electricity share proposed for 2027 have lower impacts in 14 out of 16 categories, in specific for the Land use (-31%), Ozone Depletion (-28%), Acidification (-24%) and Terrestrial and Marine Eutrophication (-21%). These results strongly suggest that the recycling of these kind of plastic waste could benefit the environment greatly.

Keywords: Circular Economy, EPS Waste Recycling, LCA, Single-use plastic

1. INTRODUCTION

A total of 0.61 kg of domestic solid waste is generated per person daily in the city of Guayaquil, from which almost 8% is plastic [1]. From this waste, expanded polystyrene represents 6.26% of all the plastic waste. Currently, the management of post-consumer plastic waste in the country is poor; therefore, swapping to the called "green plastics" does not guarantee a better management. The proposed change without the technology or experience in processing this kind of waste becomes naïve. The authors through a case study in 2019 showed that is possible the recycling of EPS post-consumer waste and developed a circular economy proposal. Using 40% of virgin resin, 30% of scrap recycling resin from the production process and 30% post-consumer recycled resin, new EPS 5x5 in. containers were obtained with the same quality as the traditional 70% virgin resin and 30% scrap recycling resin. Therefore, it is feasible to accomplish with the condition of 70% recycled material in single use EPS containers [2]. Consequently, the aim of this work is to research the potential environmental impacts avoided by the integration of the proposed EPS circular economy model plus the change in the energy mix for 2027, to the actual city´s collection system and energy mix, choosing as an example 5x5 in. food containers. For this purpose, the case study is developed to compare the three different scenarios: (a) actual linear economy (container-to-landfill) scenario with current electricity mix; (b) closed-loop recycling (container-to-container) with actual electricity mix; and (c) Closed-loop recycling with 2027 best electricity mix scenario, and their environmental impacts results are then shown.

2. MATERIALS AND METHODS

For this study, the ILCD 2011 Midpoint characterization method released by the European Commission Joint Research Centre in 2011 will be used later during the implementation of the LCA. It includes 16 impact categories listed below:

- Climate Change **(kg CO2 eq)**
- Ozone Depletion **(kg CFC-11 eq)**
- Human Toxicity; non-cancer effects **(CTUh)**
- Human Toxicity; cancer effects **(CTUh)**
- Particulate Matter **(kg PM2.5 eq)**
- Ionizing Radiation for Human Health **(CTUe)**
- Acidification **(molc H+ eq**
- Terrestrial Eutrophication **(molc N eq)**
- Fresh Water Eutrophication **(kg P eq)**
- Marine Eutrophication **(kg P eq)**
- Freshwater Ecotoxicity **(CTUe)**
- Land Use **(kg C deficit)**

- Ionizing Radiation for Ecosystems **(CTUe)**
- Photochemical Ozone Formation **(kg NMVOC eq)**
- Water Resource Depletion **(m³ water eq)**
- Mineral, Fossil & Renewable Resource Depletion **(kg Sb eq)**

3. RESULTS AND DISCUSSION
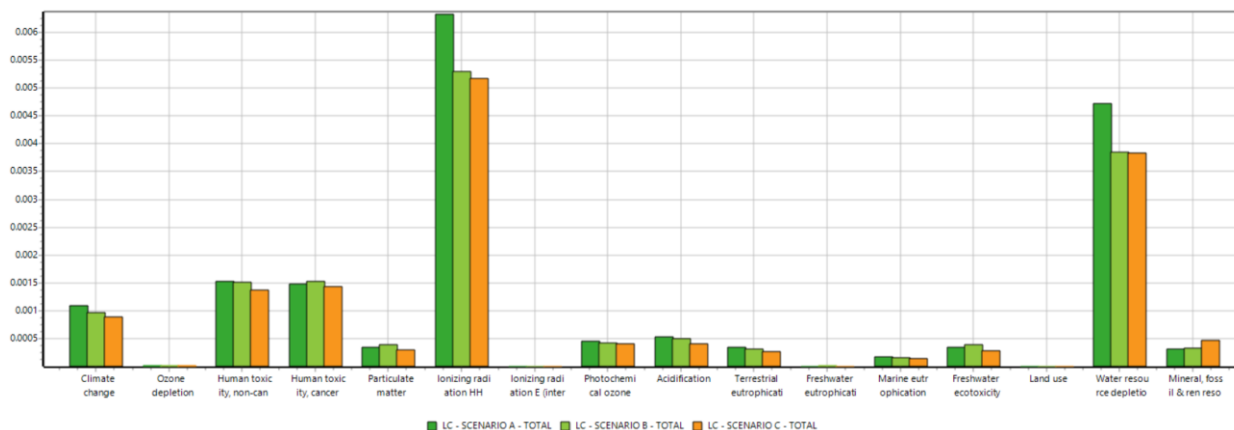
4. Fig. 1. Normalized impact assessment for each proposed scenario

Figure 1 shows the normalized impact assessment of the 16 impact categories included in ILCD 2011 Midpoint characterization. Scenario C with the 2027 electricity mix presents the best case scenario, better than Scenario b which also accounts for the post-consumer recycled resin. The results obtained through the Life Cycle Impact Analysis (LCIA) method, suggests that the scenario B has lower impacts with respect to scenario A in several impact categories (namely 9 out of 16), but scenario C presents a higher number of lower impacts than Scenario A (namely 14 out of 16). In specific, the best reductions for scenario C, when compared to scenario A are: Land use (-31%), Ozone Depletion (-28%), Acidification (-24%) and Terrestrial and Marine Eutrophication (-21%). However, the effect of washing and drying the post-consumer waste and the use of detergent affects the Freshwater Eutrophication, augmenting this impact in 40%. Additional research indicates that EPS single-use containers create the lowest global warming impact when landfilled compared to polyethylene terephthalate and polylactic acid.

4. CONCLUSION

The potential environmental impacts avoided by the implementation of a circular economy model was developed. Software Simapro 9.1 was used for the LCA implementation and the ILCD 2011 Midpoint characterization method to obtain the impacts of three scenarios. Results showed that the scenario C that considers the recycling of post-consumer EPS waste and the electricity share proposed for 2027 have lower impacts in 14 out of 16 categories, in specific for the Land use (-31%), Ozone Depletion (-28%), Acidification (-24%) and Terrestrial and Marine Eutrophication (-21%). The solid results reached in this preliminary analysis propose a valid alternative in the single use plastic waste management that future research endeavors may validate applying the LCA methodology.

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Session 10A - Environment

15:00-16:15 @ Meeting ID: 979 7648 1988

Resilience Assessment of Transportation Networks to Climate Change Induced Flooding: The Case of Doha Highways Network

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ABSTRACT
Over the past decades, the rate and intensities of natural hazards have increased significantly, attributed to the impacts of climate change. Simultaneously, the population living in urban areas has increased rapidly, converting cities into vibrant economic hubs. However, this rapid expansion led to ill-planned developments, which are expensive to maintain, let alone to fix. The emergence of unprecedented challenges accompanied by climate change has paved the way for a resilience-oriented design approach. Resilience-thinking focuses on reducing the impact and streamline the recovery process. This paper aims to address the impacts of climate change on the transportation network through flooding. We conducted the study using a graph-theoretic approach based on betweenness centrality as a metric to assess several flooding scenarios. The results show extensive damage to the network in all scenarios, which is expected considering rain and storms unusual to the region in the records used as a reference in the development. This study highlights the need to re-evaluate stormwater management plans urgently and take all the necessary mitigation measures to improve the resilience of the Doha highways network, which is crucial for the FIFA World Cup 2022 that will be held during the winter season.

Keywords: Climate Change Resilience; Complex networks; Flooding hazard; FIFA World Cup 2022; Geographic Information System (GIS); Urban Transportation Resilience

1. INTRODUCTION

Over the past decades, the annual cost of natural disasters has increased drastically; such an increase can be attributed to several factors but mainly climate change [1]. Climate change impacts include many phenomena (e.g., elevated temperatures, change in precipitation patterns). Cities rely on an extensive network of interconnected infrastructures (e.g., transportation, electrical, water, communication networks, etc.) to ensure their population's proper functionality and prosperity [2]. Among these infrastructures, transportation networks play a central role in contributing to the population's well-being and facilitating recovery efforts in the post-disaster period. The reliability of these infrastructures requires achieving robustness and flexibility while addressing their vulnerability, especially in the face of emerging and unprecedented events; in other words, it requires resilience [3].

Considering the rapid development of Doha city, mainly due to preparation for FIFA WorldCup 2022, in this study, we want to assess the resilience of the Doha road network to climate change impact. The addressed Climate change impacts focus on floodings, an emerging threat in the region [4].

2. MATERIALS AND METHODS

We are using several scenarios developed by the Ministry of Municipality and Environment (MME) that consider all the related aspects (such as design hyetographs and urban creep) and reflected it over several Average Recurrence Intervals (ARI) (e.g., 10-year ARI, 100-year ARI). ArcGIS software is used to process the road data and flooding scenarios, which yield the damaged states of the network. The network abstract then developed using Gephi software, and network centrality metrics (mainly betweenness) are extracted to conduct the resilience assessment under different scenarios.

3. RESULTS AND DISCUSSION

Based on the classification of the scenarios and the since the MME clarified that 100-years ARI aimed to long-term developments, the assessment was conducted on the Doha highways network, as presented in Figure 7.
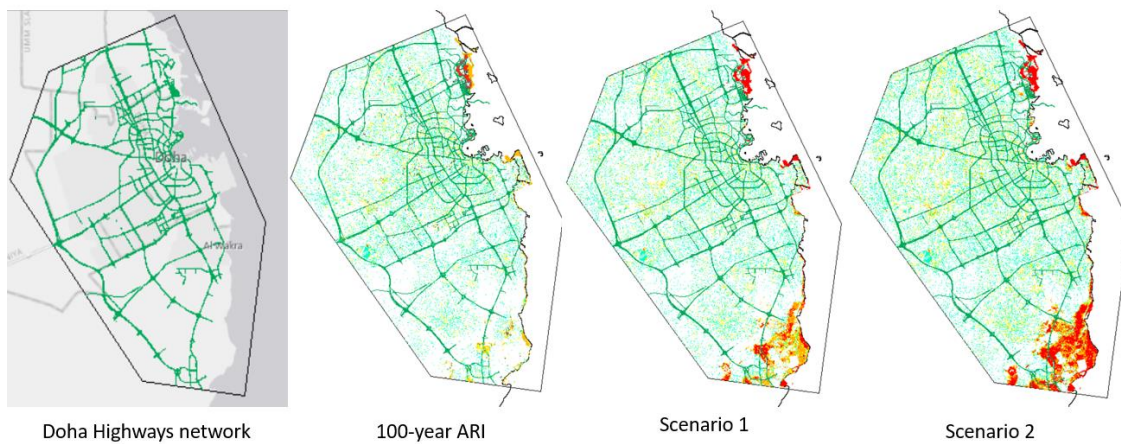
Figure 7: Study area and disturbance scenarios. Hazard categories are low, medium, high, and extreme are presented on the map as Turkuaz, yellow, orange, and red, respectively.

The previously defined hazard category (medium level), which means sedans cannot egress, showed an alarming fragmentation of the network, where betweenness centrality has dropped to less than 4% even during no climate change consideration. In comparison, these results correlate with a previous study on the Chicago transportation network by Kermanshah 2014, where the betweenness dropped to less than 15% during an extreme flooding scenario [5]. Nevertheless, The extensive damage resulting in the network highlights this critical vulnerability, especially that the precipitation patterns changed radically in recent years; Thus, there is an urgent need to re-evaluate storm management plans especially considering the upcoming FIFA World Cup 2022, which will be held in late November, a month associated with rains in the middle east.

4. CONCLUSION

The rapid increase of population in cities over the past decades has triggered an accelerated urbanization trend, creating vibrant cities with high economic value. However, the emerging challenges, such as climate change, limited the efficiency of the conventional design approach and diverted the design philosophy toward resilience-based design. This study builds on the Ministry of Municipality and Environment (MME) plans and efforts to develop the infrastructures in the city of Doha, which will host the FIFA World Cup 2022, by evaluating the resilience of the transportation network under flooding due to climate change scenarios. Because of the large scale of the assessment, we used a graph-theoretic approach with betweenness centrality as a metric to quantify system performance under flood hazard scenarios developed by the MME. The results show an extensive decline in the network connectivity under all scenarios, where more than 50% were rendered inaccessible by sedans. Moreover, the betweenness centrality dropped by a considerable magnitude highlighting the weak connectivity of the Doha highways network. Thus, there is an urgent need to re-evaluate mitigation plans and prepare for such disturbance, especially as the landmark event will be held in the winter season.

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Public Transportation Resilience Towards Climate Change Impacts: the Case of Doha Metro Network

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ABSTRACT
Since the middle of the last century, accelerated urbanization and rapid city expansion have driven the development of extensive public transportation networks to facilitate mobility throughout cities. However, these developments disregarded climate change's threat, which gained momentum in recent decades with the unusual rate of extreme disasters. These unprecedented challenges motivated the thinking about preparing these networks and ensure their resilience. This paper highlights the impacts of climate change on flooding hazards and the resulted damage to the Doha metro network. We applied a complex network approach to assess the resilience of the network under different scenarios. The results show no damage suffered under the base case; however, several stations and sections of the network are impacted under climate change scenarios. Thus, as the impacts of climate change is becoming more evident, it is critical to revisit development plans and precautions to reinforce or redesign critical infrastructures to avoid catastrophic events and substantial economic losses. Therefore, this study promotes the efforts to prepare cities for the impacts of climate change and support the development of resilient critical infrastructures to ensure the prosperity of its inhabitants, as in the case of Doha and the preparation for FIFA World Cup 2022.

Keywords: Climate Change Resilience; Doha Metro Network; Flooding hazard; FIFA World Cup 2022; Geographic Information System (GIS); Public Transportation Resilience

1. INTRODUCTION

Climate change introduces disturbing changes to precipitation patterns associated with extreme flooding that has increasingly affected the critical infrastructures in high-density urban areas [1]. Public transportation is an essential part of the critical infrastructures in any city, and also its state reflects the impact of disturbances to the city [2]. A well-designed critical infrastructure should enjoy flexibility and robustness to address its vulnerabilities under disturbances; these qualities can be reflected under the concept system of resilience [3]. The complex networks method is a widely adopted approach for resilience assessment due to its simplicity and effectiveness in large-scale assessments as it uses topological metrics such as betweenness [3]. Betweenness is widely employed for road networks [4] and metro system assessments [5].

Within the scope of FIFA WorldCup2022, Doha city is undergoing a transformational revolution in all infrastructures, but prominently in public transportation infrastructures. The development of Doha metro lines, the expanding bus lines, and the direction to use electrical buses during the mega event are incited by the commitments to deliver the most compact version of the event and adhere to strict sustainability goals [6]. However, considering that the event will be conducted during winter and the series of unusual extreme rainfall intensities, there is a necessity to assess the resilience of these public transportation networks toward the threat of flooding, which is believed to be caused by climate change [1].

2. MATERIALS AND METHODS

In this study, we assess the resilience of the Doha Metro Network under several climate change scenarios. The study uses flood hazard data of these scenarios developed and used by the Ministry of Municipality and Environment (MME). Both ArcGIS and Gephi are used in this study to conduct the assessment and identify impacted parts under each scenario. since metro lines generally run underground, we will consider the hazard based on stations subjected to high-hazard levels that the failure propagates to lines connected to these stations. As an assessment metric, we will use betweenness; since betweenness reflects the connectivity between different parts of the network, changes in its value reflect the state of the network and its resilience to different disturbances.

3. RESULTS AND DISCUSSION

It is notable that under 100year ARI, no station is damaged or threatened by flooding hazards, proving the design was conducted according to the best practices during its development (in 2009). However, the introduction of climate change impacts two critical stations directly (Education City and Hamad International Airport stations), and their failure will also affect related lines extending the impact to another seven stations (either by line failure or discontinuity). Figure 8 shows the impact of different scenarios on the metro network.
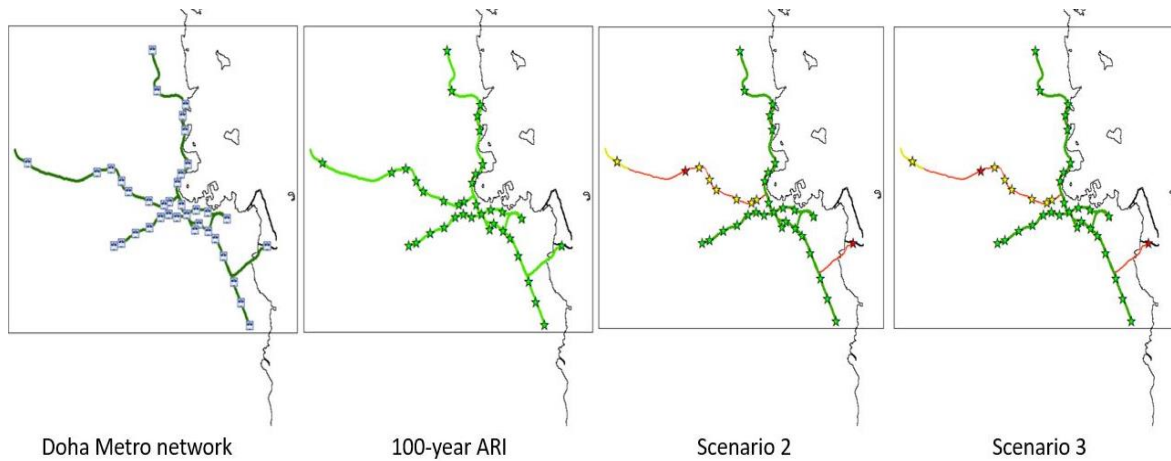
Figure 8: Doha Metro network before and during different scenarios. Green operational, Yellow indirectly affected, and red directly damaged by the flood

Also, It is very important to consider the exact role of the damaged stations, which is not captured by the unweighted complex network. Furthermore, there is an urgent need to revisit the design of such critical infrastructure to improve its resilience to climate change, especially with its vital role in hosting mega sports events such as FIFA WorldCup 2022.

4. CONCLUSION

As a result of accelerated urbanization witnessed since the middle of the past century, the need for efficient public transportation increased significantly. Metro networks provide a fast, traffic-neutral, eco-friendly, and resilient alternative for other modes of transportation. With the impacts of climate change is becoming more evident, it is critical to revisit development plans and precautions to reinforce or redesign critical infrastructures to avoid catastrophic events and substantial economic losses. Therefore, this study promotes the efforts to prepare cities for the impacts of climate change and support the development of resilient critical infrastructures to ensure the prosperity of its inhabitants.

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How Much More Evidence Do We Need to Invest in Sustainable Energy Sources and Stop Global Warming? An Answer from Maximum Entropy

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ABSTRACT

Global temperature and carbon dioxide (CO_2) nexus are one of the highest challenges in climate change science since there is controversy about the real impact of CO_2 emissions in the increase of global temperature. This work contributes to the existent literature by analyzing the relationship between CO_2 emissions effect over the Earth's global temperature, and thus to infer about the current state of global warming, for 61 years. Through a recent methodology based on maximum entropy, this study supports the results of other methodologies that identify the positive impact of CO_2 in the increase of the Earth's global temperature. To prevent future risks, besides the present urgent decrease of greenhouse gas emissions, it is necessary to stop using the planet and nature as if resources were infinite and to urgently proceed with an adequate energy transition and invest in sustainable energy sources.

Keywords: Carbon Dioxide Emissions (CO_2); Climate Change; Global Temperature; Maximum Entropy

1. INTRODUCTION

there is some evidence that CO_2 is the most relevant greenhouse gas in the increase of global warming (e.g., [1]). Thus, this study aims to contribute to this discussion, through a recent and powerful methodology in the analysis of time series, namely, the maximum entropy bootstrap, that as far as we are aware has not been used previously to explore this relationship mostly due to its novelty. Furthermore, [2] argue that the response to anthropogenic emission scenarios often require a simple model linking emissions of carbon dioxide to global temperature changes, given that future climate changes will largely be determined by future cumulative CO_2 emissions (e.g., [3]; [1]; [4]), leaving room to the need to explore the link existent between global temperature and carbon dioxide emissions (CO_2).

2. MATERIALS AND METHODS

The data for global temperature and CO_2 were collected on October 01, 2020, from (1) NASA Global Climate Change: Vital Signs of the Planet; (2) National Centers for Environmental Information, National Oceanic and Atmospheric Administration; and (3) Jet Propulsion Laboratory, California Institute of Technology, Education Section. The monthly average data for CO_2 (in PPP; parts per million) was transformed to annual values and the information for global temperature (annual global land and ocean temperature anomalies in °C) was converted to actual temperature (annual absolute values).

Monthly data for CO_2 only exists from 1958 (incomplete year and includes missing values). In 1964 there is a lack of information for three months and in 1975 there is a lack of information for one month, as well as in 1984. In these three years, the annual average of CO_2 is calculated with the existing information, and it was not considered necessary to apply imputation techniques for missing values.

Maximum entropy bootstrap for time series (e.g., [5]) is a powerful technique that allows statistical formulations free of restrictive and unnecessary assumptions usually adopted in time series analysis. The technique creates a large number of replicates, as elements of an ensemble, for inference purposes that satisfy the ergodic theorem and the central limit theorem. Those generated elements of the ensemble retain the shape of the original time series, as well as the time dependence structure of the autocorrelation and the partial autocorrelation functions. As an illustration, Figure 1 presents the original series of the annual average of CO_2, between 1959 and 2019, and five resamples provided by the maximum entropy bootstrap.

3. RESULTS AND DISCUSSION

A first and very important result is that the null hypothesis H0: $b_i=0$ ($i=2,3$) is rejected at a low significance level, whatever the model or the period considered, where b_i is the parameter associated with CO_2 (i.e., $b2$ for Model 1 to Model 4; and $b3$ for Model 5 to Model 8). Since both limits of the corresponding confidence intervals are positive, this means that an increase in the annual average of CO_2 implies an increase in global temperature.

Without loss of generality, and to be more precise from a statistical standpoint, considering, for example, Model 1 in Table 4, the interpretation should follow as considering this sample with data from 1959 to 2019, and considering the statistical model described by Model 1, it is estimated that, on average, a unit increase on the annual average of CO2 implies an increase between 0.0087°C and 0.0112°C on global temperature, with a confidence level of 99%. Clearly from the analysis undertaken we can infer that there is a positive impact of CO2 in the increase of the Earth's global temperature. A repeating pattern concerning the positive influence of emissions on global temperature through the three periods is verified by the results. However, the magnitude of the effects is higher from 1959 to 2019 using models 1 to 4 (Table 4) than using models 5 to 8 (Table 7). This is also true for both sub-periods, where the magnitude of the positive effect is superior in Table 2 and Table 3 when compared to those results presented in Table 5 and 6, respectively for sub-periods. Although the decreased magnitude from the '90s onwards, we still have a positive effect of CO2 emissions on global temperature, appealing for urgent and still needed necessary measures above all that has already been done, if the goal is to achieve the promised target.

4. CONCLUSION

This work explores through a recent technique the relationship between carbon dioxide emissions and global temperature. This methodology, in addition to its statistical advantages, is particularly appealing in the area of climate change, given the measurement precision difficulties for global temperature and concentration of CO2 usually reported in the literature. By not imposing parametric restrictions, it allows greater freedom in statistical modeling and inference. Although under different technical premises, it is estimated that an increase in the annual average of CO2 will drive always an increase in global temperature, regardless of the time series model considered.

Urgently, decision-makers should be aware that at the current rate of increase in CO2 emissions, hardly it would be possible for countries to fulfill the Paris Agreement. For that, measures against pollution increases, stricter CO2 abatement policies, a strict reduction of fossil fuel energy consumption and production, the promotion of renewable energy sources, and others, should be promoted and mandatory. Provided that the release of CO2 emissions is only reflected in the long-run global temperature effects, the current pandemic will, fortunately, lead us to reflect on the need for changing life habits given that the current reduction in CO2 emissions will only be strongly noticed in the next decades and centuries.

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Tourism and Air Pollution in Italian Regions

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ABSTRACT

This study intends to explore the impact of tourism on air pollution at a regional level for Italy, and also to investigate the evidence of a tourism-induced Environmental Kuznets Curve (EKC) for Italian regions, including variables as an economic indicator (GDP), the energy consumption, and the number of nights spent at tourist accommodation establishments from both residents and foreign tourists. Most of the studies found in the literature investigate this relationship on a national scale, while this research focuses on a regional basis. The analysis is conducted using a set of three air pollutants (NOx, PM10, and PM2.5 – the most critical in terms of air quality), over two different periods for comparison purposes: 2000-2008 and 2009-2018. The Levin-Lin-Chu unit root test proves the variables to be stationary, while the Pedroni cointegration test shows that they are integrated. A common main econometric model is employed to check the relationship among the variables: the Pooled OLS Estimator; the Granger panel causality test is conducted to see the causality among them. The tourism-induced EKC hypothesis is not validated, even if the findings show a decreasing relationship between economic growth and environmental pollution. Results also show slightly few differences between the two analyzed periods.

Keywords: Air pollutants; Emissions; Environmental Kuznets Curve; Italy; Regions; Tourism

1. INTRODUCTION

Tourism is among the most important industries for Mediterranean countries, and it is slightly gaining importance over the years, as shown by the increasing portion of GDP that this sector represents. Italy is among the most visited European destinations (the third most visited country in Europe) according to the World Tourism Organization [1]. This sector is, like any other industry, a substantial contributor to environmental degradation [2], as it puts pressure on the quality of the environment by depleting its natural resources. This is because an increment in tourism activities comes with an increased demand for energy for numerous activities such as catering, accommodation, infrastructures construction, management of tourist attractions [3] [4] [5], and especially air and road transportation since tourism activities are strictly connected to it [3]. All these high energy-consuming activities negatively affect the environment across countries in the form of different air pollutants [6], especially greenhouse gases emissions, above all CO_2 ones, which are an inevitable by-product of tourism activities and make the tourism sector one of the main causes of climate change [6]. According to the World Tourism Organization [7], the tourism sector is responsible for 4.6% of global warming, and this is the reason why the tourism industry is referred to as the "industry without a chimney" [3]. Besides the majority of the papers regarding the impact of tourism on atmospheric emissions are focused on CO_2 pollutant – a greenhouse gas with climate change effects [7] – when the purpose is to address air quality, this is not the proper pollutant to be considered, but the ones that affect human exposure and legislated in terms of human health protection. This paper aims to emphasize these air pollutants as proxy measures for environmental quality, namely the most critical ones in terms of urban areas: Nitrogen Oxide (NOx) and Particulate Matters (PM10 and PM2.5). The focal point of the present study is to empirically investigate the relationship between NOx, PM10, PM2.5 emissions, local air pollutants, economic growth, local and foreign tourism, and energy consumption through the construction of an EKC model for the Italian regions, over two sub-periods: 2000-2008 and 2009-2018. This research is based on previous studies, whose aim was to investigate the relationship among these variables and the existence of a tourism-induced EKC at a national level, generally focusing on CO_2 emissions, therefore neglecting the relevant air pollutants for air quality, which is also a consequence of tourism development. For this reason, this study incorporates emission data for the most critical pollutants regarding air quality (NOx and PM), contributing to the existing literature by providing analysis on a regional scale.

2. MATERIALS AND METHODS

The data presented are annual time series covering the period 2000-2018, for Italian regions using NUTS 2, considering the current NUTS 2016 classification (GISCO, 2020) for a total of 20 regions. The relationship between air pollutants, economic development, tourism growth, and the energy consumption is explored by using the EKC model outlined in Equation 1:

$$Pollutant_{it} = \beta_0 + \beta_1 GDP_{it} + \beta_2 GDP^2{}_{it} + \beta_3 TOUFO_{it} + \beta_4 TOURE_{it} + \beta_5 ENE_{it} + \varepsilon_{it} \qquad (1)$$

Pollutant denotes the NOx, PM10, and PM2.5 per capita emissions; GDP and GDP^2 refer to per capita GDP and the squared term of per capita GDP, respectively. TOUFO represents the nights spent at tourist accommodation establishments by foreign people, whereas TOURE from resident tourists; ENE refers to energy consumption. The subscript i characterizes the region, while the subscript t denotes the years, and ε is the error term. The natural logarithm of all variables is used in the econometric analysis. Once confirmed the Pedroni cointegration relationship, the Italian data is discussed through the estimations' analysis. The Pooled OLS Estimator model is selected for all the pollutants (NOx, PM10, and PM2.5). After these tests, the Granger causality test is conducted through the Dumitrescu–Hurlin panel Granger causality test.

3. RESULTS AND DISCUSSION

For both periods, no evidence of EKC for the Italian regions is found, even though a decreasing relationship between environmental pollution (for the three pollutants) and economic growth appears. The tourism outputs demonstrate that an increase in foreign tourists leads to a decrease in NOx, PM10, and PM2.5 emissions in the Italian regions, respectively by 0.35%, 0.46%, and 0.38% for every 1% growth of non-Italian visitors, for the first sub-period. Instead, domestic tourists' increment leads to a rise in the atmospheric pollution, by approximately the same amount they diminished in the foreign tourists' case for every 1% increase in Italian visitors.

4. CONCLUSION

The findings fail to document any evidence supporting the EKC hypothesis for any of the air pollution variables at a regional level, therefore they do not reveal any inverted-U shape relationship between environmental degradation and output growth driven by tourism for any of the two sub-periods. Even so, the results point out that tourism development has mixed impacts (both positive and negative) on the different air pollutants..

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Methodological Strategy for Potential Areas Definition for Fauna Conservation in Colombia

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ABSTRACT

The Colombian National Biodiversity Policy main objective is the biodiversity and ecosystem services management, through strategies for land conservation. This paper proposes a guide for the determination of potential areas for fauna conservation in Colombia. A map algebra equation for ArcGIS 10.8 software was proposed using land cover, species density, protected areas, land vocation, agricultural frontier and ecosystem geodatabase. This tool was used in Silvania, Colombia. The land cover in Silvania is mostly heterogeneous agricultural areas with 45.40%, followed with 24.94% by forest and semi-natural areas, artificial territories correspond to 12.04% and shrub and/or herbaceous vegetation association occupies 6.59%. The results show that fauna conservation potential areas level corresponds to 7.83% "Very High" and 22.61% to a "High" level for conservation. This guide, helps to contribute for land use planning and the construction of policies, plans and programs that contribute to fauna conservation.

Keywords: Analytic hierarchy process, fauna conservation, GIS, land use planning.

1. INTRODUCTION

Colombia ranks third in the number of terrestrial vertebrates, with 2890 species; 358 species of mammals represent 7% of the total existing; 1721 birds species ranking first in the world; finally, amphibians there are 10% and in reptiles 6% of the world, being surpassed only by Peru (1). Nowadays, environment has suffered great disturbances for different reasons, but perhaps the most important is the anthropic activity, understood from the social and economic development. Forest fragmentation is caused by several factors including natural processes. However, manmade changes are the main cause of disturbance of forest, transforming the natural landscape through the intensification of land use for economic activities(2).The society in function of obtaining benefits for itself have generated land cover changes for such purposes (3). Considering the above, the habitats fragmentation and destruction is the greatest threat for biodiversity conservation (4).

2. MATERIALS AND METHODS

Silvania is located in a valley of the Andes eastern mountain range of, which is 40 km south of Bogotá. It's altitude is 1470 m.a.s.l. The city has 163 km2, distributed in 7.48 km2 urban area and 155.44 km2 rural area, the total population is 22,100 inhabitants (5).

A map algebra was performed using ArcGIS 10.8 software. Eq. 1 obtained from the Saaty matrix (6) was applied, which consists of comparing two units "a" and "b", where one is preferred over the other.

$$CA = (0.21 \times LC) + (0.31 \times SD) + (0.25 \times PA) + (0.09 \times LV) + (0.04 \times AF) + (0.11 \times ES) \qquad (Eq. 1)$$

Where: CA = Potential areas for fauna conservation, LC = Land cover, SD = Species density, PA = Protected areas, LV = Land vocation, AF = Agricultural frontier, and ES = Ecosystem.

The obtained values were normalized to achieve homogeneity and evaluate their consistency. (7).

Sentinel-2 and SPOT-5 image were used for land cover classification. The photointerpretation of the satellite images was made with the Geographical Information System (8) and following the Corine Land Cover methodology adapted for Colombia-CLCC (9). Land cover were classified according the conservation or alteration degree, where altered by humans were rated 1, while natural areas 5.

Fauna information was collected on from the information system on biodiversity in Colombia (SIB). The species density was determined using the Kernel Density tool for ArcGIS 10.5 software, this allowed calculating the entities seen as points of each output cell, where the surface values tend to be higher at the same location of the points and decreases with the increase of the distance from these points. The areas with the highest density were rated 5, while those with the lowest values 1.

3. RESULTS AND DISCUSSION

The results showed that forests and seminatural areas and shrub and/or herbaceous vegetation association are linked to a higher density of species, highlighting the southeastern area, likewise the hot spots of species density are located in areas near the protected areas, while the artificial territories and agricultural areas associated with human activities do not allow the settlement of fauna that is generally associated with tree or shrub species, likewise, in these land cover impacted by humans there are high noise levels, which scares animals away (10); this reveals the need to expand protected areas in order to generate fauna conservation zones and biological corridors for the mobilization of species. The fauna conservation potential areas were obtained from the map algebra. A "Very High" level corresponds to 4.8% of Silvania's area, these areas are suitable for conservation because they have coverages less disturbed by human impacts, high species density and adequate land vocation, instead 21.1% corresponds to a "High" level for conservation; in spite of this potential, most of them are not included within protected areas or conservation areas, which makes them susceptible to transformation by human activities such as agriculture or urban development. Zones with "Medium" conservation potential (33.0%) present greater disturbances, but with an adequate management plan they can be brought to a high potential.

4. CONCLUSION

The GIS as a tool for analyzing fauna conservation potential areas, helps to contribute for land use planning. Silvania has a large number of potential areas for fauna conservation; these areas are close to declared protected areas, Thus, there must be a relationship between these areas in order to carry out fauna conservation projects. The very high and high areas conservation potential in Silvania are close to another cities, so it is necessary joint policies to include strategies for fauna conservation in the land use planning. The fauna conservation is not delimited by geographic or political limits, the natural limits are beyond the cities is limits.

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Session 6C- Life Cycle Analysis Methodologies
17:00-18:00 @ Meeting ID: 948 1336 4454

E126   **17:00-17:15**

Life Cycle Assessment of Bioethanol from Corn Stover from Soil Phytoremediation

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ABSTRACT

This work aims to evaluate the potential environmental impacts of bioethanol production from corn stover, comparing four different acids (Sulfuric, Nitric, Hydrochloric and Acetic acids) to perform the biomass pre-treatment. The study follows a life cycle thinking perspective, accounting for all the life cycle stages from corn stover grinding, to biomass pre-treatment, enzymatic hydrolysis, fermentation, filtration and ethanol distillation, on a "gate-to-gate" approach. The life cycle inventory was developed using mainly primary data from laboratorial experiments and complemented whenever necessary with information from literature and from the Ecoinvent V3.0 database available in the SimaPro 8.0.2 software. For the environmental impact assessment, the ILCD Midpoint 2011 methodology was used. Results show that in general, the sulfuric and hydrochloric acids have a better environmental performance than the acetic and nitric acids. Also, results show that pre-treatment, followed by enzymatic hydrolysis are the process steps with the highest relative contribution to the potential environmental impacts. Thus, an improvement analysis should focus on these process steps, for example to reduce fossil energy consumption by implementing renewable energy sources.

Keywords: Acid pre-treatment; Agriculture residues; Bioethanol; Enzymatic hydrolysis; Life cycle Assessment; Lignocellulosic biomass

1. INTRODUCTION

Bioethanol is the most widely used biofuel in the world. Bioethanol production from biomass is a way to reduce crude oil consumption and the environmental pollution. One possible renewable source for bioethanol production is corn stover, which consists of the leaves, stalks, and cobs of maize (corn) plants left in a field after harvest. This way it is possible to give another end use for this agriculture waste, using it as a raw material on the biofuels industry, instead of sending it to final deposition, and promoting a more circular economy. However, before implementing this solution on an industrial scale, it is necessary to carry out economic and environmental evaluations. Hence, this work aims to evaluate the potential environmental impacts of bioethanol production from corn stover cultivated in soil contaminated with metals aiming at its phytoremediation, following a Life Cycle Assessment (LCA) methodology. The study is based on laboratory data obtained experimentally [1] aiming at the optimization of the pre-treatment and enzymatic hydrolysis steps of bioethanol production from corn stover derived from contaminate soil phytoremediation.

2. MATERIALS AND METHODS

In this study, the potential environmental impacts of bioethanol production from corn stover are evaluated, following the LCA methodology, on a "gate-to-gate" approach, comparing different acids to perform the pre-treatment of the lignocellulosic biomass: Sulphuric acid, Nitric acid, Hydrochloric acid, Acetic acid.

The functional unit selected for this study is the production of 1 L of bioethanol.

The life cycle steps considered for the study are: grinding of the corn stover, acid pre-treatment, enzymatic hydrolysis, fermentation, filtration, and distillation. The corn sow and growth and the bioethanol consumption are out of this study scope. For the defined life cycle steps, all material, energy and water inputs and emissions for air, soil and water were taken into account. The generation of energy (electricity or fuel), and the production of the auxiliary materials used in the process were also taken into account.

Inventory data, including materials, water and energy were mainly obtained from laboratorial experiments [1]. Electricity consumption was estimated considering thermodynamic principles and the power of the equipment used for the thermostatic bath with agitation, time and temperature of operation. The water consumption

corresponds to the volume needed for the assays in the bath, based on the equipment's capacity. Experimental data was complemented with information from the EcoInvent V3.0, such as for obtaining the Portuguese energy mix for electricity production and the transportation of materials from the source to the laboratory. Some auxiliary materials such as acids and bases used in the experiments were defined by EcoInvent. Other information is from the literature. The corn stover used in the study was cultivated in Estarreja soil, in Portugal, where the plants were used for soil phytoremediation. The auxiliary materials used in the process come from Lisbon. So the consumption of diesel in the transportation of materials to the laboratory is estimated considering the distance from suppliers and the average diesel consumption of the means of transport used. Cut-off criteria and allocation of energy and material consumption as well as emissions were not defined. Table 1 synthetizes the inventory data for the production of 1 L of bioethanol from corn stover. This is an attributive study, since the environmental impacts are evaluated based on an existing process for bioethanol production from corn stover. The potential environmental impacts were estimated using the ILCD Midpoint 2011 methodology, using the SimaPro 8.0.2 software. This method was developed by the European Commission in 2011, in order to reconcile the various existing LCA methods [2].

3. RESULTS AND DISCUSSION

Four scenarios were defined for the biomass pre-treatment stage, each one using a different acid (Sulfuric acid, Nitric acid, Hydrochloric acid, Acetic acid), and keeping the remaining stages unchanged. H_2SO_4 contributes less than the other acids to the total potential environmental impact, in nearly all impact categories, except for FRD in which the contributions of HNO_3 and CH_3COOH are higher and for AP in which the contribution of HNO_3 is higher. The HNO_3 is the acid with the higher contribution to the total environmental impacts, except for WRD in which the contribution of HCl is higher, and for OD in which the contributions of HCl and CH_3COOH are higher. The HCl contribution to the total environmental impacts is higher than the other acids for the EC category and, it is second highest, after CH_3COOH, in the OD category. The CH_3COOH contribution to the total environmental impacts is higher than the other acids in the OD category. It is the second highest, after HNO_3 in CC, POF, EP and FRW, and it is the second highest, after HCL, in the OD, EC and WRD categories. In general, it is observed that sulfuric acid and hydrochloric acid have a better environmental performance than the acetic and nitric acids. This is due to the fact that the production processes of the first acids are already well optimized at the industrial level with minimized environmental impacts. The pre-treatment step, followed by the enzymatic hydrolysis, have the highest relative contribution to the potential environmental impacts. This means that one needs to focus on these process steps for an analysis of improvements. After analyzing possible improvements to the bioethanol production process, it is recommended to reduce fossil energy consumption, through the implementation of renewable energy sources, in particular photovoltaics, and also, to look for closer suppliers to reduce diesel consumption in the transportation of the auxiliary materials for the bioethanol production process.

4. CONCLUSION

In this work, bioethanol production from corn stover was evaluated from an environmental point of view on a life cycle thinking perspective. The pre-treatment, followed by enzymatic hydrolysis, are the process steps with the highest contribution to the potential environmental impacts. Four acids are compared to perform the pre-treatment of corn stover, showing that it is preferable to use sulfuric or hydrochloric acid to perform that operation, since they have lower contributions to the potential environmental impacts, as the industrial production of these acids is already well established and optimized for minimizing the environmental impacts. Nitric followed by acetic acid presents the highest Climate Change impacts. The use of renewable energy for grinding or enzymatic hydrolysis has the potential to reduce the Fossil Resources Depletion.

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E034   **17:15-17:30**

Life Cycle Assessment of Italian electricity production and comparison with the European context

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ABSTRACT
This work aims to evaluate the Life Cycle of the current electricity mix (2018) and future (2030) of some European Union member states (Belgium, Denmark, Finland, France, Germany, Portugal and Spain), to be compared with the results obtained for the Italian case.

The major efforts by the European Commission have been in containing climate-altering emissions: this has been seen in the policies that the different countries considered have adopted. According to the 2030 scenarios, there is an average reduction of 42% in the impacts on Climate change, the best result after Acidification (impact category closely linked to the first). Only one country does not show a reduction in greenhouse gas emissions: Belgium. In this country, the end of nuclear power and the increase of imports and gas causes an increase in emissions by 2030.

The reduction of Climate change emissions has gone to the detriment of another impact category, the consumption of resources (mineral, fossil and renewable), which has seen an increase in precisely those countries that have reduced CO_2 emissions the most: Spain, France and Portugal.

Keywords: Electricity mix; electricity production; energy scenario; European energy production; Life Cycle Assessment

1. INTRODUCTION

One of the main European Union goals is to ensure clean energy for all Europeans. Therefore, the objectives of transition towards a low carbon system and the reduction of environmental pollution are set, but also an efficient use of resources, which allows a competitive energy market accessible to all citizens. In this context, the European reference scenario 2016 [1] is an important tool, that allows to analyze the long-term effects of climate, economic and environmental policies of each member state.

From a sustainable development perspective, it's important to consider that the evolution of the energy system must also take into account environmental trade-offs and ensuring compatibility between energy and climate objectives and any other impacts.

An important tool is the Life Cycle Assessment (LCA) methodology that allows to assess the environmental profile of a system / product through its entire life cycle, taking into consideration a variety of categories of environmental impact. Furthermore, considering the growth of non-thermoelectric renewables, in particular wind and photovoltaic, the "life cycle" approach assumes a particular importance.

2. MATERIALS AND METHODS

The objective of this study is to compare the evolution of the environmental impacts of the Italian electricity mix from 2018 to 2030 with that of other European countries: Belgium, Denmark, Finland, France, Germany, Portugal and Spain.

Functional unit is 1 kWh of electricity Gross National Consumption (GNC). All life cycle phases, from cradle to grave, are included in the analysis: fuel supply, power plant construction, power plant operation and power plant end-of-life.

The impact categories considered and the related evaluation methods are those suggested by the ILCD Handbook [2] with the recommendation level I and II: Climate change; Ozone depletion; Particulate matter; Ionizing radiation HH; Photochemical ozone formation; Acidification; Terrestrial eutrophication; Freshwater eutrophication; Marine eutrophication; Mineral, fossil and renewable resource depletion.

SimaPro 8.3 software was used to perform the life cycle assessment.

The Italian electricity mix, updated to 2018, was modeled as defined in [3]. For the other European countries, current electricity mix (2018) was modeled considering Eurostat data for 2018 [4].

In order to model 2030 scenarios, the European reference scenario (Euref) [1] was chosen as reference. For the Italian case, also the scenario outlined by the Integrated National Energy and Climate Plan (INECP) to 2030 [5] was considered.

3. RESULTS AND DISCUSSION

All countries, excepting Belgium, show a general reduction of impacts from 2018 to 2030. If impacts trends in

2030 (%) are compared to impacts in 2018, a reduction can be noted regarding the impact categories: Climate change, Photochemical ozone formation, Acidification, and Terrestrial eutrophication. Ionizing radiation HH and Mineral, fossil & Renewable resource depletion show increase. This impacts evolution reflects the commitments made by the several member states in decarbonizing their respective electricity systems. In particular, the phase out of coal in some countries or its reduction in others contribute significantly to reducing the energy mix impacts. Belgium is the only country where Climate change category increases from 2018 to 2030. This country, in 2030, foresees the decommissioning of nuclear plants, the production of which is offset by natural gas and a greater import of electricity. The latter is still affected by the presence of coal. Resource consumption is the only impact category for which there is a significant increase in impacts for Italy (INECP scenario) and two other states, Spain and Portugal, and to a lesser extent for France and Italy (Euref scenario): it is interesting to note that these are the countries for which the reduction of CO_2 is most marked. This increase is driven by solar and wind. These sources are those with the lowest CO_2 equivalent emissions per kWh produced, but also those with the highest consumption of resources. For all analyzed countries, the main sources of impacts related to the consumption of resources are nuclear, wind, solar and imported energy (the impacts of imports are mainly due to nuclear and wind power). As for the Mineral, fossil and renewable resource depletion impact category, France remains the country with the greatest impact per kWh consumed in both 2018 and 2030, due to the mix strongly centered around nuclear power (in 2030 nuclear constitutes 70% of French electricity consumption).

4. CONCLUSION

The major efforts promoted by the European Commission have been to contain greenhouse gas emissions: this has been seen in the policies that the various countries analyzed in this study have adopted. According to the estimates of the energy mix of these countries by 2030, there is an average reduction of 42% in the impacts on Climate change, the best result after the reduction of acidification (impact category closely linked to the first). In this context, Italy, through the adoption of the INECP, foresees reductions of 50%, therefore well above the average of the countries analyzed, standing behind only France and Portugal. Only one country does not show a reduction in greenhouse gas emissions: Belgium. In this country, the disposal of nuclear power for the benefit of imports and gas causes an increase in emissions by 2030.

It is important to note that the Euref 2030 energy mix scenarios are based on the implementation of policies established at national level up to 31/12/2014. New energy plans have been presented to the European Commission by each member state.

The reduction of climate-altering emissions is at the expense of another impact category (the consumption of resources) for which an increase is expected precisely for those countries that had most reduced CO_2 emissions: Spain, France and Portugal.

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E131   **17:30-17:45**

Life Cycle Energy of Vehicles on Lightweighting and Alternative Powertrain Strategies – A Review

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ABSTRACT

To improve vehicles environmental performance, different strategies have been explored namely to reduce the use stage energy. To avoid problem shifting, a life cycle perspective should be used to compare alternative solutions. This paper aims to compare existing studies focused on life cycle energy (LCE) of vehicles to analyze the impacts and benefits regarding two trending improvement strategies: lightweight materials and alternative powertrain selection. A Literature review was performed to systematize quantitatively the LCE results of different studies (e.g. presented among figures, tables, and literature text). The LCE results were compiled and normalized for the same driving distance, 200 000 km, per life cycle stage. Moreover, the study discusses research findings on the application of the two strategies to improve overall vehicles' LCE. As lightweight materials have generally higher embodied energy, the material selection is highly influenced by end-of-life scenarios. It was observed that carbon/glass fiber composites generally have the highest embodied energy, being a preferable option for vehicles that last longer driving distances. Innovative powertrains sourced by renewable energy sources, electric mixes, can significantly reduce vehicles' LCE use stage, counteracting the benefit of lightweight design. Thus, the benefit of both strategies should be studied together.

Keywords: automotive; life cycle energy; lightweight material; powertrain; primary energy; vehicle

1. INTRODUCTION

The transport sector is responsible for around 25% of carbon dioxide (CO_2) emissions in European Union, and road transport represents more than 70% of those emissions. There are currently two trending strategies to reduce energy consumption and CO_2 emissions of a vehicle's use phase: a) lightweight vehicles, and b) alternative vehicle powertrains. Measures to improve a vehicle energy consumption should be analyzed based on a Life Cycle Assessment methodology (ISO 14040/ 14044), which tracks the life cycle (LC) potential environmental impacts of a product or service.

This paper aims to compare the existing studies focused on cumulative energy demand (life cycle energy - LCE- in GJ) of vehicles, analyzing the main impacts and benefits regarding the two above mentioned strategies.

2. MATERIALS AND METHODS

A search for recent literature published in the past 10 years was undertaken with the goal of selecting a sample of articles presenting LCE results: a) eight studies on lightweight materials were selected and analyzed [1-8] and; b) for the alternative powertrain scenarios, LCE results were gathered from four studies [9-12]. The LC results were computed for the same lifetime driving distance (200 000 km).

3. RESULTS AND DISCUSSION

Most studies for passenger vehicle with conventional powertrain (ICEV) show that lightweighting is a worthwhile strategy to reduce vehicles LCE for a 200 000 km driving distance. Nevertheless, depending on End of Life (EoL) scenario, the preferable lightweight material may change. Results showed that improvements in material recovery and recycling technologies of aluminium, magnesium and composites could promote an offset of their production impact (through avoided burdens). Given that, lightweight materials with high embodied energy (e.g. composites) are generally more advantageous for longer driving distance vehicles (e.g, trucks) and should see future improvements through the incorporation of recycled materials in their production. Vehicles with innovative powertrains, namely battery electric vehicle (BEV) and fuel cell electric vehicles (FCEV), sourced by renewable energy sources (or electric mixes), can highly reduce use stage LCE when compared to ICEV. However, depending on the primary energy sources of the BEVs and, FCEVs (e.g., regional electric mix; or other fossil fuel-based) these powertrains may end up having higher LCE.

4. CONCLUSION

This work presents an uniformized review of LCE studies focused on two trending strategies to reduce vehicles

energy consumption: alternative lightweight material and powertrain selection.

Overall, the authors conclude that both strategies have the potential to reduce the LCE of the reference scenarios, i.e. steel in the lightweight strategy and ICEV in the powertrain. However hot-spots for improvements are identified regarding the lightweight materials' EoL and powertrains' energy sources.

The development of better EoL scenarios (feasible disassembly, material recovery, and recycling strategies) may be more beneficial than lightweighting, specially for electric vehicles. The authors recommend that, the embodied energy of alternative lightweight solutions for electric vehicles should always be considered to avoid problem-shifting, since an increase in embodied impact may not be offset by mass-induced energy savings at use stage.To complete, both strategies should be studied together through a life cycle perspective and including EoL.

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Life Cycle Analysis of A Combined Electrolysis and Methanation Reactor for Methane Production

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ABSTRACT

The focus of this paper is to evaluate the environmental impacts of an innovative 1 kW pilot plant for methane production, following the life cycle thinking approach. The process is based on the combinations of alkaline water electrolysis, which generates syngas using a carbon source, with a methanation reactor that converts the syngas to methane. The life cycle assessment (LCA) takes into account the pilot plant construction materials, electricity and reactants used, for a functional model of a mole of methane produced per hour of operation. Data from an existing experimental unit, in particular reaction conversions, were used complemented with data from the literature and inventory databases. Energy and the construction materials used to build the experimental unit are the main factors influencing the environmental performance. Several scenarios were defined varying the electricity source and the biomass source, showing the results that the former is more relevant to reduce the process environmental impacts.

Keywords: Alkaline water electrolysis; Methanation reactor; Combined process; Methane production; Life cycle assessment

1. INTRODUCTION

Currently most of the energy used by human societies is generated using fossil fuels. The decrease in oil reserves, uncertainties related to the fuels price, environmental pollution, in particular the climate change impacts, are among the many problems that arise with the consumption of fossil fuels. Moreover, there is an increased awareness from all stakeholders of the environmental issues linked to industrial activities. The EU's climate policy, called the European Green Deal, aims for Europe to become the world's first climate-neutral continent by 2050. Fulfilling this goal requires a fundamental transformation of the Europe's energy system, in order to bring safe, sustainable, competitive and affordable energy to all EU consumers, families and businesses. Thus, nowadays there are an increase in R&D activities, in order to reduce the environmental impact of production activities, for example by using more renewable resources such as biomass, to obtain more sustainable biofuels that will contribute to decarbonize energy generation. A good example is the development of Power-to-Gas (PtG) technologies, using renewables (solar and wind) as energy sources and carbon capture from waste streams, is considered an interesting option, allowing the production of fuels and/or chemicals while contributing for a more decarbonized and circular economy [1].

2. MATERIALS AND METHODS

This study aims to assess the life cycle environmental impact of methane production using a combined alkaline electrolyser and methanation reaction [1,2]. An attributive "cradle-to-gate" study was considered, following the methodology defined in the ISO standards, ISO 14040:2006.

The functional unit, FU, is 1 mole of methane produced per hour. The synthesis gas production process, from alkaline water electrolysis, is carried out in a 50x50x60 cm pilot plant. A reservoir is used to store the alkaline electrolytic solution, which is fed from the top. The electrolyzer is a tank where the electrodes are placed and where the electrochemical reactions that produce syngas occur, operating at 373 K and 5 bar. Electricity may come from the existing supply network, for which the Portuguese electricity mix was used, or from local renewable energy sources, in particular photovoltaic or wind power. A maximum electricity supply from the grid, equal to 1 kW, has been considered. The emissions and the environmental impacts were taken into account, with the exception of water, for which the impacts resulting from its treatment were not considered. For transportation of reactants and other materials a value of 100 km by truck was assumed. The quantity and type materials used to construct the experimental setup were obtained from the process units' characteristics. Inventory data was

mainly gathered from laboratorial experiments [2], in particular reaction conversions. In order to use the data, it is necessary to perform some mass balances for the electrolyzer concerning the carbon and electrolyte consumed. The later can be estimated from the electrolyte that needs to be added to maintain the level above a fixed value, that ensures that the electrodes are fully covered. The estimation of consumed carbon depends on the type of carbon source. For graphite electrodes it was done by weighting the electrodes before and after the experiments. For biomass it was estimated from the difference between the initial mass and the remaining mass in the electrolyte solution. Both electrolyte and carbon consumption were expressed as a flow, according to the selected functional unit. Regarding energy consumption, for the electrolyzer a maximum power consumption of 1kW was assumed, considered enough to operate it and all the instrumentation and auxiliary equipment. Concerning the reactor, the energy required to heat the reactor to the operational temperature was determined using thermodynamic calculations. Since the study was performed under European conditions, the ILCD 2011 methodology was selected. Thus, the following set of indicators was considered: CC - Climate change, AP - Acidification potential, OD - Ozone depletion potential, FE - Freshwater eutrophication potential, POP - Photochemical ozone formation potential, MRD - Mineral resource depletion, and HT - Human toxicity. All calculations were done using the LCA software Simapro V8.5.2 PhD version.

3. RESULTS AND DISCUSSION

The various items of the inventory were divided in four classes: transportation of construction materials and reactants, raw materials - production of the reactants and other materials needed to operate the pilot scale unit -, construction materials, and energy. Results show that transportation is the least important aspect, contributing at most 5 % to the ozone depletion potential. Concerning energy/electricity generation and utilization, it is dominant in the POP and CC environmental categories. It also represents around 50 % of the total impact in the HT category. As described above, currently most of the energy is generated burning fossil fuels, leading to greenhouse gas emissions, in particular CO_2, and pollutants especially SO_X and NO_X, that have significant environmental impacts. An obvious suggestion for improvement is the utilization of renewable electricity, in particular generated locally using photovoltaic systems, instead of electricity obtained from the grid. The construction materials are relevant in the MRD and OD environmental impact categories. Although changes in the construction materials are limited by technical constraints, it is important at least try to identify which materials are more relevant to the process system environmental impact. Raw materials are dominant in the HT and FE impact categories. As graphite can be considered as a non-renewable material, there is also interest in using a renewable carbon source, in practical residual or agricultural or forest origin. Thus, it is possible to define four scenarios by varying the type of electricity source and the carbon source, in particular changing to PV electricity and residual biomass respectively. Results show that changing both aspects result in lower environmental impacts. Comparing the relative variation, it can be concluded that changing the electricity from the distribution grid leads to more significant reductions than changing the carbon source, in all cases superior to 80 %.

4. CONCLUSION

The environmental impacts of producing methane in a process that combines a electrolyzer and a methanation were evaluated using the LCA methodology. Results show that besides transportation, all the remaining aspects, energy, reactants, and construction materials, are relevant to the process environmental performance in different impact categories. Four improvement scenarios were defined by changing the electricity source, grid to PV, and biomass source, graphite to biomass. Results show that changing the electricity has more impact than changing the biomass source.

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Session 11A- Modelling, Simulation and Forecasting of
Energy and Carbon Markets

17:00-18:00 @ Meeting ID: 979 7648 1988

E048	17:00-17:15

Generalized Maximum Entropy in Electrical Energy Price Modeling for Households and Non-Households in Portugal

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ABSTRACT

In a high tax burden environment related to electricity prices in Portugal, it is needed to establish fiscal and economic-political measures to lower the electrical price weight imposed on both households and non-households. The most effective way is to first be aware of its determinants. This paper contributes to the existent literature by analyzing how important are fuel costs, emissions, GDP, and renewable energy share in energy consumption in explaining the variations in Portuguese electricity prices for both households and non-households, using generalized maximum entropy estimation. Results suggest that when income increases, electrical energy prices increase 0.0026 Euro/kilowatt-hour for households and 0.0034 Euro/kilowatt-hour for non-households. Fuel costs even lead to higher electricity prices for both, with the highest burden being on the non-household side. Results also point that carbon emissions negatively influence electricity prices and that reductions in electricity bills for non-households may be achieved through the increased share of the industrial sector energy in gross final energy consumption. Thus, increased renewable energy shares do not seem to be the solution to lower electricity prices, despite being necessary to reach sustainability goals.

Keywords: Electrical Energy Prices; Ill-Conditioned Problems; Info-Metrics; Regression Modelling

1. INTRODUCTION

In the Statista Research Department report [5] it is noticed that since the first half of 2010, household electricity prices have assumed an emerging trend. Besides paying some of the highest prices in Europe, Portuguese households' electricity prices are higher than in many countries worldwide [5]. This is mostly associated with the high tax burden, where approximately half of the price of electricity is tax-related [1]. Additionally, higher energy costs place challenges in industry competitiveness once electricity represents a high proportion of firms' total energy costs [3, 4].

2. MATERIALS AND METHODS

The variables considered for the regression modeling are the electrical energy price households (EPh; medium size households; in Euro/kilowatt-hour) and the electrical energy price non-households (EPnh; medium size consumers; in Euro/kilowatt-hour) as the dependent variables and gross domestic product per capita (GDP; in purchasing power standards, EU27, 2020), gas prices households (GPh; medium size households; in Euro/GJ), gas prices non-households (GPnh; medium size consumers; in Euro/GJ), oil prices (OP; in Euro/liter, Brent crude petroleum price by barrel), coal prices (CP; in Euro/per tonne), carbon dioxide emissions (CO2; in million tonnes), the share of renewable energy in gross final energy consumption (SRE; in %) and share of industrial sector energy in gross final energy consumption (SIS; in %) as the independent variables. The statistical models for $i = 1, 2, \cdots, 10$, are defined as

$$EPh_i = b_1 + b_2 GDP_i + b_3 GPh_i + b_4 OP_i + b_5 CP_i + b_6 CO2_i + b_7 SRE_i + b_8 SIS_i + e_i, \qquad (1)$$

and

$$EPnh_i = b_1 + b_2 GDP_i + b_3 GPnh_i + b_4 OP_i + b_5 CP_i + b_6 CO2_i + b_7 SRE_i + b_8 SIS_i + e_i, \qquad (2)$$

where e represents the error component. Since both models are ill-conditioned, and both are based only on ten observations, generalized maximum entropy estimation [2] is computed as an alternative to traditional methodologies that usually provide unstable estimates in these empirical scenarios.

3. RESULTS AND DISCUSSION

The estimated parameters of the models in (1) and (2) are presented in Table 1 and Table 2. The median presented in both tables corresponds to the median of the 1000 estimates obtained by bootstrapping residuals. The percentile method is used to compute confidence intervals.

Table 1. Results from model in (1): electrical energy price households.

	Estimate	Median	CI 90%	CI 95%	CI 99%
b_1	-0.1077	-0.0961	(-0.1164, -0.0760)	(-0.1209, -0.0714)	(-0.1274, -0.0568)
b_2	0.0026	0.0048	(0.0023, 0.0082)	(0.0020, 0.0090)	(0.0015, 0.0111)
b_3	0.0127	0.0195	(0.0140, 0.0255)	(0.0128, 0.0267)	(0.0114, 0.0296)
b_4	0.58e-09	0.15e-08	(0.48e-11, 0.56e-06)	(0.19e-11, 0.20e-05)	(0.14e-12, 0.10e-02)
b_5	0.85e-03	0.15e-02	(0.44e-03, 0.28e-02)	(0.28e-03, 0.31e-02)	(0.12e-03, 0.56e-02)
b_6	-0.0043	-0.0103	(-0.0186, -0.0030)	(-0.0203, -0.0019)	(-0.0234, 0.0007)
b_7	-0.0004	-0.0039	(-0.0138, 0.0076)	(-0.0152, 0.0099)	(-0.0194, 0.0140)
b_8	-0.0100	-0.0098	(-0.0132, -0.0062)	(-0.0138, -0.0053)	(-0.0150, -0.0031)

Table 2. Results from model in (2): electrical energy price non-households.

	Estimate	Median	CI 90%	CI 95%	CI 99%
b_1	-0.1093	-0.0974	(-0.1122, -0.0837)	(-0.1164, -0.0810)	(-0.1213, -0.0666)
b_2	0.0034	0.0049	(0.0025, 0.0079)	(0.0022, 0.0085)	(0.0016, 0.0098)
b_3	0.0160	0.0239	(0.0179, 0.0306)	(0.0165, 0.0321)	(0.0141, 0.0398)
b_4	0.47e-10	0.48e-09	(0.58e-11, 0.58e-07)	(0.26e-11, 0.20e-06)	(0.45e-12, 0.50e-03)
b_5	0.47e-03	0.92e-03	(0.13e-03, 0.20e-02)	(0.70e-04, 0.22e-02)	(0.76e-05, 0.48e-02)
b_6	-0.0055	-0.0114	(-0.0181, -0.0051)	(-0.0197, -0.0041)	(-0.0214, -0.0019)
b_7	0.0012	0.0031	(-0.0043, 0.0115)	(-0.0053, 0.0128)	(-0.0086, 0.0164)
b_8	-0.0113	-0.0101	(-0.0129, -0.0072)	(-0.0134, -0.0065)	(-0.0141, -0.0040)

From tables 1 and 2, one can conclude that variables gross domestic product, gas prices (households and non-households), oil prices, coal prices, carbon dioxide emissions (except for the 1% significance level), and the share of industrial sector energy in gross final energy consumption are consistently significant when considering any of the models, at all the confidence levels accounted for. Variable share of renewable energy in gross final energy consumption does not seem to impact the Portuguese electricity prices at either the households or the non-households levels, and, when considering model (1) and the confidence interval at the 99% confidence level, also the carbon dioxide emissions variable has a regression coefficient that cannot be considered significantly different from zero.

4. CONCLUSION

The implementation of energy conservation projects, upsurge energy conservation awareness, and resource efficiency for both households and non-household in Portugal. This could be a way to reduce the vulnerability of electricity prices and ensure competitiveness. For that, a clear tax burden alleviation would as well be detrimental, and results point that higher production capacity, and increased shares of fossil fuels, will only increase electric energy prices.

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Do Renewable, Non-Renewable Energy, Carbon Emissions and Kof Globalization Influencing Economic Growth? Evidence from Brics' Countries

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ABSTRACT

This study explores the possible effect on economic growth of renewable and non-renewable energy consumption and the disaggregated KOF index on the BRICS economies among 1990-2018. For this purpose, the Dynamic Panel Generalized Method of Moment (GMM) was applied. The findings indicate the increase among the interaction of economic and social globalization (de facto measure) and decrease effect (de jure) on Economic growth, while, the interaction of social and political globalization decrease the Economic growth, considering de facto measure for the both of that indexes. In addition, it was also observed that the increase in emissions positively affects economic growth, as well as the consumption of non-renewable energy; on the other hand, it was observed that the consumption of renewable energies tends to reduce economic growth. On the globalization effect, the findings indicate the increase among the interaction of economic and social globalization (de facto measure) and decrease effect (de jure) on Economic growth, while, the interaction of social and political globalization decrease the Economic growth, considering de facto measure for the both of that measures.

Keywords: BRICS' countries; Economic Growth; Energy Consumption; Generalized Method of Moment (GMM); Globalization Index.

1. INTRODUCTION

The link between economic growth and renewable and non-renewable energy consumption is one of the most researched topics in the field of energy saving, however, few studies tried to analyze the relationship among globalization measures, energy consumption, environmental pressures and economic growth. For example, according the brief literature review, the relationship between globalization and economic growth, [1] shows that globalization has a positive impact on economic growth, notice that countries with less restrictive economic flows, on average, had higher rates of economic growth. In this sense, [2] demonstrate that the number of trading partners is positively related to the growth of the economy. While, [3] analyzed the international trade to stimulate growth in both short and long term, and the evidences also indicates a higher level of economic openness reduces short-term growth volatility. In [4] study, the results indicate the economic globalization increase the environmental degradation, while the social globalization decrease the degradation; and no statistically evidence was found for the political globalization. Recently, in study developed by [5] , the political globalization measure produced different effects in developed countries and the same estimation reveals a significantly no evidence in developing countries; other of the hand, the economic globalization measure indicated the relocation of polluting industries from developed to developing countries.

To the best of our knowledge, the relationship between economic growth, renewable and non-renewable energy and the interaction of KOF globalization economic, social and political measures in the BRICS Group Countries (Brazil, Russia, India, China and South Africa) has not yet been study. In our new proposal model of the economic growth, following the studies developed by [5] we include the interactions among KOF Globalization in economic, social and political dimensions. That specific aim to explain the existence a trade-off between economic growth and these measures of globalization. Therefore, the present study is relevant to the design of appropriate globalization interactions on different dimension, including meeting the objectives for economic growth policies in the integrated BRICS' countries. Other of the understanding in our relationship proposed, that may exist the significantly effects among these interactions of KOF globalization dimensions and economic growth and that same effects are fundamental for the expansion of these economies growth (BRICS) and simultaneously to determine policies and strategies that allow economic growth and globalization effect.

2. MATERIALS AND METHODS

The research focuses on five economies with the potential to become consider developed: Brazil, Russia, India, China and South Africa and included a time series from 1990 to 2018. The data were retrieve from the World Development Indicators (WDI), compiled by the World Bank, KOF Swiss Economic Institute and from the British Petroleum (BP) database. This research uses a multivariate model to study the dynamic relationship between the follows variables, Renewable and Non-Renewable energy consumption, Carbon emissions, Economic Growth and the new KOF Globalization measures proposed by [6]. For this relationship propose we

used GMM techniques. This method gives us a computationally convenient methodology to achieve consistent and asymptotically distributed estimators of the parameters of statistical models [7] the best GMM estimator is the one with an optimal weighting matrix, which reduces the asymptotic variance of the estimator.

3. RESULTS AND DISCUSSION

The analysis of the relationship postulated in dynamic terms, we must choose the estimation in which it fulfils the premise that one should reject the null hypothesis (no autocorrelation) in the first-order test, and not reject the second-order test. Under this condition, it should be decide by estimating the GMM - one-step System (LSDV) and the both of GMM-One step difference and System, developed by [8]. The dynamic results of model proposed for these both of GMM one-step, shows that Renewable and Non–Renewable energy are positively and negatively associated with GDP per capita and its coefficient is highly statistically significant at 5% and 1% level respectively. In addition, we find that the effect interaction by KOF economic and KOF social measure (de facto) and (de jure) has a significant positive and negative impact at 1% level on GDP per capita respectively; while, the effect interaction by KOF economic and KOF political (de jure) and the effect interaction by KOF social and KOF political (de facto) are negative and significant effect at 1% level to promote the economic growth per capita in BRICS' countries.

4. CONCLUSION

This study explores the possible effect on economic growth of renewable and non-renewable energy consumption and the KOF disaggregated. In addition, we included in that economic growth model the interactions among KOF Globalization measures (de facto and de jure) considering the economic, social and political dimensions for the BRICS' countries. Considering in mind the results of GMM System estimators, the positive impact of non-renewable energy on economic growth and negative impact of renewable energy on economic growth was verify. Moreover, in our Economic growth model applied in BRICS' group of countries, the findings indicate the increase among the interaction of economic and social globalization (de facto measure) and decrease effect (de jure) on Economic growth, while, the interaction of social and political globalization decrease the Economic growth, considering de facto measure for the both of that indexes.

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Does Economic Sectorial Diversification Affect the Relationship Between Carbon Emissions, Economic Growth, Energy Consumption, Coal and Gas Consumption? Evidence from Opec Countries Using Panel Cointegration Analysis

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ABSTRACT

This work aims to investigate a relationship between economic and environmental drivers under the economic diversification condition including seven economic activity sectors for a set of nine OPEC countries during 1974-2016. For validating the two Environmental Kuznets Curve –EKC proposed, through the long and short-run estimations, including the Pooled Mean Group, Mean Group, and Dynamic Fixed Effect estimators. Results of the cointegration panel estimators show, for some sectors the validity of the EKC in the form of an inverted U shape, alternating with the U-shaped form. However, the validity of the Kuznets curve with the panel data does not make it clear which OPEC countries are in the most favorable conditions to mitigate the polluting effects.

Keywords: Carbon emissions, Environmental Kuznets Curve, OPEC Countries, Sector diversification.

1. INTRODUCTION

In the recent past, economic diversification has presented itself as a present and future challenge for some member states of the OPEC countries group. Despite different levels of diversification among this group of countries, these challenges impose strategic and effective policies, as well as concrete actions that will lead to the reduction of the collateral effects of oil production and other fuels by leveraging other sectors of the economic activity. This means that member countries of OPEC might fail in stabilizing the oil market, guaranteeing secure demand and supply at reasonable prices. Under these differential objectives and challenges, it seems interesting to understand the efforts that the OPEC countries are implementing in the economic diversification and how these affect the mitigation of greenhouse gases at different levels – aggregate and sectorial. In the literature, some related studies can be found for a group of 10 OPEC countries, such as [1] or for individual ones such as [2] in Algeria and [3] in Qatar. Regarding the validation of the EKC curve in the OPEC countries at an individual level, we highlight the recent study of [4], which analyses the EKC validation in the period 1970-2014 in Saudi Arabia. Some authors such [5], [6], and [7], also evidenced that technological innovations must be highlighted as a statistically insignificant determinant to mitigate the CO2 discharge. Still, regarding Saudi Arabia, we evidence the paper of [8], which has studied the environmental Kuznets curve relationship for the period 1971-2011, by including in the analysis the variable Energy Consumption in the road transport sector. Regarding OPEC members, [9] with an ARDL approach investigate the EKC hypothesis in Algeria, showing no evidence of it. Even so, in India, the inverted U-shape curve premise was validated with the ARDL procedure for the periods of 1971-2014 and 1971-2015 [10], [11], respectively. In another study, [12] investigate the EKC hypothesis for the OPEC countries group considering 10 members, for 1977-2008, using an ARDL approach.

2. MATERIALS AND METHODS

We tested the EKC hypothesis, in a panel dataset of 9 OPEC countries which includes Algeria, Ecuador, Iran, Iraq, Kuwait, Qatar, Saudi Arabia, United Arab Emirates, and Venezuela. The data used in this study refers to the period 1974-2016. The selected variables include carbon dioxide emissions, the total GVA, and Energy Consumption. The carbon dioxide emissions are measured in tons per capita; the total GVA by sector represents the total Added Value in the economy and is measured in Dollars at constant prices of 2010; and, the variable energy consumption is measured in kg of per capita equivalent oil.,the Value-Added is disaggregated in a group of 7 sectors, following [13]. The estimation can be done by a few econometric techniques, which Pooled Mean Group (PMG), the Mean Group (MG), and the Dynamic Fixed Effects (DFE) approaches were selected.

3. RESULTS AND DISCUSSION

In the environmental relationship assessment, the energy, oil, and gas consumption, are statistically significant at 1% and 10%, respectively. In terms of fuel type, the long-term elasticity of the CO2 emissions is positive and statistically significant for the energy consumption in aggregate terms, while the elasticity of the oil consumption

is negative. In the short term, according to the PMG estimator, there is statistical evidence at the usual significance levels of 1%, 5, and 10% to validate the inverted U-form EKC curve for the relationship between CO2, the GVA, and the Square GVA in sector 1, sector 2 and sector 3. This structural effect is of extreme importance since the economic growth verified in some sectors (which contributed to the structural effect) mitigates the effect of the global emissions in the OPEC panel.

4. CONCLUSION

In general conclusion, our results for the first EKC approach show a partial response regarding the validation of the EKC hypothesis. Results of the cointegration panel estimators show for some sectors the validity of the EKC in the form of inverted U shape, alternating with the U-shape. We also evidence for some sectors, such as sector 2 and sector 5), that their contributions to the decrease in emissions are continuous. Given that the results show a non-convergence separately, i.e., the validation of the Kuznets curve in the form of an inverted U-shape We believe that the intrinsic and extrinsic vulnerabilities have dispersed impacts between the different countries that compose the OPEC sample. According to our econometric results on the Kuznets environmental assessment, the expected signs of the sectoral GVA coefficients confirm the importance of the cause-effect relationship of economic growth and carbon emissions-

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Using Decision Tree to Select Forecasting Algorithms in Distinct Electricity Consumption Context of An Office Building

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ABSTRACT
The flexibility and management in the storage and control of building expertise in the energy optimization can be enhanced with the support of algorithms involved in forecasting tasks. These play an important role on obtaining anticipated and accurate consumption predictions associated to different contexts through extensive consumption patterns analysis. This paper evaluates the most viable forecasting algorithm for consumption predictions of a building in different contexts according to two alternatives: artificial neural networks and k-nearest neighbors. These algorithms use patterns of data from consumptions integrated in different contexts while retaining additional information from sensors data. The different contexts are classified on a sequence of periods that take place from five-to-five minutes. The decision criterion to evaluate which of the two forecasting algorithms is the most suitable in each five minutes periods is supported with decision trees that select the forecasting algorithms that looks to be more suitable followed by a logical answer that clarifies if the selection was the most viable option. Parameterization updates concerning the depth are studied to understand the forecasting accuracy impact. The decision trees approach has the potential to improve the accuracy of prediction as it plays a promising role in decision making.

Keywords: Decision tree, Load Forecast, Neural networks.

1. INTRODUCTION
The forecast of electricity consumption is very relevant for the energy system planning and for smart grids operations in real-time, namely regarding the flexible control of electricity consumption, the so called Demand Response [1]. A promising forecasting application consists in a decision tree method to predict the energy consumption of a smart city. The prediction activities are performed with the support of a parameterization involving different measures used to predict electricity consumptions in different contexts [2]. An alternate application optimizes the energy management system and reduces the cost of energy consumption. The comparison of three forecasting methods including Neural Networks, Decision Trees and Gradient Boosting Decision Tree is performed reaching the insight that the latter is more accurate [3].

The presents work makes use of the forecast made in [4]. Although decision trees are used in a lot of applications, decision rules integrated in hierarchical methodologies, is has not been used to consider the benefit of analyzing the best forecasting algorithm in different contexts as evidenced in this paper.

2. MATERIALS AND METHODS
Several aspects are considered in the selection of the best forecasting algorithm as the most appropriate choice in different periods describing short intervals. The first step is the obtaining of consumption forecasts according to two prediction algorithms, Artificial Neural Networks and K-Nearest Neighbours. These are considered in a decision-rule based learning that trains a decision tree in order to obtain rules that select and evaluate the best forecasting algorithm in different short periods. The rules rely on electronic devices obtaining information including consumption, CO_2 and light intensity and rely also on time features including the day of the week. The decision tree depth is updated accordingly in order to control the rules complexity.

The train sample considers all the five minutes except the first from 18 to 24 November 2019. The factors studied consist on the light intensity, CO_2, consumption and the period allocated. The day of the week is discarded from the analysis as this additional information makes more difficult to perform observations. The train and test sample consider 5 similar patterns with daily activities from Monday to Friday between 700 and 1300 W and 2 additional patterns with Saturday and Sunday between 500 and 600 W. Friday presents more productivity reaching consumption out of the usual but valid until 2320 W. The daily activity starts between 10 AM and 12 PM reaching consumptions between 700 and 1300 W. Nearly at 7 PM the consumption resumes the inactivity with behaviors between 500 and 600 W.

3. RESULTS AND DISCUSSION
The test sample considers all the first five minutes from 18 to 24 November 2019. Similar aspects to the train data are presented including the five similar patterns with daily activities from Monday to Friday displaying consumption from 700 to 1300 W being followed by two different patterns from the weekend displaying

consumptions between 500 and 600 W. The weekly profile starts to show daily activity during 8AM changing to higher productivity at some point between 11 AM and 12 PM displaying consumptions above 700 and below 1300 W. From this range the higher activity is more evidenced between 4 PM and 7 PM. The productivity resumes the inacticity during 7PM displaying consumption between 500 and 600 W. Four possible scenarios are considered with depth variations that go from 3 to 6. The accuracy results of each scenario show that increasing the depth high enough will make the rules complex enough to result in more accurate forecasts. The depth increase from 3 to 4 shows no improvements maintaining an accuracy of 66.96. However depth increases to 5 creates accuracy improvements to 67.86 %. The impulsive increase comes from the depth change to 6 where the accuracy shows to have 71.43%. This means that depth increases to 6 make the rules complex enough to increase the accuracy in this scenario. The decision rules construction initially split data into two possible sets, one with data from Monday to Friday and another with weekend data. Daily activities days make the predictions more in favor for KNN than ANN. The scenario with depth three assigned to three states that consumptions equal or below 479 W should consider the CO_2 data while the weekend use of this sensor is useless on inactivity times. It is also observed that the rules are not complex enough in this scenario to consider light intensity.

4. CONCLUSION

This paper presents pros and cons concerning the forecasting algorithm that looks more appropriate in each five minutes context according to two alternatives: Artificial Neural Networks and K-Nearest Neighbors. These are supported by trial and test studies that verify if the forecasting algorithm selection was the most appropriate through a rule integrated in decision tree process. The depth parametrization shows that low values will result in high accuracy concerning the forecasting algorithm selection, however increasing high enough may result in accuracy nearer to 100%. The forecasting tasks also show that these only benefit if these are applied to the week days from Monday to Friday as the weekends do not benefit from the sensors inactivity and the consumption presents low activity concerning a low range variation to present any insight if any of the two algorithm should be more trustable in each five minutes context. The sensors show to enhance the rules created in the decision tree supporting the expected insights that KNN is the most appropriated algorithm.

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E086   **8:30-8:45**

Electricity Demand Prediction for Sustainable Development in Cambodia Using Recurrent Neural Networks with ERA5 Reanalysis Climate Variables

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ABSTRACT

Sustainable energy development plays a prominent role in energy planning to maintain natural resources and mitigate the usage of fossil fuels. In this study, recurrent neural networks (RNNs) were developed to examine the 66 climate variables, collecting from the European Center for Medium-Range Weather Forecast (ECMWF) and power demand in Cambodia. The statistically significant climate variables were filtered by considering the cross-correlation between power demand and each climate variable. Moreover, the wide range of feedback delays was computed from the power demand dataset and was defined using the 95% confidence intervals. The comparison between a nonlinear autoregressive neural network with exogenous inputs (NARX) using historical power demand with the correlated climate variables and a nonlinear autoregressive neural network (NAR) using only historical power demand dataset was made. The various benchmarked models were evaluated and compared their performances using statistical indices such as normalized root-mean-square error (NMSE) and coefficient of determination (R^2). The results showed the NARX model could perform well and better than the NAR model for predicting electricity demand time-series.

Keywords: Electricity demand; NARX; NAR; ERA5; Climate variables; Cambodia

1. INTRODUCTION

Energy planning on the demand side is the crucial task for addressing in terms of sustainable development against the global warming caused by fossil fuel generations. Demand management provides the particular aspects of the future perspective for decision-makers to manage the green and clean energy generations in the energy mix. A well-prepared electricity demand planning is entirely crucial for the reliability and sustainability of the energy supply. At the same time, numerous factors could affect electricity consumption, such as climate factors (temperature, dewpoint, and so on) and socio-economic factors (population, gross national product, imports and exports, occupants, family composition, household income, and so on)[1], [2]. The objectives of this study are described as follows:

1) Development of the optimized recurrent neural network (RNN) models for future prediction of electricity demand.
2) Identification of the correlated climate variables for improving prediction outcomes.
3) Comparison of prediction techniques using (i) NAR model using historical data, and (ii) NARX model with historical electricity demand and climate variables, in term of their performance.

2. MATERIALS AND METHODS

The study area is located in Phnom Penh city in Cambodia. The site selection is based on the available data from 2013 to 2018 for electricity demand and the ECMWF-ERA5 Reanalysis climate variables. The climate variable data extraction is based on the longiture and latitude of the Grid substation of power demand.

A nonlinear autoregressive model (NAR) neural network model is used the historical dataset only as the input data to predict itself for future values [3]. The output function of the NAR model can be mathematically given in Eq. (1):

$$y(t) = f(y(t-1), y(t-2), \cdots, y(t-d_y)) \tag{1}$$

where y is the historical power demand dataset over (t) time, d_y is the feedback delay or lagged feedback output, and f is the activation function in the neural network model.

A nonlinear autoregressive model with exogenous inputs (NARX) has the same structure as the NAR model, but the NARX model has external inputs. Therefore, the equation of the NARX model is expressed as Eq. (2).

$$y(t) = f(y(t-1), y(t-2), \dots, y(t-dy), x(t-1), x(t-2), \dots, x(t-dx)) \qquad (2)$$

where x is the exogenous input dataset, and d_x is the input delay (ID). The NARX's configurations are based on the NAR's configuration; nonetheless, ID and correlated input variables need to be explored. Since 66 ERA5 climate variables could be utilized as the inputs in the NARX model, statistically significant variables were executed from the total of ERA5 climate variables by employing the cross-correlation function between power demand and ERA5 climate variables.

The feedback delay impacts the closed-loop simulated production as well as multistep predictive outcome, and it was defined by determining the auto-correlation function of the input dataset (power demand). Consequently, sufficient feedback delay is crucially important, which permits the training process could visibly understand the characteristic of the historical data. In this study, the critical configurations for this NAR model are described as follows: (1)The feedback delays (FD). (2) Numbers of hidden layer neurons. (3) Transfer function. (4) Activation function of hidden and output layers. (5) The weights and bias of this model.

The performance of models was evaluated by using error indices: normalized root-mean-square error (NMSE) [4], coefficient of determination (R^2), mean absolute error $(MAE, [MW])$, mean absolute percentage error $(MAPE, [\%])$, and root-mean square error $(RMSE, [MW])$.

3. RESULTS AND DISCUSSION

Six climate elements such as 2-meter dewpoint temperature (D2M), skin temperature (SKT), soil temperature level 1 (STL1), soil temperature level 2 (STL2), surface thermal radiation downwards (STRD), and 2-meter temperature (T2M) were widely validated as the most influential elements in the electricity prediction simulation. For the GS1 site, the results showed that the NARX model could perform much better than the NAR model by improving NMSE (14.54 to 1.343), R2 (0.678 to 0.902), MAE (5.192 to 2.288), RMSE (6.745 to 3.713), MAPE (0.435 to 0.432) as shown in Table 1.

Table 1. Statistical comparisons of various predictive models for GS1 site

Model	NMSE	R2	MAE [MW]	RMSE [MW]	MAPE [%]
NAR	14.654	0.678	5.192	6.745	0.435
NARX	1.343	0.902	2.288	3.713	0.432

4. CONCLUSION

NARX neural network model using the historical electricity demand dataset with six correlated climate variables could perform more outstanding than the NAR model using only the historical electricity demand dataset. Also, the various types of temperature could be proved the relationship between climate variables and electricity demand to improve a certain vision for the future electricity demand prediction.

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The Role of Demand-Side Management (DSM) and Photovoltaics Integration as a Mitigation Measure for Climate Change Impacts on Energy Demand

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ABSTRACT

Due to the increasing population and electricity consumption in Qatar and worldwide, several countries have started taking measures to reduce the carbon footprint associated with the growing energy demand. Furthermore, the climate in hot and humid countries like Qatar is becoming warmer over the years. This causes electricity consumption for cooling to increase, causing a rise in carbon emissions. Research is still being conducted on how renewable sources, along with other measures, can be optimally applied and how they can be integrated into building design to reduce energy consumption. Especially in Qatar, the application of renewable energy into buildings is more complex and limited. The purpose of this research is to test whether the application of demand-side management for a residential villa would efficiently reduce its annual energy consumption, hence reducing the environmental impact. This paper studies the energy demand of a residential villa case in Qatar for a reference year using DesignBuilder as an energy modeling software and proposes an optimum system for photovoltaics (PV) integration using HOMER software. The results show that PV integration on the villa rooftop reduces the energy demand and is found to be an economically and environmentally attractive solution.

Keywords: Climate change; Demand side management; Design builder; Homer Grid; Renewable energy; Solar PV

1. INTRODUCTION

In recent years, Qatar's economy has greatly expanded, increasing in population, infrastructure projects, and the number of worker expatriates. This has increased electricity demand in several sectors. The temperature during summer in the Gulf region and the middle east, in general, can reach over 40 °C, and the majority of the energy use in these countries is for cooling [1]. Furthermore, the heat waves will be more frequent and intense in the future because of climate change, which may cause a rise in residential energy consumption by 30% [2]. This only increases pressure on the electricity generation and causes stress on the power grid. Thus, to solve this, measurements to reduce total and peak demand should be put into effect. Demand-side management (DSM) is a set of initiatives and incentives that encourage consumers to optimize energy use by minimizing or shifting their energy use during peak hours. The renewable energy, such as solar or wind energy, reduces energy demand from the grid [3,4]. The declining tariff and governmental incentives in the past years have made the solar photovoltaics (PV) dominate the renewable energy market [5,6].

This study aims to evaluate the energy demand of a residential building in Qatar and assess how the DSM application would be beneficial in managing and reducing the energy demand. An energy modeling software, Design Builder, is used to estimate the residential building's energy demand over one year. The total annual energy demand obtained from Design Builder is used as an input to HOMER software to generate an optimal PV system design for the building.

2. MATERIALS AND METHODS

An architectural drawing for the selected building was obtained from the owner. An hourly ASHRAE weather file for Qatar was also obtained and used for modeling energy demand in DesignBuilder (v.6.1.8.021). A 3-D model of the selected villa was built according to the dimensions on the architectural drawing. An annual energy demand assessment for the house was carried out using the Energy Plus (v.8.9) simulation engine [7]. The annual energy demand of the villa was then used as an input to HOMER GRID, where the villa was considered the load. A hybrid system design was built, including batteries and PV modules as a renewable energy source. The system was evaluated, and the optimum system design was generated based on an economic and environmental assessment. The results from HOMER show all applicable system designs with several combinations of batteries, PV modules, grid power, and converters. The total costs and renewable energy fraction for all system designs are also estimated.

3. RESULTS AND DISCUSSION

The energy consumption due to room electricity, lighting, and water systems (from Design Builder) is almost constant throughout the year. However, cooling energy consumption fluctuates throughout the year, reaching a

maximum of 6,373.34 kWh in August. In addition, it can be seen from the figure that the main load is from cooling systems, especially in the summer months. The total annual demand for the villa was found to be 91,099.89 kWh. The hybrid system including a load, which is the villa, a converter, PV modules, and an energy storage system, was built in HOMER GRID, combinations of these components were evaluated to generate the optimal system designs. It can be seen from the results that the optimal system design involves PV module integration without a battery. The net present cost (NPC) is the present value of the sum of all the costs of the system over its lifetime minus the revenue over the lifetime. The optimal system had an NPC of $21,117 instead of the base system with an NPC of $35,332, thus reducing $14,215 in costs. It also had a renewable fraction of 0.557%, which means net carbon emissions are reduced. On HOMER, many combinations of different system components were evaluated. It was shown that the optimal design had PV modules and was connected to the grid but had no energy storage system. The net present cost of the hybrid system is lower than the conventional system due to the reduced consumption from the grid.

4. CONCLUSION

In GCC countries like Qatar, it is challenging to implement taxation to reduce energy consumption, as electricity costs are very low for residents. In addition, implementing price-based and incentive-based programs would not be effective, as research in similar countries has shown. To solve this issue, renewable energy integration is implemented in this study as a DSM strategy to reduce the peak loads and reduce emissions. In this paper, a residential villa in Qatar was modeled for energy demand. The total annual energy demand for the villa was relatively high, with the cooling systems being the primary load. Then the hybrid system was modeled on HOMER where multiple combinations of system equipment were evaluated, and the optimal systems were generated. It was found that the hybrid system that included PV module integration without a storage system had the lowest costs, with a reduction of $14,215 in total costs, and had reduced emissions when compared to the base system. These results support the concept that renewable energy integration can be financially and environmentally attractive, especially in hot climate countries like Qatar. This reduces the dependence on non-renewable sources, hence reducing emissions and lowering the impact on global warming and climate change.

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Engaging Domestic Users on Demand Response for Heating Cost Reduction with A Recommendation Tool: Case Study in Belgrade

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ABSTRACT

The European Union has established a legislative framework that aims to enable consumers and businesses to take information-based decisions to save energy and money. Additionally, the increase of Distributed Energy Resources (both on generation and consumption) requires additional efforts to maintain the reliability and stability of the electric grid and the need of flexibility from residential buildings. The present study introduces a domestic decision support tool for reducing heating costs. This app provides detailed recommendations to end-users based on the day-ahead hourly weather forecast, electric and district heating tariffs predictions, heating demand, and heating systems dynamic performance. The tool was tested in 6 dwellings of a neighbourhood of Belgrade during the last months of 2021 heating season (March-May). Energetic results suggest that 40% of participants followed the given recommendations and changed their heating pattern. Additionally, survey results show that end-users found the lack of information and knowledge as the main barrier to actively participate in the energy market, also preferring to have automatic control in their heating system. Authors conclude that recommendation tools are key elements in user-engagement, but they should be supported by additional information and training.

Keywords: Demand Response; Heating electrification; Recommendation tools; User-Engagement.

1. INTRODUCTION

The European Union (EU) has established a legislative framework for the promotion of energy efficient and carbon-neutral building stock by 2050. Such framework aims to enable consumers and businesses to take informed choices to save energy and money [1]. Additionally, the energy generation and its use are being transformed. As such, many authors have illustrated that Greenhouse Gas (GHG) emissions are reduced when electric technologies are used, as long as the renewable energies have relevance in the electric mix [2–4]. This requires additional efforts to maintain the reliability and stability of the grid along with the consolidation of users' engagement. Under this context, EU funded HOLISDER [5], in which framework the present work is included, aimed to develop a set of components and tools to enable Demand Response (DR) in building and small-tertiary sectors, empowering end-users.

In the present work the model presented in [6] was adapted to fit the particularities of a Serbian neighbourhood, enabling end-users to benefit from participation on implicit DR schemes. In particular, the model gives day-ahead recommendations to select the cheapest heating system in an hourly basis. Users receive these recommendations every day through an app. The model was tested in real-life environment during last months of 2021 heating season (March-May). Furthermore, energetic results are shown in addition to end-users' feedback.

2. MATERIALS AND METHODS

The present work continues with the authors' previous investigation about the electrification of buildings' energy demand [3], and the potential role of Heat Pumps (HP) on domestic DR participation and enhancement of user engagement in the energy market [6]. As shown in Fig. 1, a set of recommendations are generated and sent to the users' smartphones, in order to minimize heating costs by using the day-ahead hourly weather forecast, electric and District Heating (DH) tariffs predictions, apartments heating demand, and the performance of the HP.

3. RESULTS AND DISCUSSION

Energetic results suggest that 40% of the participants followed the given recommendations and changed their heating consumption profile, from using DH exclusively to combining it with the use of a HP when it was recommended. On the other hand, the rest of the users remain using solely the DH.

In addition, a survey was conducted among the participants. The main outcome shows that end-users believe that the lack of information and knowledge would be the main barrier for not participating in DR programmes. Finally, up to 70% of the respondents would prefer to have automatic controlling in their heating, ventilation and air conditioning (HVAC) systems, with or without the option to override it, to optimize its use from a DR perspective.
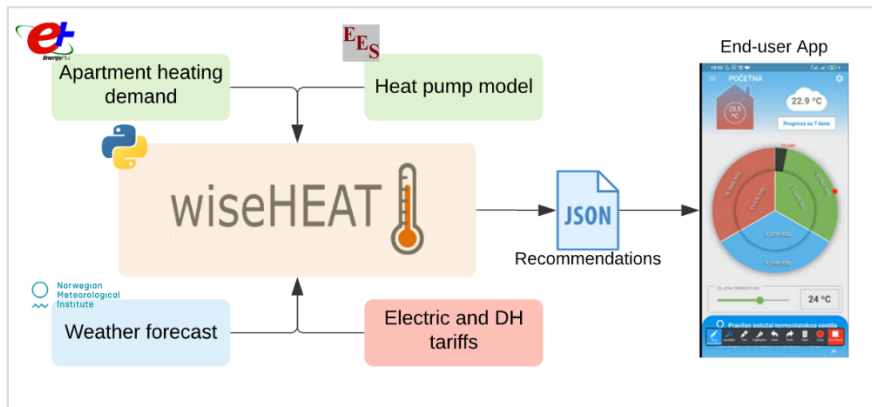
Fig. 1: Overview of the proposed model for the most cost-effective heating system selection.

4. CONCLUSION

As a conclusion, authors believe that the presented tool would help end-users to actively participate in DR programmes and enhance user-engagement. It is important to mention that recommendation tools should be provided with additional information/explanation to ensure end-users' long-term commitment. Thus, a higher use is expected next heating season, once the users are more familiar with the app.

In future works, further developments will be done in order to investigate strategies to reduce not just the heating cost, but also the energy consumption or greenhouse gas emissions.

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Exploring the Potential of Nearly Zero-Energy Retrofitting for Generic Office Buildings in Cairo, Egypt

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ABSTRACT

Energy consumption of the building sector has increased dramatically over the past decade. In Egypt, existing buildings consume 60% of electrical energy. Improving existing buildings through energy retrofitting and using different techniques of integrated PV may serve as a step towards improving the energy performance in buildings in Egypt and achieving nZEB levels. This research aims to explore the potential of achieving nZEB levels through retrofitting office buildings' typical prototypes in Cairo, Egypt, with basic designs, layouts, and orientations. In this study, 12 hypothetical office buildings (linear, square (courtyard), and L-shaped) with both open and closed plans N-S and E-W oriented were simulated using DesignBuilder. The proposed retrofitting strategy succeeded in decreasing annual energy consumption by 46%-65% for all retrofitted cases. Four retrofitted cases met the nZEB target, these are the closed squared office building oriented E-W, closed squared office building oriented N-S, the closed linear office building oriented E-W, and open-plan linear office building oriented E-W. This study may be considered prototypical to encourage policymakers to urgently enforce existing energy conservation codes and set retrofitting measures, to start a national retrofit process of existing office buildings in Egypt.

Keywords: Energy retrofitting; nearly Zero Energy Building (nZEB); Office building; PV cells; Egypt.

1. INTRODUCTION

There is growing worldwide interest in improving sustainability measures; reduction of building energy consumption and associated greenhouse gas emissions [1] which contributes to urban environmental drawbacks such as UHI [2]. One of the most widespread strategies across the globe in the past few years is the Nearly Zero Energy Building (nZEB) aiming at designing highly sustainable buildings [3], based on both energy-saving and energy production through renewable energy resources [4]. An nZEB is a very energy-efficient building that should cover the energy (or at least a very low amount of it) required from renewable energy sources [5]. The target of Egypt Vision 2030 is to save 25% of today's consumption [6] urged developing energy efficiency codes as a critical first step [7]. According to the latest census report in Egypt, there were approximately 16.2 million buildings in Egypt in 2017, of which about 0.8 Million buildings are office buildings [8]. Therefore, this research aims to explore the potential of achieving (nZEB) levels through retrofitting existing office buildings in Cairo, Egypt.

2. MATERIALS AND METHODS

The dynamic simulation package DesignBuilder used in this study is validated [9] and is reliably used as a building performance simulation tool. Annual energy consumption and the energy produced from PV cells were calculated for 12 office building base case studies (linear, square (courtyard), and L-shaped) with open and closed plans oriented N-S and E-W to cover multiple design possibilities and orientations to examine nZEB potential. The base cases have a floor area of $1000m^2$ and are 15 typical floors high. The retrofitting strategy is proposed combining the following three retrofitting actions; 1) Increasing building envelope insulation (walls and roof), changing glazing and adding shading according to the Egyptian Energy code [7], 2) Adding mixed-mode ventilation to the HVAC system, replacement of lighting with LED, and installing integrated PV cells on the roof, shade, and glazing, and 3) Adding temperature and light control sensors and automated windows and vents to allow natural ventilation. Applying this retrofitting strategy to each of the 12 base cases gave a total of 24 alternatives to be simulated by DesignBuilder.

3. RESULTS AND DISCUSSION

The proposed retrofitted strategy succeeded in decreasing annual energy consumption by 46-65% and CO_2 emissions by 59%-72% for all the retrofitted cases. Regarding the energy consumption nZEB levels, all open and closed square-shaped office buildings in E-W and N-S orientations met the target of annual energy consumption per area which is below 130 kWh\m². For the linear office building only the closed and open layouts oriented E-W met that target, but none of the L-shaped office buildings' layouts and orientations met the target. PV cells' energy production results indicate that building shape and orientation could affect the energy demand, the linear-shaped office building oriented E-W with the long side facing south has the highest PV energy produced. Only 4

retrofitted cases met the nZEB target; these are the closed, squared office building in both E-W and N-S orientations, also, the closed and open-plan linear office building oriented E-W.

In general, the squared cases consumed the least energy, while, the L-shaped consumed the most. The squared cases with integrated courtyard have the best energy performance. Integrated usage of a courtyard in office buildings improves daylight and natural ventilation conditions which could save energy. Moreover, the open-plan cases consume less energy than closed ones in all squared, linear, and L-shaped cases. This may be explained by the open-plan type's greater need for lighting to serve the entire building. In an open-plan layout, all spaces are used as a working area, whereas only half the lighting power is needed to serve the corridor spaces of the closed plan type. Also, due to higher internal loads and a different ventilation strategy, the open plan tends to be warmer than the closed one. Furthermore, the energy reduction varied for different orientations under the same climate situation, the energy consumption of the linear cases differs with the orientation, and the E-W cases consumed less energy than N-S cases. Finally, when comparing energy consumption with international nZEB levels of France, UK, Austria, USA, and UAE which is lower than 110, 160, 170, 150, 110 kWh/m^2 respectively, to the averages of all retrofitted office building cases ranges (112-153 kWh/m^2), showed that this study is a successful step guide towards nZEB in Egypt.

4. CONCLUSION

In this study, the potential of achieving nZEB levels in varying office building shapes, layouts, and orientations was examined. The proposed retrofitting strategy combined the three retrofitting actions and succeeded in decreasing annual energy consumption by 46-65% and CO_2 emissions by 59-72% for all the retrofitted cases. The use of integrated PV as a RES achieved nZEB levels. Therefore, retrofitting existing office buildings may serve as a step towards improving the Egyptian building stock's energy performance. Moreover, achieving nZEB levels could bring together environmental and economic benefits. Four retrofitted cases met the nZEB target, these are the closed squared office building oriented E-W, closed squared office building oriented N-S, the closed linear office building oriented E-W, and open-plan linear office building oriented E-W. This study may be considered prototypical to encourage policymakers to urgently enforce existing energy conservation codes and set retrofitting measures, to start a national retrofit process of the office buildings in Egypt.

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E140   **9:30-9:45**

The Impact of Using Different Weather Datasets for Predicting Current and Future Energy Performance of Residential Buildings in Egypt

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ABSTRACT

As prognostic methods for buildings' performance in present and future, energy simulations mainly rely, among other inputs, on weather datasets including Typical Meteorological Years (TMY), where the selected measurement period of the weather station is a crucial parameter. To quantify the predicted energy consumption's discrepancies that may occur while using a recently generated TMY (2018-TMYx) instead of the commonly used Egyptian TMY (ETMY) that were created in 2003, both weather datasets, in addition to their future climate change projections in 2050 and 2080, were applied into Design Builder's energy performance simulations for two residential buildings in different regions of Cairo and Aswan, Egypt. Results show that using weather datasets from different periods caused a maximum difference in annual energy consumption per flat by 933 kWh in present and 1508 kWh in 2080. The study proves the obsolescence of the commonly used ETMY due to the significant differences in energy simulation readings compared to the 2018 datasets.

Keywords: Climate Change; Energy Efficiency; Energy Performance Analysis; Weather Datasets.

1. INTRODUCTION

The present study aims to evaluate the impact of the weather datasets on the accuracy of energy simulation readings both in the present conditions and for the years 2050 and 2080.

2. MATERIALS AND METHODS

The '*.epw' weather file format of the ETMY- 2003, and the TMYx-2018, for two climate zones in Egypt; Cairo and Aswan were utilized in energy simulations using Design Builder (V.3.0.0.105) interface for EnergyPlus. ETMY can be downloaded from the EnergyPlus web site [1], while the TMYx is available online from the repository of free climate data for building performance simulation [2]. The future climatic conditions for both zones were generated by CCWorldWeatherGen [3] based on medium-high carbon emission profile. Two of the commonly used building designs for new Egyptian urban settlements were modeled in Design Builder. Both buildings comprise six floors; each contain four residential units of an approximate area of 86 m^2 for Building 1 (B1) and 85 m^2 for Building 2 (B2), at which the average number of occupants per apartment is four.

3. RESULTS AND DISCUSSION

The average dry bulb temperature of the TMYx is slightly higher than that of the ETMY, reaching a maximum increase of 0.8 °C in Cairo in January and 2.3 °C in Aswan in February, while it decreases in Cairo, for instance, by 0.4 °C in present in February and by nearly 0.8 °C in future in July and August. As the climate in the TMYx is slightly warmer, it is much drier than that of the ETMY especially during winter and spring months. The maximum average decrease in relative humidity is 10% in Cairo in January and the same in Aswan in February. Despite the annual reduction in energy consumption by nearly -112 kWh for B1 and -51 kWh for B2 when using the TMYx in present in Cairo, which is connected to the extreme climatic conditions of the present ETMY, energy consumption and cost dramatically rise according to climate change in the same region when using the TMYx, reaching a maximum annual increase of around 298 kWh and 549 kWh per flat in B1 and B2 respectively in 2080. In Aswan, however, using the TMYx escalates the overall energy consumption for all periods, reaching a maximum annual increase of 1508 kWh per flat in B2 in 2080. On the other hand, the maximum increase in annual energy cost in Cairo is nearly 188 EGP per flat in 2080, while in Aswan, it reached 608 EGP during the same year. Consequently, for a whole urban settlement of 4000 residential units, there is a potential increase in energy cost by nearly 2.43 million EGP that were not calculated from energy simulation using the outdated ETMY.

4. CONCLUSION

To make accurate predictions that are close enough to the actual building energy performance, weather datasets should reflect the real climatic conditions of their regions in present and future. To scrutinize the reliability of utilizing the most common weather data files of Egyptian cities for energy simulation, which are referred as ETMY, they were thoroughly compared with another recently generated data sets in 2018, to be referred as TMYx. By selecting weather data for two Egyptian cities that represent two distinct climatic regions; Cairo and Aswan

and their future conditions in the years 2050 and 2080 according to climate change using CCWorldWeatherGen, energy simulations using Design Builder interface for EnergyPlus were conducted for two residential building models. Using the TMYx demonstrated a significant increase in overall energy consumption predictions and, consequently, energy cost, especially for the long term energy assessments, as the annual energy consumption differences in 2080 reached 1508 kWh per flat in Aswan. Hence, the resultant variations of using different weather data sets may diminishes the suitability and the efficiency of recent passive urban and architectural designs that took place according to results from energy simulations that used obsolete weather data, as they would provide an insignificant contribution towards energy efficiency regarding the overwhelming energy consumption increase due to the recent climate conditions.

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E134   **8:30-8:45**

The Interest of Dairy Farmer on Extension Activity Related to Adopt the Mobile Anaerobic Digester Technology at East Java Province, Indonesia

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ABSTRACT

The farmer extension activity was allowed to increase the livestock productivity, like in dairy farmers. In the backyard and semi-intensive system of dairy cattle raising, the socio-economic identification of farmers was important for the success of the new technology adopted. Hence, the purpose of this study was to know the socio-economic background of the dairy farmer, included age, education level, raising cattle experience, and the number of cattle occupied was affected to the farmer interested in the extension activities related to adopt a mobile anaerobic digestion (AD) technology. The stratified random sampling was applied by involved 93 dairy farmers of Batu City, East Java, Indonesia. The depth interview for data collection and followed by multiple regression analysis. The socio-economic variables were significantly ($p<0.05$) correlated to the interested in an extension activity. While the partial t-test showed that the age of farmer and education level were significantly ($p<0.05$) on interest but farming experience and the number of cattle were not significantly ($p>0.05$) to the interest of extension. The education level was a major role in the interested extension. Hence, the educational level could be the main consideration in the intervention of extension related to adopting the mobile anaerobic digester.

Keywords: anaerobic digester, dairy farmer, extension, interest, manure

1. INTRODUCTION

The dairy livestock product is the one kind of agricultural product that could support the economic growth of small-hold farmer in Indonesia. The fresh milk supply in Indonesia is still imported fresh milk around 80 % to cover the national supply [1]. The lack of capital is the main problem that affected a small number of cattle ownerships. Hence, dairy farmers need help to access the financial resources for cattle ownership possibilities that could may reduce the gap in milk production. The potency of dairy manure waste in East Java in 2020 reached 17,047,950 kg or 17,047 tons per day [2]. Hence, this was a huge number waste for biogas production, but factually there was a very small number of the manure that was processed to convert biogas production.

The expansion of biogas technology among agricultural households was slow diffusion rates in many developing countries [3]. Meanwhile, small-holder dairy farming was still less attention in manure waste management due to the lack of simple and cheap technology-related manure waste management. This study was carried out to evaluate the dairy farmer's interest in extension intervention, especially to adopt mobile anaerobic digestion (AD) equipment which affect on the utilization of manure waste for biogas sources in a small-holder scale.

2. MATERIALS AND METHODS

This recent study was conducted at Batu City, East Java province, Indonesia. The purposive random samples were applied for chosen at eight villages of Batu city region. An ex-post-facto cause to affect research design was used in this study [4]. Dairy farmer respondents were selected randomly from each village up to the total sample number were 93 respondents.

The questionnaire attempted to produce data of this study was the age of the dairy farmer, the education level of the dairy farmer, the experience of raising dairy cattle, and the number of dairy cattle kept by the farmer. To determine the factors that influence dairy farmer's interest in the extension activity related to the mobile anaerobic digester equipment in the study area, a multiple linear regression model using the ordinary least square (OLS) method was applied. The level of statistical significance of the variable was tested by using a t-test at a 5 % level of significance. The F test was carried out to predict the effect of age, education level, experience of dairy cattle raising, and the number of dairy cattle raised by farmers to the interest in extension activities by simultaneously (jointly).

3. RESULTS AND DISCUSSION

The F test was carried to determine the independent variables, namely age, education level, experience in dairy cattle raising, and the number of livestock occupied which simultaneously (jointly) influenced the dependent variable or farmer's interest in an extension activity. This recent study showed that the socio-economic background simultaneously significantly affected ($p<0.05$) farmers interested in an extension activity. The age of the dairy farmer was a significant effect ($p<0.05$) on the farmer interested in extension activities with a negative constant value (-0.141). It was illustrated that the older age of farmer, the lower interest in participating in extension and vice versa. It was stated by Baba et al., [4] that the older farmer, the lower of participation in the extension activity. Also, the education level was significantly affected ($p<0.05$) on the farmers interested in extension activities with a negative coefficient (-0.048). Thus the higher of education level, the lower the interest in extension activities. According to Yekti et al., [5] study that education level was significantly influenced by the adoption of technology on zero waste management of dairy cattle.

Nevertheless, the experience of raising dairy cattle was not significantly affected ($p>0.05$) to the farmers interested in extension activities. As we known that Indonesian dairy farmer has experience in dairy cattle raising more than 30 years. Thus, it might be the farmer experienced was not affects on the interest of extension activities. Furthermore, in this study indicated that the number of livestock was not significantly affected ($p>0.05$) to the farmer interested in extension activities. This situation occurred might that the dairy cattle raising in Batu City was not the primary business or secondary income. Hence, the number of dairy cattle ownerships has not endorsed the farmers to interest in extension activities including a different type of mobile AD technology.

4. CONCLUSION

The socio-economic variables which consisting of age, education level, the experience of dairy cattle raising, and the number of cattle occupied was a significant effect simultanously on the interest of dairy farmers to participate in the extension activities related to the adoption of a mobile AD technology. The educations level was the highest influence to the interest of dairy farmers in this study. Hence, the particular strategies to increase the adoption of innovation through the intervention of extension activities were included human capital resources both farmers and external sources such as livestock ownership, the environment, and the government policies. The extensive training is better accompanied by demonstrations on innovation intervention; strengthening farmer institutions; upgraded of extension workers quality, variation of media delivering, and methods of delivering information.

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Coated Catalyst Plates for Effective Degradation of Industrial Effluents Via Innovative Photocatalytic Reactor

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ABSTRACT

The highest total organic carbon (TOC) removal efficiencies of 89.5% and 94.3% were attained using a composite of carbon nanotubes (CNTs) and lanthanum vanadate ($LaVO_4$) (CNTs/$LaVO_4$) for pharmaceutical and agrochemical wastewaters, respectively compared to a composite of Matériaux de l′Institut Lavoisier metal organic framework-53 (MIL-53(Al)) and zinc oxide (ZnO) (MIL-53(Al)/ZnO) and pristine titanium dioxide (TiO_2). The optimum operating parameters were pH = 6.8 and flow rate = 108.6 mL/min for pharmaceutical wastewater, whereas the pH and flow rate values of 6.5 and 108.6 mL/min, respectively achieved the highest degradation efficiency for agrochemical wastewater using CNTs/$LaVO_4$. The mineralization rates of pharmaceutical wastewater were 89.5%, 84%, 74%, 69.8% and 60.5% under five succeeding runs using CNTs/$LaVO_4$, whereas the TOC removal efficiencies of agrochemical wastewater were 94.3%, 93.1%, 85.8%, 76.2% and 73.2% in the five following runs.

Keywords: Operating conditions; Photodegradation; Photocatalysis; Real wastewaters

1. INTRODUCTION

The frequent need of pharmaceuticals for the medication of animals and humans as well as the wide use of pesticides for pests fight have attracted wide attention due to the environmental concerns of the release of pharmaceuticals and pesticides to water streams without sufficient treatment [1]. Due to the biopersistence of pharmaceuticals and pesticides, conventional biological treatment processes cannot be considered viable for the degradation of these pollutants. According to the drawbacks of the conventional treatment processes, researchers have focused on the development of new techniques that can efficiently transform bio-resistant toxins to safe compounds. Photocatalysis process has proved its superiority among advanced oxidation processes towards the degradation of the aforementioned contaminants. The commonly used semiconductors (e.g., titanium dioxide (TiO_2) and zinc oxide (ZnO)) suffer from the problems of wide bandgap and incessant concourse of charge carrier [2]. Different semiconductors were synthesized such as a composite of carbon nanotubes (CNTs) and lanthanum vanadate ($LaVO_4$) (CNTs/$LaVO_4$) and a composite of Matériaux de l′Institut Lavoisier metal organic framework-53 (MIL-53(Al)) and zinc oxide (ZnO) (MIL-53(Al)/ZnO) due to the ability of CNTs and MIL-53(Al) to reduce the bandgap and recombination rate of the composites. The majority of studies have dealt with the suspended-mode of photocatalysts; however, this mode reported some limitations according to previous work [3]. Therefore, the synthesized catalysts were loaded on glass plates to face the problems of suspended-mode using polysiloxane due to its characteristics as well as the problems of other attachment methods [1]. The construction of an innovative reactor was also carried out in order to treat real wastewaters, because the literature did not pay attention to the design of photocatalytic reactors widening the gap between application and research [4].

In this study, various catalysts were employed to treat effluents from agrochemical and pharmaceutical industries using the designed photo-reactor. The specification of optimum values of operating parameters was conducted via response surface method (RSM). The assessment of the performance of the coated-plates under successive runs was conducted.

2. MATERIALS AND METHODS

Pure TiO_2 was purchased from Sigma-Aldrich. The chemicals used in the preparation of CNTs/$LaVO_4$ and MIL-53(Al)/ZnO were mentioned in our previous studies [1,5]. The preparation as well as the characterization of the aforementioned catalysts were discussed elsewhere [1,5]. Moreover, the steps needed to prepare the coated plates were previously explained elsewhere [2]. The lengths, widths and heights of different components of the reactor, positions of coated plates and light source, were previously discussed in our previous study [3]. The volume of

contaminated solution was 200 mL and the recirculation of flow continued for 2 h. The pharmaceutical and agrochemical wastewaters were compiled from two companies located in Alexandria. The total organic carbon (TOC) values of the industrial effluents during treatment were estimated using total organic carbon analyzer (Shimadzu TOC-L, Japan). The compounds in the real pharmaceutical and agrochemical wastewaters were recognized using liquid chromatography-tandem mass spectroscopy as mentioned in our previous study [2]. Response surface methodology (RSM) was used to accomplish outstanding association between studied parameters that cannot be fulfilled using usual experiment design.

3. RESULTS AND DISCUSSION
A comparison between the degradation performance of pristine TiO_2, CNTs/LaVO$_4$ and MIL-53(Al)/ZnO was performed and the highest TOC removal efficiencies of 89.5% and 94.3% were attained using CNTs/LaVO$_4$ for pharmaceutical and agrochemical wastewaters, respectively. The superiority of the aforementioned catalyst was as a result of the decline of the joint between charge carrier after the addition of CNTs. The highest degradation efficiency was accomplished at pH of 6.8 and 6.5 in the case of pharmaceutical and agrochemical wastewaters using CNTs/LaVO$_4$, respectively. At low pH values, the removal efficiency may be declined due to the decrease of hydroxyl ions causing the decline of reactive oxygen species generation. In alkaline medium, the formed carbonates from the trap of carbon dioxide in the solution disabled the activity of hydroxyl radicals. The optimum flow rate was 108.6 mL/min for pharmaceutical and agrochemical wastewaters. The rise of flow rates values above 108.6 mL/min for pharmaceutical and agrochemical wastewaters inhibited the degradation efficiency due to the abrasion of coated catalyst particles. The removal efficiencies were 89.5%, 84%, 74%, 69.8% and 60.5% in the case of pharmaceutical wastewater, whereas 94.3%, 93.1%, 85.8%, 76.2% and 73.2% were the mineralization ratios of TOC for agrochemical wastewater in the five succeeding runs using CNTs/LaVO$_4$. The reduction in the removal efficiency of TOC was due to the loss of active sites in the following runs.

4. CONCLUSION
The highest TOC removal efficiency was attained using CNTs/LaVO$_4$ in the case of pharmaceutical and agrochemical wastewaters. The optimum values of pH (6.8 for pharmaceutical wastewater and 6.5 for agrochemical wastewater) and flow rate (108.6 mL/min for pharmaceutical and agrochemical wastewaters) were estimated using RSM. The removal efficiencies of TOC were 89.5%, 84%, 74%, 69.8% and 60.5% in the five succeeding runs in the case of pharmaceutical wastewater, while the degradation ratios were 94.3%, 93.1%, 85.8%, 76.2% and 73.2% in the five following runs for agrochemical wastewater.

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Determination and Quantification of Nitrogen Species During the Different Stages of Dairy Wastewater Treatment in A Sequencing Batch Reactor

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ABSTRACT

In this study, nitrogen removal analyses of ammonium, nitrite and nitrate, as well monitorization of dissolved oxygen (DO), at different phases of a sequencing batch process, were carried out to investigate the process of nitrification-denitrification on a synthetic dairy wastewater. Total nitrogen (TN) removal efficiency increased with each cycle with 84.2%, 89.1%, 90.9% and 92.3%, for day 1, 2, 3 and 4, respectively. Most of the nitrogen removal occurred due to assimilation during cell growth. Ammonium, nitrite, nitrate at the end of cycle 4 showed significant variation when compared with cycle 1, with 41.4%, 78.6% and 70.4% reduction, respectively. This work allows to conclude that SBR is an effective method of reducing the nitrogen content of dairy wastewater.

Keywords: Dairy Wastewater, Denitrification, Nitrification, Nitrogen, Sequencing Batch Reactor, Wastewater treatment

1. INTRODUCTION

The dairy industry generates between 4 to 11 million tons of wastewater worldwide annually [1]. Therefore, it is necessary to stem sustainable and efficient alternatives to treat those effluents.

Nitrogen in dairy wastewaters can be present in its organic forms or as ions (ammonium, nitrate, nitrite) [2]. Nitrification and denitrification are commonly employed in biological methods to mitigate the effects of discharging high concentrations of these compounds into the environment [3]. Nitrification occurs in two steps. On the first step ammonia is oxidize into nitrite. This reaction product is posteriorly converted into nitrate. Nitrate resulting from the nitrification is converted via the denitrification process into nitrous oxide and atmospheric nitrogen released to the atmosphere [4].

Microorganisms involved on denitrification are heterotrophs and need an external carbon source to reduce NO_2^- and NO_3^-. Nevertheless, an excess of carbon sources might induce an additional biomass growth that increases nitrogen assimilation. This phenomenon contributes to the system overall nitrogen removal [5]. Considering a general composition of the biomass as $C_5H_7NO_2$, a carbon mass/nitrogen mass ratio of, approximately, 60:14 is verified. This way, on the cell growth process, for each gram of nitrogen, 4.29 grams of carbon are necessary.

This work aimed to ascertain and quantify the nitrogen species present in the reactional content at the different stages of dairy industry wastewater treatment in a Sequential Batch Reactor (SBR). The reactor conditions stipulate the nitrogen species concentrations. Depending on the surrounding environmental factors and treatment stage, nitrogen can be found inside the reactor in the form of ammonium (NH_4^+), nitrite (NO_2^-), nitrate (NO_3^-) or organic.

2. MATERIALS AND METHODS

The identification and quantification of the nitrogen species of synthetic dairy wastewater were performed on an aerated SBR with 4 L of working volume. After an acclimatation period of activated sludge, the experiment lasted 4 cycles operating within the same conditions. The feed was composed of low-fat milk with a dilution of 1:80, with a composition of 0,388 mg/L $N-NH_4^+$, 0,0280 mg/L $N-NO_2^-$, 0,406 mg/L $N-NO_3^-$ and 104 mg N/L, thus nitrogen is mainly in its organic form. Ammonium, nitrate and nitrite were determined by molecular absorbance spectrometry, using a SKALAR segmented flow autoanalyzer. The Total Nitrogen and Total Carbon were measured using standard methods.

3. RESULTS AND DISCUSSION

The DO concentration behavior was similar on every treatment cycle. Ammonium concentration decreases during the aerobic stage. Nitrite and nitrate experienced an increase of concentration at the beginning of each sequential batch, followed by a decrease. The nitrate concentration increase during the aerobic stage results from the nitrite oxidation and the decrease is verified during the anaerobic phase in which this species is converted into nitrogen

gas forms or ammonium. It was verified a concentration reduction of 70.4% to nitrate, 78.6% to nitrite and 41.4% to ammonium. The total nitrogen removal efficiency obtained was 84.2%, 89.1%, 90.9% and 92.3%, for days 1, 2, 3 and 4, respectively. This evolution can be explained by biomass acclimation to environmental conditions. During this study C:N ratios in the affluent were lower than 5. Thus, according to a previous study [6], it is possible to infer that the main cause of nitrogen removal is assimilation due to heterotrophic cell growth. TC and TN evolution similarities might confirm that C and N assimilation occur as consequence of biomass growth. However, heterotrophs have a growth rate that is 10 times higher than that of nitrifying bacteria [7]. This way, short SBR cycles such as the ones verified in this study, promote the heterotrophs growth rather than that of nitrifiers. This fact can also contribute to explain the reduced observed nitrification rate.

4. CONCLUSION

The nitrification process was easily verifiable during each cycle, as the nitrate concentration increases during the aerobic stage, and ammonium concentration decreases during the same period. Dissolved oxygen was directly responsible for removing ammonia, showing a notorious effect in the process of nitrification. After two and a half hours of aeration almost all ammonium has been converted to NO_2^- and NO_3^-. Due to the fact that denitrification is slower than nitrification [8], this phenomenon is difficult to observe considering only the sedimentation phase. Nevertheless, it is observable a slight reduction of NO_3^- and NO_2^-, and an increase of NH_4^+ concentrations during the anoxic phase. Additionally, when considering the time-lapse between one cycle and another (anaerobic phase), denitrification and nitrate reduction to ammonium are observed. TN removal efficiency increased with each cycle, starting on 84.2% on day 1 and ending at 92.3% on day 4. The observed efficiency is mainly due to nitrogen assimilation during cell growth. Nitrification and denitrification only contribute partially to nitrogen removal. It is proven that SBR is an appropriate and reliable treatment system to perform the joint removal of organic and ammonia nitrogen in dairy industry wastewater.

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E082   **9:15-9:30**

Mbbr Bioscrubber Combination for Removal of Volatile Organic Compounds from Waste Air Stream of A Furniture Factory

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ABSTRACT

In this paper, a bioscrubber composed of a packed-bed column of LECA and an MBBR as secondary treatment is studied as an alternative to thermal oxidation of VOC in a gaseous effluent to lessen power consumption and mitigate the environmental impact of a furniture factory located in the north of Portugal. The bioscrubber showed high removal efficiencies of n-butyl acetate throughout all monitoring periods. Three of the experiments comply with the European Union imposed outlet airstream VOC limit of 50 mg_C/Nm^3 for this type of industry. Removal efficiencies higher than 90% were achieved for concentrations below 550 mg_C/Nm^3. Higher concentrations had 80% removal efficiency but would not be under the legal limits. Under the set conditions, the microorganism's elimination capacity is limited by the inlet VOC concentration. The experiments suggest an interesting and sustainable alternative that replaces direct fossil fuel consumption and reduces carbon emissions.

Keywords: Absorption; Air Quality; Air Stream Treatment; Bioscrubber; Moving Bed Biofilm Reactor; Volatile Organic Compounds

1. INTRODUCTION

Organic solvents are widely used in a variety of processes, producing volatile organic compounds (VOC) as unsought by-products, generating air pollution and health problems [1]. One of these VOC is n-butyl acetate, a versatile green solvent produced by either the esterification of acetic acid with n-butanol or by the transesterification of n-butanol with methyl acetate [2], applied in plastics, liquors, resins, gums, and coatings industries [1] [3], and widely used in paint dilution and cleaning activities in the furniture industry. A BS system is based on the absorption or physical separation of gaseous compounds in an aqueous phase in an absorber column, and subsequent biological treatment in a second stage in a liquid-phase bioreactor. [4].

The Moving Bed Biofilm Reactor (MBBR) was used as the secondary treatment, for its recognized ability to oxidize carbon and nitrogen, for requiring a smaller reactor than an activated sludge system and for its biomass retention capacity in floating mobile plastic carriers [5] (McQuarrie and Boltz, 2011.

According to the Portuguese [6] and European law [7] the VOC emissions (expressed in total carbon) for the furniture sector in the European Union must be lower than the emission limit value of 50 mg_C/Nm^3. Thus, the objective of the present work is to study the possibility of reducing the consumption of fossil fuel used in the thermal elimination of VOC emissions resultant from the solvent-based paint lines. For this it was used a bio-based and more environmentally sustainable technology, and, simultaneously, it was ensured the compliance with the defined emission limit values.

2. MATERIALS AND METHODS

The bioscrubber uses the biofilter column described in [8] as a primary treatment, and a Moving Bed Biofilm Reactor (MBBR) with 3.8 L of working volume, and a "Bioflow 9" carrier fraction of 45-50%, working as a secondary treatment. Four different experiments (B1, B2, B3 and B4) were conducted to evaluate the performance of the bioscrubber system under different inlet VOC concentrations with minimal water flow variations and keeping the same airflow. All the experiments were conducted until carbon concentration in the water was steady for at least 6 days.

Total carbon (TC) and Total Nitrogen (TN) present in the water were measured by nondispersive infrared sensor (NDIR) and chemiluminescence, respectively, using Shimadzu TOC-VCPH/CPN Total Organic Carbon Analyzer and TOC-Control V software. Chemical Oxygen Demand was measured according to the SM 5220 D. Closed Reflux, Colorimetric Method.

The VOC concentration of airflow at both inlet and outlet of the column was measured with a Photo-Ionization Detector using a Tiger LT gas detector with 0.1 ppm as minimum resolution.

The industrial effluent characterization at the plant was performed using FID detector Signal according to EN 12619:2013 for VOC. Airflow was measured with a Pitot Type S Isostack Basic Tecora according to EN ISO 16911:2013.

3. RESULTS AND DISCUSSION

Efficiency of VOC removal from the air stream was consistently above 90% for B1, B2 and B4. B2, except for a few days, was constantly hitting the 100% mark, while B4 efficiency was below 85% for most of the time frame. Biological VOC elimination capacity was higher for higher inlet VOC concentrations due to the availability of carbon source. When changing from B2 to B3, the consumption rate increased but stabilized after a few days. This might be credited to the rapid development of the microorganisms due to the availability of substrate. It is also important to notice that variations of the VOC inlet did tableffect normal operation and therefore did not have an impact on the removal efficiency. Carbon concentration in the water stream varies according to the VOC inlet concentration. Lower VOC concentrations translate into lower carbon accumulation in water. When reaching a steady state, experiments B1, B2 and B3 proven to be effective at reducing the inlet VOC concentration to values below 50 mg_C/Nm^3. In fact, B3 and B4 present a similar elimination capacity. This proposes a limit for the microorganism's elimination capacity at around 7.251 $g_{VOC}.m_{water}^{-3}.h^{-1}$ for the present amount of water in recirculation. Therefore, VOC concentrations above 550 mg_C/Nm^3 hinder the system and outlet VOC concentrations of 50 mg_C/Nm^3 are no longer tangible.

4. CONCLUSION

From this study it is possible to conclude that the biofilter combination with MBBR effectively hinders carbon accumulation in the water due to the microorganism's consumption of the carbon present in the VOC. The system can withstand significant variations of VOC concentration without compromising its' operation and the microorganism's survivability. The elimination capacity of the microorganisms appears to be limited to 7.251 $g_{VOC}.m_{water}^{-3}.h^{-1}$, meaning that VOC inlet concentrations higher than 550 mg_C/Nm^3 will not be further treated to 50 mg_C/Nm^3 for the proposed system. Nevertheless, removal efficiencies higher than 90% were reached for concentrations below 550 mg_C/Nm^3, and around 80% when concentration was between 550 and 615 mg_C/Nm^3. During all phases, clogging, pH and nutrient limitation did not represent a problem, as the system operated for 4 months without any major issues. Although further studies should be conducted regarding this matter, sludge production was minimal, without the need to discharge sludge from the sedimentation tank.

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E075   **9:30-9:45**

Development of Polymeric Support for the Immobilization of TiO$_2$ Photocatalyst: Approaches and Efficiency

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ABSTRACT

Photocatalytic oxidation is an interesting advanced oxidation process (AOP) for the removal of recalcitrant pollutants from water. If solar light is applied as radiation source, the operating costs can be lower. However, the use of powder photocatalyst is a major drawback of the technology since suitable separation technologies are required and catalysts recovery is difficult. This work aims to test the suitability of using polymeric supports to immobilize titanium dioxide (TiO$_2$) in the reactor and apply it for parabens removal from water by solar photocatalytic oxidation. Polyurethanes (PU) and polydimethylsiloxane (PDMS) membranes were prepared and modified with TiO$_2$. While PU materials are only able to adsorb (35% in 1 h) parabens whichever the modification applied, modified PDMS was able to promote parabens photocatalytic oxidation removing 20% in 1 h under solar conditions. Plasma/UV modification was able to lead to catalytically active PDMS membranes (16% of methyl paraben (MP) removal) and further entrapment of TiO$_2$ in the polymeric matrix did not improve the process (18% of MP removal). Thus, only the superficial TiO$_2$ was active. The results show that PDMS is a suitable material to support TiO$_2$ aiming solar photocatalytic wastewater treatment processes.

Keywords: Advanced oxidation processes; Contaminants of emerging concern; Parabens; Polymeric supports; Solar photocatalytic oxidation; Supported TiO$_2$

1. INTRODUCTION

Public health and ecological concerns regarding the presence of contaminants of emerging concern such as pharmaceuticals and personal care products (PPCPs) in water are growing. In fact, water scarcity due to its exponential consumption is increasing and global warming intensifies the appearance of such contaminants in water sources. These compounds are not efficiently removed by the conventional wastewater treatment and are discharged untreated to natural water courses[1], still their potential impact is not well known Parabens are used as preservative agents in many PPCPs. AOPs such as photocatalytic oxidation appear as suitable alternatives for their removal [2].

TiO$_2$ is the most usual photocatalyst in this approach since it can produce hydroxyl radicals in the presence of suitable radiation such as sunlight radiation that can be used as a costless radiation source. Typically, this catalyst is used as powder to minimize the mass transfer resistances but has problems for the catalyst recovery and reuse. Alternatively, to allow the catalyst reuse, powder can be immobilized onto a support, that can have different sources. However, immobilization of TiO$_2$ on a support may also bring some disadvantages that may compromise oxidation efficiency.

In this work, three different materials (one PDMS and two PU) were used to prepare films. These materials has their transparency and flexibility as highly advantageous for the purpose of this work. The novelty of this work was focused on the assessment of the oxidation efficiency of parabens when using these polymeric materials as support matrices for the photocatalyst TiO$_2$. TiO$_2$ was immobilized in the polymeric films either by entrapment (achieved during films preparation) or superficially (achieved by plasma followed by UV irradiation). The use of low-cost energy from the sun to promote oxidation is an important advantage of such process.

2. MATERIALS AND METHODS

PU films were prepared by solvent evaporation. Desmopan$^®$ was dissolved in dimethylformamide to a 10% (w/v) PU solution and 1 mm films were obtained. PDMS pre-polymer and cross-linking agent were mixed at the ratio of 10:1 by mass and films with 2 mm thickness were produced [3].

Several approaches were tested to immobilize TiO$_2$ onto the polymeric membranes. Several types of materials were prepared involving TiO$_2$ entrapped in the polymers (E), entrapped in the polymers and also modifying the surface with plasma/UV to add superficial TiO2 (E+P). These materials performance was compared to the one attained when only the surface modification of the membranes using plasma/UV was applied (P).

For the photocatalytic oxidation with sunlight radiation a circular membrane covering the glass reactor (50 mL) bottom were placed and the liquid stirring was promoted by bubbling air. The parabens concentration along the reaction was followed by the HPLC-DAD.
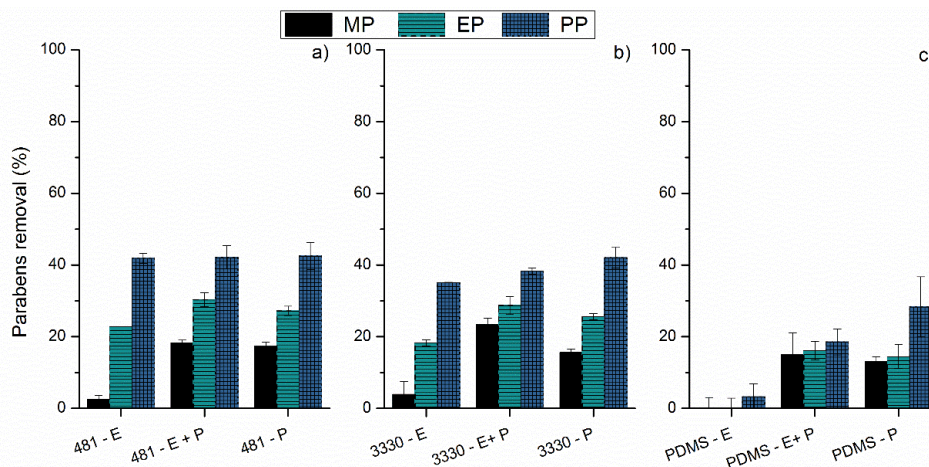
3. RESULTS AND DISCUSSION

Fig 1. TiO$_2$ immobilization methodology effect over parabens degradation for a)Desmopan 481, b) 3330; c) PDMS supports.

The parabens removal is not a function of TiO$_2$ immobilization method when the support is PU. Still, the use of plasma/UV seems to slightly increase MP removal when compared to the case where the membranes were not subjected to plasma treatment, probably due to the increase in their hydrophilicity. For PDMS the degradation was very low with entrapped TiO$_2$ (E) , removals of about 30% for PP were obtained when PDMS was modified using plasma/UV and TiO2 was added to the surface. Moreover, no further improvement was achieved when TiO$_2$ was added by both methods (E+P). Thus, one may conclude that only superficial TiO$_2$ is available for the degradation reactions since it is exposed to both pollutants and light.

4. CONCLUSION

PU materials remove parabens from water by adsorption. Contrarily, parabens removal by TiO$_2$ modified PDMS membranes under solar conditions was achieved organic contaminants oxidation. When comparing the performance of membranes modified by different processes it was concluded that TiO$_2$ entrapped in the polymeric matrix was not active. Differently, TiO$_2$ added to PDMS surface by plasma/UV was the main responsible for the photocatalytic activity. This study proved for PDMS support 30% of PP removal in 1 h of reaction. These results show that PDMS is an interesting material to support TiO$_2$ in photocatalytic wastewater treatments using clean and cheap solar energy.

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ICEER 2021

Oral Flash 2

10:00-12:15 @ Meeting ID: 948 1336 4454

E078	10:00-10:07

Comprehensive Evaluation of the Planned Development of Intermittent Renewable Sources within the EU

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ABSTRACT

This paper deals with an assessment of the steps taken and planned by the EU (European Union) to achieve its climate neutrality by 2050. Emphasis is placed on the reality of achieving RES (renewable energy sources) in total energy production in individual countries according to the required values for 2030. A detailed analysis of the previously set goals of penetration of RES and their historical fulfillment was performed. Furthermore, an evaluation of the planned shutdown of traditional combustion sources and the overall loss of constant production power, which keeps the energy system stable with a sufficient amount of standby power in real time is performed. In connection with these facts of the EU plans of the shift away from coal power plants and the nature of the intermittent electricity generation of the used renewable sources within the EU and the historical dynamics of the RES production capacities installation are evaluated.

Keywords: Coal power plants shut down, Decarbonization, Energy transition, EU climate goals, Renewable energy.

1. INTRODUCTION

Today, more than ever before, the EU is under increasing pressure to protect the climate and the environment, which are being negatively affected by the nature of the behavior and the energy and material demands of everyday life in modern society. With its long-term energy and climate policy, the European Commission plays a leading role in reducing greenhouse gas emissions (GHG), especially CO_2, primarily produced during electricity generation by traditional combustion sources. For this reason, the ongoing massive transformation of the energy system and the overall approach to energy within the EU countries has accelerated in recent years. This dynamic transformation means increasing the shares of renewable electricity sources (RES) in total electricity production, optimal and efficient use of energy and energy resources, and for this purpose, demands for higher penetration of storage technologies in energy infrastructure.

The increase in the ambitions and goals of the EU's energy and climate policy is evidenced by the newly set strategy and comprehensive plan until 2030, presented in December 2019 under the title European Green Deal [1]. In addition, the European Green Deal package also includes 'Climate Law' embedding and legal commitment for the EU to achieve climate neutrality by 2050, which only predicts future higher demands for accelerating energy transformation and changing the energy mix of individual EU countries.

The main objective of the work is to identify whether ambitious targets of the 2030 Climate and Energy Framework, with 32% of RES shares in total electricity net production and 40% cuts in GHG emissions compared to the 1990 level, are reachable. Deep research in RES development, such as past results and current state, is required to achieve this goal.

Thus, a literature review has been done to observe what was already accomplished in this direction. Thereby, the RES generation potential in the EU is considered underused due to strong dependence on fossil fuel, lack of investment in the energy infrastructure, unstable policy frameworks for RES energy support schemes, and plans of building new nuclear power plants [2]. But other studies deal only with selected EU countries [3, 4, 5], and since each country has its own GHG emission and RES share contribution, therefore, it is important to examine all EU countries conjointly.

2. MATERIALS AND METHODS

The research method and analysis of this paper consist of three separate parts. Within the first stage, the identification of binding goals of the European climate and energy policy and the vision of the EU until 2050 is performed. The second part is related to the need to move away from fossil fuels. Therefore, the coal power plant (CPP) shift away plans are explored to analyze zero-emission targets by 2050. CPP shift-away plans are obtained from officially published national plans and an assessment of the progress made in the use of coal by EU countries. The last methodology part, a comprehensive evaluation of past renewable energy contributions in electricity supply (RES-E) in the EU, is performed. The analysis includes energy generation and GHG emissions over time

and the ability of EU Member States to shift away from fossils. For this research, statistical data from Eurostat and International Renewable Energy Agency (IRENA) databases are used [6], and information regarding GHG emissions is taken from European Environment Agency [7]. At the end of this paper, the discussion on how well the 20 % target of RES shares till 2020 was met is taking place, and results based on provided cases and analysis of selected countries are presented.

3. RESULTS AND DISCUSSION

The aim of this work was to analyse whether the EU and Member States are able to reach carbon neutrality goals. And the study has shown that RES development in different countries will depend on certain energy sources, as geographically they have different potentials. Also, conventional energy sources will continue to play an important role in maintaining energy security in many countries, especially in the countries of the Central and Eastern European region. In Latvia, Slovenia, Slovakia, Romania and Bulgaria, the future high representation of hydropower is expected. In contrast, in Poland and Lithuania, wind energy will play a dominant role. However, despite 2020 goals were met by the EU, there are uncertainties on reaching set goals by 2050 in the majority of EU members, because of lack of investment in the energy infrastructure, unstable policy frameworks for RES energy support schemes, and plans of building new nuclear power plants.

There are several proposals existing on how the EU can meet carbon-neutrality by 2050 and it would require usage of advanced storage technologies, broader electrification and new bio/hydrogen energies. All these mentioned technologies will need sufficient financing for their sufficiently rapid development for the successful replacement of decommissioned production capacities using fossil fuels. This should be ensured by the EU taxonomy classification system, which will assess investments according to the main environmental criteria, whether the project or technology is environmentally friendly, sustainable and will contribute to the EU's climate and energy transformation objectives. In the future, only projects that are in line with low-carbon and climate protection policies will be funded.

Furthermore within our future study we will place emphasis on investigation of the EU interconnected electricity system and forecast how to ensure smooth energy transition. We also think there are more barriers in RES expansion. For example, barriers, such as end consumer electricity prices, taxes for RES support, and sufficient cross border capacity between EU countries.

4. CONCLUSION

The transition to carbon-free energy within the EU cannot be assessed across the board for all Member States due to different current dependence of EU Member States on fossil fuels and thus, each EU Member State may have various problems on RES penetration in the future. Moreover, barriers to development in RES penetration within the European interconnected electricity system are, in particular, the maintenance of a constant production capacity that will be available at all times to maintain the stability and safe operation. This will also cause an increased need to use storage technologies that will play a crucial role in energy transformation.

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Effect of Temperature on the Thermolysis of Waste Polyethylene Terephthalate (PET) and Its Application in Methylene Blue Removal

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ABSTRACT

Polyethylene terephthalate (PET), a major plastic waste, is recycled into solid carbon by thermal decomposition under autogenic pressure. PET is carbonized at 500 to 1000 °C and the effect of temperature on the properties and yield of the synthesized carbons or char is studied and discussed using SEM, TEM, EDX, XRD, FTIR and BET analysis. The synthesized char (SC) exhibits a range of microporous to mesoporous structures with a pore volume and surface area ranging from 0.2029 to 0.0573 cm^3 g^{-1} and 448.88 to 3.3 m^2 g^{-1} respectively. SC was employed in the removal of methylene blue (MB) and the effect of contact time is investigated. SC produced at 500 °C demonstrated the highest adsorption capacity of 77 mg g^{-1} due to its high surface area and high pore volume.

Keywords: Adsorption; graphene; Polyethylene terephthalate (PET) waste; recycling; thermolysis.

1. INTRODUCTION

Plastics have been widely used in both household and industries due to their numerous applications [1]. Plastics are characterized by many desirable properties such as low cost, lightness, formability and durability [2]. Enormous quantities of end-of-life plastics are consequently generated annually which are generally immune to natural degradation cycles and hence pose severe threats to the environment [3]. Meanwhile, plastic production has increased and is expected to triple by 2050 [4]. PET contains about 75% total carbon and recycling its waste is the best solution to treat waste plastics [5].

In our work, PET waste is upcycled into high-value carbon by thermal decomposition from 500 to 1000 °C under autogenic pressure. The effect of temperature on the crystallinity, surface functional groups, morphology, surface area, yield, and purity of the synthesized char (SC) are investigated using various analytical techniques. The potential application of SC is demonstrated with MB removal and some adsorption parameters are studied.

2. MATERIALS AND METHODS

Waste PET bottles were washed with distilled water, sun-dried and then shredded. 10 g of shredded PET was placed in a 420 mL stainless steel autoclave and heated at 500, 600, 700, 800, 900, and 1000 °C in separate tests. The target temperature was maintained for 2 hours and the setup was afterwards left to cool overnight. The char (SC) was collected and stored in a desiccator. The SC is labelled by SC-thermolysis temperature. For instance, SC-500 refers to char synthesized at 500 °C. 0.2 mg/L of each SC was employed in methylene blue (MB) adsorption for 1 h.

3. RESULTS AND DISCUSSION

SC-500 reported the lowest yield of 15%. However, the yield increased with temperature as more C-H and C-C bonds break [6]. The increase in yield after 700 °C thermolysis was relatively steady which suggests that some gaseous hydrocarbons remained despite higher thermolysis temperatures. Nevertheless, these gases serve as reducing agents keeping the carbon in the solid form [6]. The highest yield of 33% was reported at the 1000 °C thermal decomposition. Blocks of irregular sizes and shapes were observed from SEM analysis depicting possible graphitization and agglomeration of sheets with increasing temperature. Shadows observed from TEM images confirm the agglomeration of the graphene sheets thus the blocky nature of the SEM micrographs. Graphitization was further confirmed by the presence of characteristic XRD peaks at 2θ value of ~26°, 42° and 44° corresponding to the (002), (100) and (101) diffraction planes of graphite. These peaks were sharper with increasing temperature which indicates an improvement in graphitization with temperature. The FTIR peak at 1600 cm^{-1} in SC is attributed to C=C stretching which is a fundamental property of sp2 graphite. SC also contained oxygen functional groups such as O-H bonds which are favourable for organic contaminants removal [7]. Moreover, such oxygen functional groups are frequent in graphene materials. EDX spectroscopy revealed the synthesis of high purity carbon (over 92%) at all temperatures. SC-500, 600 and 700 exhibited microporous morphology while SC-

800, 900 and 1000 exhibited a mesoporous structure. The high pore volume observed in SC-500 and 600 (448.88 and 361.03 m^2 g^{-1} respectively) was attributed to the increase in the number of pores due to the arrangement of carbon layers resulting in the creation of micropores [8]. Furthermore, possible activation effect in the surface and bulk of the char due to the presence of large quantities of hydrocarbon radicals and some hydrogen and water vapour at 500 and 600 °C can cause the amorphous nature and high pore volume and high surface area of their char products [6,9]. However, the reduction in pore volume and surface area from SC-700 to 1000 (156.45 to 3.3066 m^2 g^{-1}) was attributed to the agglomeration of graphene sheets with temperature. Meanwhile, the increase in mean pore diameter from SC-700 to SC-1000 (1.646 to 69.835 nm) was attributed to the dominant occurrence of the pore widening effect than the pore-opening effect, resulting in a decrease of the specific surface area and micropore volume [10,11]. In the MB adsorption test, the adsorption capacity of SC decreased with increasing thermolysis temperature. This trend reveals the suitability of porous amorphous SC produced at lower temperatures for contaminant removal than the crystalline SC. SC-500 achieved the highest adsorption capacity (77 mg g^{-1}) due to its high surface area and the existence of several polar functional groups.

4. CONCLUSION

The effect of temperature on the thermolysis of waste PET from 500 to 1000 °C under autogenic pressure is analyzed and discussed. The process generally produced high purity carbon (graphene) with an increase in yield as temperature increases. SEM, TEM, XRD and FT-IR results indicated that higher temperature thermolysis of PET produced higher crystalline carbon allotropes (from amorphous to graphitic carbon as temperature increases). However, the graphitic sheets are agglomerated with reducing BET surface area and pore volume as temperature increases. Adsorption test revealed that amorphous carbon synthesized below 600 °C are the most suitable for MB removal. It is concluded that PET converted into highly porous amorphous carbons are more suitable for organic pollutants adsorption than their crystalline char products.

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Water Quality Characterization and the Related Implications within Il-Magħluq Ta' Marsaskala (A Special Area of Conservation)

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ABSTRACT

Il-Magħluq ta' Marsaskala is a small saline marshland in the south of Malta. It is characterized with brackish water housing peculiar salt-tolerant marsh communities and protected species that include the Mediterranean killifish, *Aphanius fasciatus*. This Natura 2000 Special Area of Conservation (SAC) is made of two different types of Annex I (Council *Directive* 92/43/EEC) habitats which are Habitat 1150* and Habitat 1410. This study focuses on water quality characterization and its implications within this SAC. Monitoring of water quality and abundance of the killifish was carried out over a period of one year (November 2017 – November 2018). Temperature, pH, and dissolved oxygen were taken on-site while phosphates and nitrates were analyzed in the laboratory. The fluctuations observed in the water quality parameters can be attributed to seasonal variations, and possibly to anthropogenic activities surrounding the study area. The water quality can also be affecting the killifish population since a total of 22 individuals were recorded during this study. The density of killifish is excessively low when compared to data collected from similar studies within the same study area in previous years.

Keywords: Aphanius fasciatus; Brackish; Malta; Mediterranean; Special Area of Conservation; Wetlands

1. INTRODUCTION

Il-Magħluq ta' Marsaskala is made up of brackish water hosting peculiar salt-tolerant marsh communities. It is also the habitat of some protected species such as the *Aphanius fasciatus*. The brackish water found here forms from the freshwater from the valley system and rainwater entering the pool that combines with the seawater that enters through the connection under the road [1]. Whilst the saline marshland is surrounded by an urban area, the pool also has agricultural land on its western and southern sides. This research will focus on characterizing the water quality of this area of study and studying the anthropogenic activity that may affect this special area of conservation. This study complements similar studies done in the same site since pressure on the water quality and the fauna present in this water body is always increasing; pressures include run-off from the nearby agricultural fields, alien species and illegal dumping [1]. Such studies will ensure adequate management of both the area and the species.

2. MATERIALS AND METHODS

Water quality data was collected on a monthly basis between November 2017 and November 2018. The site was divided into three different points to reflect the different ponds that characterize the study area and for each point the same approach was used: temperature, dissolved oxygen and pH were collected in-situ, while phosphates and nitrates were analyzed in the laboratory. A capture-release method was used so that the *A. fasciatus* population can be recorded.

3. RESULTS AND DISCUSSION

The results provide an overview of the pool as a whole (values from the three sampling points yielded a mean value: Fig. 1a – e).

During the one-year sampling period only 22 individuals of *A. fasciatus* were captured. The discrepancy is quite significant when compared to the 417 individuals recorded in the same study area back in 2011 [2]. The results depict significant inter-seasonal fluctuations in all the parameters, and this can limit the population of any given species. Given that *A. fasciatus* can tolerate a wide range of water quality conditions, it is important to consider both the direct and indirect implications that certain water quality parameters can have on other physicochemical attributes. For instance, whilst temperature can directly influence levels of dissolved oxygen in water, it can also have indirect effects on other parameters. An example of this would be ammonia, which could originate from fertilizers from the surrounding fields; toxicity of ammonia tends to vary depending on both temperature and pH fluctuations [3].
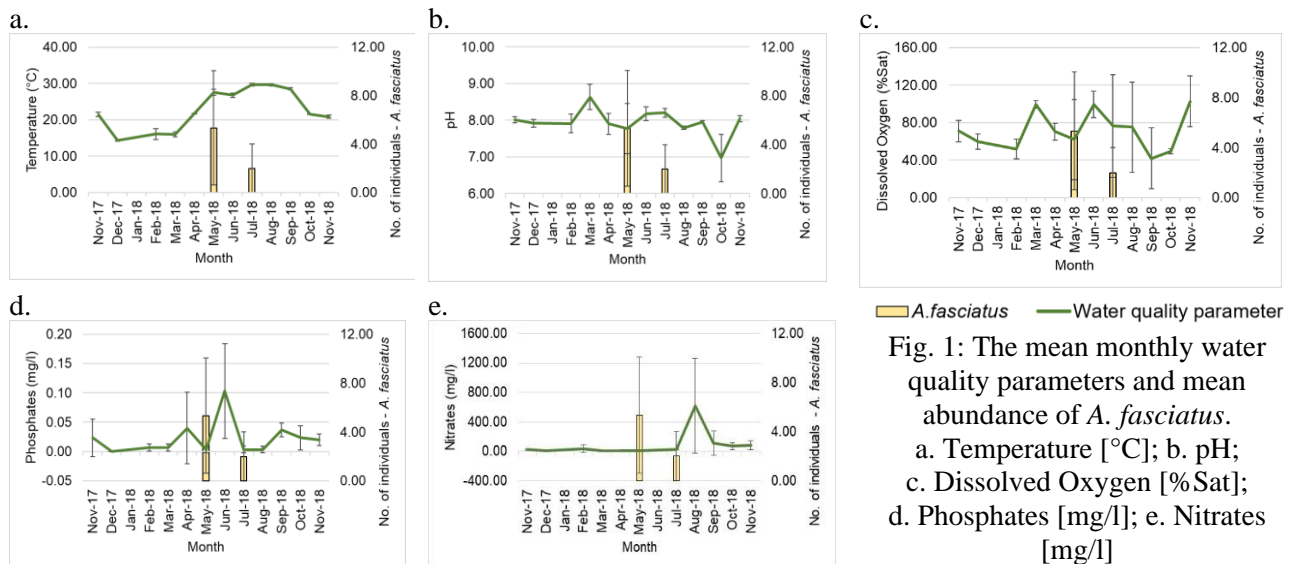
Fig. 1: The mean monthly water quality parameters and mean abundance of *A. fasciatus*.
a. Temperature [°C]; b. pH; c. Dissolved Oxygen [%Sat]; d. Phosphates [mg/l]; e. Nitrates [mg/l]

Diffuse runoff from agricultural land is still considered to be a major source of phosphorus in many European lakes [4]. High amounts of phosphates can result in eutrophic conditions which will eventually impact and decrease the amount of dissolved oxygen in the waterbody. Similarly, high concentrations of nitrates, which could be the outcome of increase in run-off from the nearby agricultural fields, can directly yield eutrophic conditions. Nitrates can also indirectly induce strong phosphate eutrophication in wetlands during which oxygen levels in the water will eventually decrease thus impacting the mortality rate of the living organisms as well [5].

The water quality characteristics highlighted in this study could imply that the overall small size of the population of the killifish is partly due to stress-induced mortality, arising from the large seasonal fluctuations. Such fluctuations are the consequence of several factors both natural, such as freshwater runoff at the mouth of the valley, as well as anthropogenic ones, such as engineering works at the wetland-sea interface [1]. Biotic factors such as predation can also influence the population of the killifish.

4. CONCLUSION

The results demonstrated that seasonal variation play a vital role in the water quality of the area. When compared with similar studies, the number of individuals observed in this study is significantly low. It is therefore evident that the population of *A. fasciatus* at *Il-Magħluq* marshland site is highly vulnerable, even though according to EUNIS this species' threat status is of least concern. This study gives an insight of what is going on with respect to the existing management plan and can be potentially useful to improve on current legislation and policies to protect this special area of conservation.

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Smart Home Energy Management Processes Support Through Machine Learning Algorithms

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ABSTRACT

Smart Home Energy Management Systems can manifest energy consumption reduction targets in the residential sector and can be viewed as an approach to transform the consumer into an active prosumer. The present paper presents a smart home energy management system that includes flexible appliances, electric vehicles, and energy storage units. Efficient forecasting algorithms support the robust operation of the smart home energy management system. Specifically, the smart home energy management system receives as inputs forecasts of demand, renewable energy sources including photovoltaics and Wind Turbine generations, and real-time prices. In order to minimize energy costs, a variety of algorithms is compared to provide highly accurate forecasts.

Keywords: demand response; forecasting; optimization; prosumer; smart home.

1. INTRODUCTION

This paper presents a methodology that involves the synergy between a Smart Home Energy Management System (HEMS) and supervised and unsupervised machine learning algorithms for a prosumer. The resources of the prosumer involve Photovoltaics (PV) and Wind Turbine (WT) systems, Electric Vehicles (EV), Energy Storage Systems (ESS), and flexible loads. The HEMS receives as inputs the state-of-charge of the ESS, EV operational characteristics, and loads such as heater/air conditioner, refrigerator, water heater, and others. The prosumer is connected to the grid and receives real-time prices from a retailer. Through machine learning algorithms, forecasts of RTPs, PV, and WT generation are obtained. The forecasting processes are critical to optimal utilization. Thus, in the paper, forecasting algorithms of different types and complexity are examined, namely General Regression Neural Network (GRNN) and Elman Neural Network (ENN) [1,2]. In the literature, the most common method of input selection is to employ a correlation. In the present paper, the input selection is based on clustering. The K-medoids algorithm is utilized [3]. This approach allows the user to select different clusters and different amounts of historical data for training. Thus, it is feasible to create training sets with more similar patterns and achieve between forecasting training. In addition, the HEMS optimization problem is formulated and solved as a mixed-integer linear problem.

2. MATERIALS AND METHODS

The forecasting algorithms outputs will be tested on an optimal HEMS model consisting of different appliances classified into six load types: (i) uncontrollable loads (fixed load), (ii) curtailable loads (full curtailment during specific periods), (iii) adjustable loads (the load demand can be adjusted), (iv) uninterruptible and independent loads (operation for a certain time period after their start-up decision), (v) uninterruptible and dependent loads (the operation of one appliance has to be finished in order for a start-up decision for another dependent appliance and/or the operation of one dependent appliance is subject to the concurrent operation of another appliance), and (vi) thermostatic loads (air-conditioning, refrigerator, and water heater). In addition, an ESS is also considered along with an EV, providing the option for interaction with the grid, purchasing and/or selling electricity. Moreover, a PV and a WT are also installed, enabling the household owner for additional exchanges with the power grid. The objective function concerns the minimization of the household's total net daily cost, namely the total cost for grid electricity purchases minus the total revenues from electricity sales to the grid.

3. RESULTS AND DISCUSSION

The scheduling profile is similar in both cases. A number of time shifts occur at various periods. The peak value equals 14.31 kW at the ENN case and 17.11 kW at the GRNN case (Fig. 1). Both occur at the 1st of the 96 15-min intervals of the day since the lowest electricity price of the day occurs during that time slot. The HEMS determines the higher load values during periods of combined low RES availability with low electricity prices. During these intervals, the HEMS purchases electricity from the grid, utilizing the total amount of its on-site RES generation for its direction consumption simultaneously. During medium and high RES availability, the HEMS is a net electricity exporter to the grid, and the intervals of low RES availability, the HEMS is a net electricity importer (Fig. 2).
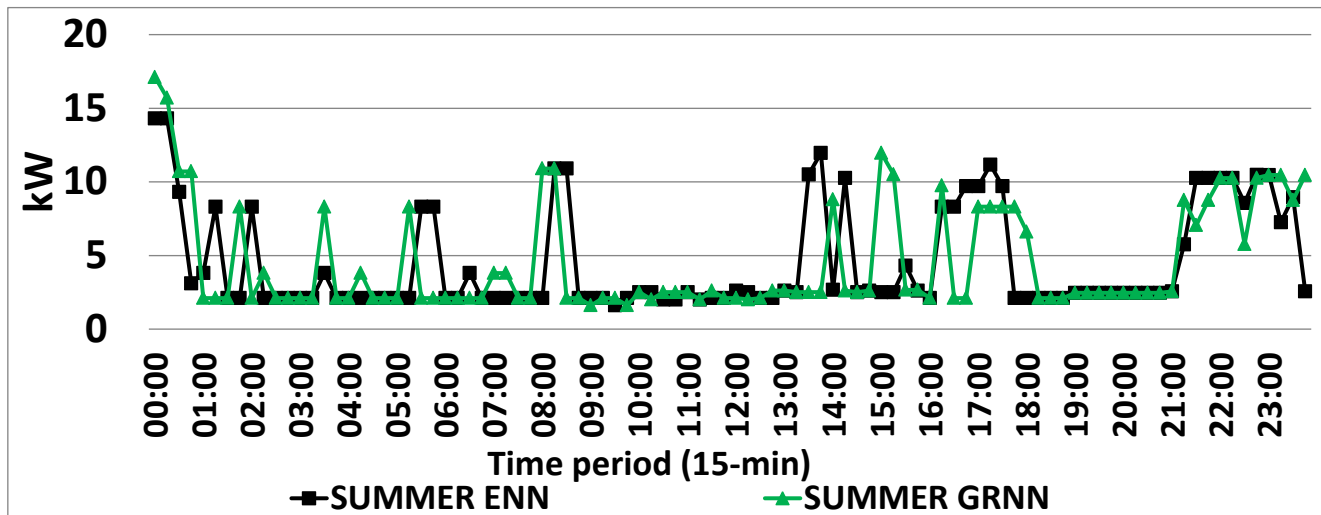
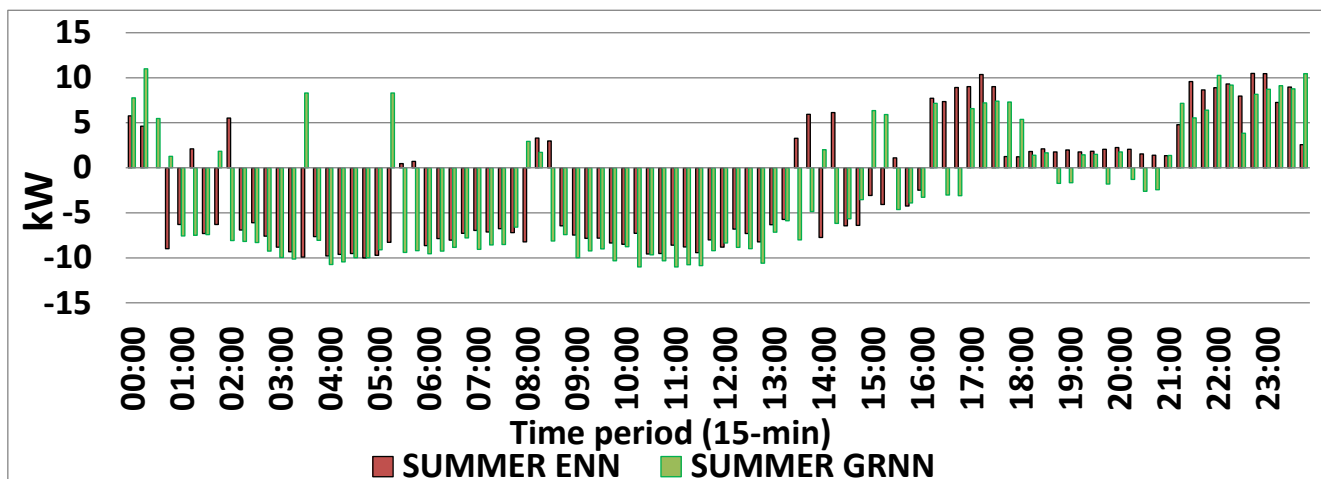Fig. 1: Optimal load scheduling on each applied technique.

Fig. 2: Net electricity trading balance on each applied technique.

4. CONCLUSION

The results show the impact of RES and electricity price forecasting on the load scheduling, the energy trading balance, and discharge/charge cycles of energy storage and EV. Although the absolute numbers are pretty small for a HEMS case, this could significantly impact aggregated cases, both at an economic and operational level. The increased forecasting accuracy together with the balancing role of ESS could alleviate the impacts of significant fluctuations in the demand and price forecasts.

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Agroforestry Systems As the New Strategy for Bioenergy – Case Example of Czech Republic

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ABSTRACT

The paper deals with the analysis of economic efficiency of innovative agroforestry systems (AFS) using coppiced tree belts (CTB), which combine the advantages of traditional alley cropping with the short rotation coppice (dense plantation of fast-growing trees for biomass – SRC) on an agricultural field. We have analyzed and compared such innovative agroforestry system (AFS-CTB) with conventional food crops production in conventional 4 crop year rotation (winter barley, winter wheat, rapeseed and corn). The minimum price of production, (based on net present value criterion), was performed to enable simultaneous assessment of annual and perennial crops over time in order to obtain also economic evaluation and comparison. Our results show that AFS-CTB generate similar income and profits as from conventional annual crops when cultivating on suitable sites and adhering to good farming principles. The results obtained confirm that the AFS concept is economically viable and is thus one of the real options for diversifying the activities of agricultural operators and for increasing ecological stability.

Keywords: agroforestry system; biomass; coppiced trees belts; economic effectiveness; minimum price calculation

1. INTRODUCTION

Agroforestry (AFS) system is a concept of integrated land usage where both forestry and agricultural elements are combined to make the system as consistent as possible with the principles of sustainability and biological balance [1]. One of the objectives is to balance production with resource conservation and thus environmental protection [2]. In recent years, there has been a significant discussion about the decline of biodiversity in the landscape. Society faces the dual challenge of increasing biomass production to meet future demands for food [3], materials and bioenergy, while addressing the negative impacts of current (and future) land use [4]. Therefore, the non-productive functions of agroforestry systems are also the main reason for establishing agroforestry systems.

2. MATERIALS AND METHODS

We have analyzed innovative agroforestry system - coppice tree belts (AFS-CTB) with conventional food crops production in normal 4 crop year rotation (winter barley, winter wheat, rapeseed and corn). Agroforestry systems with coppiced trees belts can be established and cultivated in a number of variants - according to the conditions of the location and needs of the farmer. To optimize environmental and economic benefits, we have proposed following parameters of CTB for large fields (over 20 ha) with basic scheme of 1-ha (100x100 m):

- 5.5 m-wide belts with 3 rows of coppiced trees (poplars Max-4, 'AF2'; willow 'Rokyta', 'Tora')
- distance between CTBs is approximately 26 m

In larger field areas it is assumed that the scheme would be repeated and the total area of CTB would cover 16% and conventional food crops 84% of total available area. For proposed agroforestry system AFS-CTB we have collected yields of coppices trees from existing "narrow" SRC plantations as well as newly established CTBs. For rotating annual crops in AFS we have used yields form statistical yearbooks. We have measured and collected field yields of individual rows in several SRC including edge rows. The methodology for the economic evaluation of AFS is based on the fundamental principles of the basic methodology for economic evaluation of energy crops adopted from [5], namely on calculation of net present value and minimum price of production.

3. RESULTS AND DISCUSSION

From results of field measurement in narrow SRS we can say that biomass production of AFS-CTB can be higher per growing area than in large SRC plantation due to positive edge effect (more light and water, and residual nutrients in the subsoil; less competition among trees) and it can vary up to 250 % of the average from the whole field. Input data on conventional crop prices have been adopted from the Report on the Market for Grains, Oilseeds and Feed [6]. Data on the cost of conventional crop production was taken from the Czech norms on agricultural production [7]. Conventional crop and CTB yields are estimated based on the Assessed Land

Valuation Units (BPEJ) [8]. Minimum prices for different yields and discount rate for woodchips were calculated in order to show the range of possible outputs. Our results of economic analyses show that if the cultivation of the AFS-CTB is provided on suitable sites for fast-growing tree species and adhering to good farming principles, the discounted cash flow from CTB can have the same value as that of annual conventional crops after the expected production period (22 years), i.e., the CTB would be as economically efficient.

<p style="text-align:center">Expected yields from CTB in t(DM)/ha.year</p>

	6.8	9.0	11.3	13.6	15.8
Discount	Minimum price of woodchips in EUR/t				
10%	78	57	56	37	36
13%	89	65	52	42	41
16%	103	74	59	47	47

4. CONCLUSION

A major factor that affects the economic efficiency of AFS-CTB are costs associated with establishing, operating and eliminating the CTB. From an analogy with SRC plantations, it can be deduced that these costs account for about 52% of the total costs of CTB. The minimum price of CTB woodchips is also significantly influenced by biomass yield in t/ha. The obtained results show, especially for the two lower expected yields, that the minimum price of CTB woodchips (interpreted as a price of woodchips that would have the same economic effect as if the producer had only grown conventional crops) under current conditions cannot compete with woodchips from forestry biomass. The size of the discount (i.e., the expected economic return on business) also plays an important role. The discount rate reflects the risk of doing business. It can be reduced by limiting the risks associated with the implementation of the CTB as part of the AFS, e.g., getting long-term contracts to supply woodchips, limiting the fluctuation of woodchip prices, etc. Redirecting part of the operating subsidies to the establishment of the CTB would also play an important role in limiting risks for the producer. An important benefit is the solution of erosion-prone land, where this risk is eliminated and other non-productive functions of the landscape are improved, which can contribute to increased yields of individual crops. The fundamental question for a comprehensive AFS evaluation is proper pricing of such environmental benefits.

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Principal–Agent Approach to Energy Executive Compensation Design

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ABSTRACT

The principal–agent problem attracted attention from researchers 20 years ago in connection with Enron. The paper reports on the behavioral experiment of designing energy executive compensation contracts. An experimental approach based on principal–agent theory was applied 1) to design a fixed and variable component of the compensation contract, 2) to assess the impact of information disclosure on the terms of the contract, 3) and to estimate the response of the manager's efforts to the terms of the contract. Hypotheses testing showed that (a) disclosure does not affect the decision-making of the owners (principals) on the size of the energy executive compensation package to the management (agents), (b) the nature of the disclosure has no significant impact on the manager's acceptance (or rejection) of the compensation package, (c) the growth of the energy executive compensation package has an impact on the growth of the manager's efforts, (d) disclosure has a significant impact on the decision-making of managers about the level of their efforts.

Keywords: Behavioral experiment; energy company governance; principal–agent problem

1. INTRODUCTION

The principal–agent problem attracted attention from researchers 20 years ago in connection with the bankruptcy of an energy trading and distribution company Enron Corporation.

The contribution in this study extends the analysis of the impact of information disclosure on the terms of the energy executive contracts, and estimation of the executive efforts to the terms of the contract.

2. MATERIALS AND METHODS

The study is carried out within the framework of behavioral game theory. Analysis of covariance is used to analyze experimental data.

3. RESULTS AND DISCUSSION

3.1. Impact of disclosure on owners' decisions about the size of the energy executive compensation package

The zero-hypothesis is as follows: H_0 - disclosure does not affect the decision-making of owners.
The zero-hypothesis is not rejected: disclosure does not affect the decision-making of owners about the size of the offer of the compensation package.

3.2. The impact of disclosure on the acceptance (or rejection) of the compensation package by the manager

The zero-hypothesis is as follows: H_0 - Acceptance and rejection of the compensation package by the manager does not depend on disclosure. The zero-hypothesis cannot be rejected: the nature of the disclosure does not have a significant effect on the acceptance (or rejection) of the compensation package by the manager.

3.3. The impact of the increase in the energy executive compensation package on the increase of managers' efforts

The zero-hypothesis is as follows: H_0 - The increase in the compensation package does not affect the growth of the manager's efforts. The zero-hypothesis is rejected. Thus, such behavior of managers can be described as rational.

3.4. The impact of the increase in the energy executive compensation package on the increase of managers' efforts

The zero-hypothesis is as follows: H_0 - Disclosure does not affect managers' decision-making. The zero-hypothesis cannot be rejected, as the differences in decisions taken are statistically insignificant.

4. CONCLUSION

1. Impact of disclosure on owners' decisions about the size of the energy executive compensation package. The zero-hypothesis is not rejected: disclosure does not affect the decision-making of owners about the size of the offer of the energy executive compensation package.

2. The impact of disclosure on the acceptance (or rejection) of the energy executive compensation package. The

zero-hypothesis cannot be rejected: the nature of the disclosure does not have a significant effect on the acceptance (or rejection) of the energy executive compensation package.

3. The impact of the increase in the energy executive compensation package to on the increase in the manager efforts. The zero-hypothesis (the increase in the energy executive compensation package does not affect the growth of the manager's efforts) is rejected. Accordingly, the growth of the compensation package has an impact on the growth of the manager's efforts. This confirms the rational behavior of managers.

4. The impact of disclosure on managers' decisions about the level of their efforts. The zero-hypothesis (disclosure does not affect managers' decision-making) cannot be rejected. Disclosure has a significant impact on managers' decisions about the level of their efforts.

Heat Requirement in an Indoor Recirculating Aquaculture System

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ABSTRACT

To provide optimum growing conditions in the indoor recirculation systems it is important to maintain the water quality (temperature, pH, oxygen concentration, salinity, hardness, etc.). Heating the buildings and the makeup water requires a substantial amount of energy since optimum growth temperatures exceed the normal temperature of supply water (surface, well water). In this paper three different heating systems are analyzed: ground source heat pump, natural gas boiler and pellet boiler. The annual running cost of the heating system in both cases (with heat recovery and no heat recovery) is the lowest for the natural gas boiler, followed by the ground source heat pump and the pellet boiler.

Keywords: biomass boiler, heat pump, heating, indoor recirculating aquaculture

1. INTRODUCTION

Recirculating aquaculture technology means re-use of water in the production system of farming fish or other aquatic organisms. Although recirculating aquaculture systems (RAS) offer a number of advantages, their energy consumption through Life Cycle Analysis is 1.4–1.8 higher than in flow-through systems [1]. The fish tanks are fed with fresh water from spring or borehole water, which is filtrated and heated to a constant temperature throughout the year between 18°C and 20°C. Cooling the recirculated water is also required during the summer due to heat captured inside the building [2]. Heating can obviously be delivered to the entire unit or to the water [3]. Direct heating of RAS waters is typically avoided to minimize scaling on heated lines. In this study, an analytical model and a computational program written in the GNU Octave programming language based on the mass and energy conservation and stationary heat transfer were developed to obtain the monthly variation of RAS heat losses and the heating requirements. The cost of three different heating systems was also estimated.

2. HEATING LOAD OF THE FISH TANK WATER

The heating load was calculated by using the methodology for the calculation of swimming pool heating loads [4, 5]. The heat required for water heating has to cover the heat losses through water evaporation (Φ_{evap}), heat radiation from the water surface to the ceiling (Φ_{rad}), heat convection at water surface (Φ_{conv}), heat conduction through the wall ($\Phi_{cond,a}$) and bottom of the tank ($\Phi_{cond,g}$), and the heat for fresh water (renovating feed water) heating (Φ_{ren}). The heating load is the sum of heat losses calculated at design operating conditions:

$$\Phi_w = \Phi_{evap} + \Phi_{conv} + \Phi_{cond} + \Phi_{ren} \tag{1}$$

The indoor air temperature is determined by the heat losses of buildings through air ventilation (Φ_a), with air infiltration (Φ_{ainf}) and heat conduction through the building envelope (Φ_T) according to the following equation:

$$\Phi_a + \Phi_{ainf} + \Phi_T = \Phi_{evap} + \Phi_{conv} + \Phi_{cond,a} + \Phi_{sun} \tag{2}$$

A case study was developed for an indoor RAS located in Galati, Romania. The RAS consists of 6 circular water tanks with a total surface area of 461 m^2 and a volume of 706.5 m^3. The water tanks are placed inside of a building with a floor area of 782 m^2 and a height of 2.8 m.

3. RESULTS AND DISCUSSION

It can be seen in Fig. 1 that in June, July and August the indoor air temperature becomes higher than the water temperature, which makes the heat exchange between tank water and indoor air to change its direction. Figure 2 shows the monthly heating demand for both cases: with heat recovery from exhaust air and drained water and without heat recovery. Obviously, the operation without heat recovery mode implies a higher heat demand. Figure 3 shows the share of the different heat losses of RAS in both cases with and without heat recovery for the representative months: January and July. In January, in the case of heat recovery, the loss through building envelope has the biggest share, followed by loss through ground, with evacuated water and evacuated air. In July, the heat loss with evacuated water has the largest share and is followed by loss through building envelope, in both cases with and without heat recovery. In this month, the heat with evacuated air and heat transmitted through ground become heat inputs. Figure 4 shows the yearly operation costs for different heating systems. The ground source heat pump system has the highest capital cost (65000 €) and the lowest annual energy consumption (3416 €). The natural gas boiler system has the lowest capital cost (3000 €) and an average annual fuel cost (7116 €).

The pellet boiler has an average capital cost (5600 €) and the highest annual fuel cost (12558 €). The annual running cost of the water heating system in both cases (with heat recovery and no heat recovery) is the lowest for the natural gas boiler, followed by the ground source heat pump and the pellet boiler.
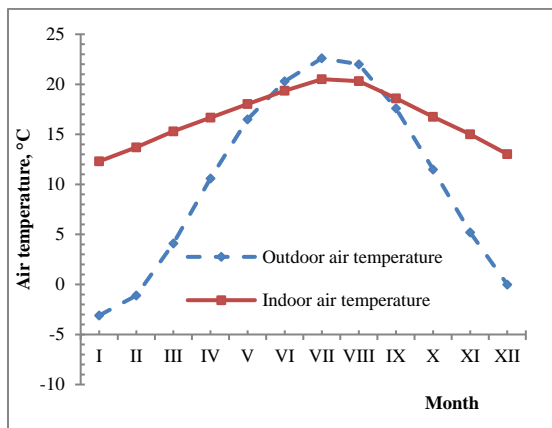

Fig. 1. Outdoor and indoor air temperature variation (with heat recovery).
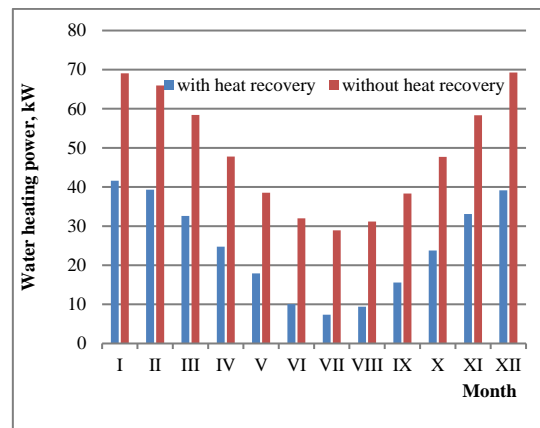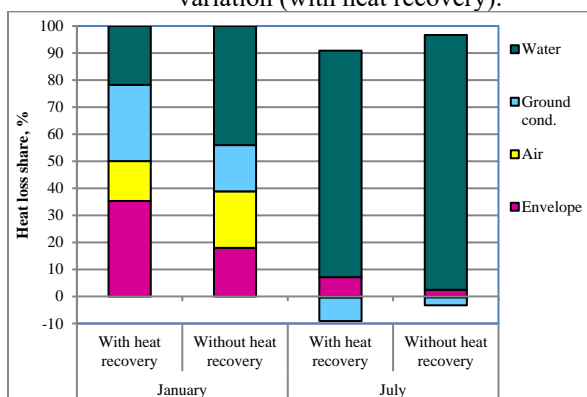

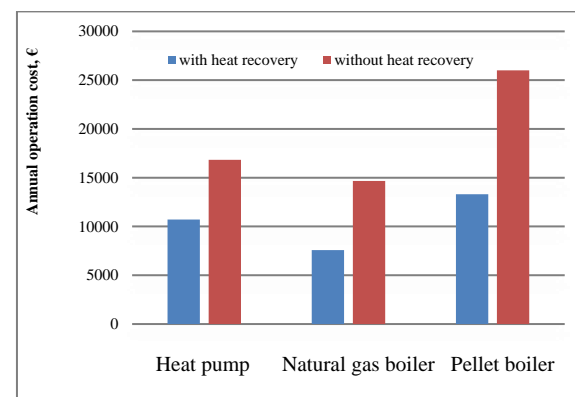**Fig. 2.** Monthly heating demand.

Fig. 3. Share of heat losses of RAS.

Fig. 4. Annual cost of heating.

4. CONCLUSION

The relative importance of the heat losses, in both cases with and without heat recovery, of a RAS located in Galati, Romania was analysed. The share for heat loss with evacuated water is the largest in the hottest month (July), in both cases, and in the coldest month (January), in the case without heat recovery. The largest share in January with heat recovery is for heat loss through the building envelope. The heat with evacuated air and heat transmitted through ground become heat gains, in July. An economic analysis of three different heating systems to cover the heat demand, ground source heat pump, natural gas boiler and wood pellet boiler was also presented. The results show that heat recovery can reduce heating demands by 50%. The economic analysis shows that the annual running cost of the water heating system is the lowest for the natural gas boiler, followed by the ground source heat pump and the pellet boiler.

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Level of Knowledge, Perception, and Awareness Regarding Climate Change Among the People of Dammam, Saudi Arabia

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ABSTRACT

The adverse impacts of climate change have been experienced across the world, including the Dammam City in Saudi Arabia. While there are many efforts targeted to fight climate change, their success is dependent on the public having sufficient knowledge about the issue. Hence, the fight against climate change urgently requires an increase in public awareness for effective mitigation measures. Thus, this study seeks to identify the level of understanding and awareness of the people of Dammam about climate changes, causes and impacts on humanity. The study involved 310 respondents who are residents of Dammam and gave their responses by completing an online questionnaire. The findings revealed that 90% of the respondents were aware of the recent climate change problem and they had acquired that knowledge from conventional sources like social media and 67% were very worried about the impacts of climate change. The results also showed that 40% had very little knowledge or no knowledge about the causes of climate change and its impacts. The study concluded that slightly above half of the residents of Dammam have moderate knowledge, understanding, and awareness of climate change. The study recommends more efforts be directed toward expanding public knowledge on climate change.

Keywords: Awareness, Climate Change, Saudi Arabia, Knowledge, Cause and Impacts.

1. INTRODUCTION

Human activities are the main reason for the changes in climate, globally [Devine-Wright and Quinn, 2020]. Climate changes, like global warming, have been shown to have an increasing effect in recent decades. It is well believed that environmental damage by humans is the cause of rapid climatic changes [Abel et al., 2018]. Global warming is indeed the main effect of human activities on habitat pollution. Knowledge of climate changes is vital for humans to adjust to new life, which majorly depended on changes in the temperature. Knowledge serves as a basis for the making of human decisions [Hoegh-Guldberg et al., 2019]. These changes demand people to adapt to the new life that was originated from the environmental changes. People's attitudes towards acting can only be shaped by increasing their ecological knowledge. The increase in environmental knowledge will help to eliminate human activity that contributes to climate change and will eventually save human life from climate change damages. This research will explore how many people know about their actions affect today's climate.

2. MATERIALS AND METHODS

Quantitative data collection and analysis methods were used in the research. To collect data from the respondents, a questionnaire was used. The questionnaires were used between January and March 2021 with QuestionPro. Snowball sampling was applied to distribute the link to the survey via email and social media, with the recipients of the survey link sharing it with their acquaintances living in the area. The number of people that had expressed their willingness to participate in the study was 310 individuals. The study examined the awareness of climatic changes among Dammam residents. The research was broadly based on knowing whether they knew weather differences, climatic condition causes, climate change impacts, potential remedies for global warming and methods to lessen carbon emissions from the atmosphere.

3. RESULTS AND DISCUSSION

The collected data has been analyzed with the SPSS software. This software is used primarily for the analysis of statistical data. Number of respondent's level of primary education (7%) varied from those who had college/university level (47%). The self-reported information of climate change and its consequences on human life are shown. 90% of the respondents knew about climate conditions and global warming through social media. The people living in Dammam who took part in the study, 26% of them cannot differentiate clearly between climate and weather, 26% of the respondents were explicitly able to answer this and 48% had a partial understanding. The study about the level of concern towards climate amidst Dammam residents showed that 67% are afraid of climate condition changes. The study showed that 10% of study participants believed that climate change skills are linked to supernatural forces, 75% did not think that the supernatural forces are behind climate change. Besides this, out of 310 respondents, 120 were highly familiar with the greenhouse gas effects and their contribution to the climate. However, 6.4% did not know about the greenhouse effect knowledge. Another study showed that less than 10% of respondents had no knowledge of fossil fuels and their effects. Nearly two-thirds of participants were either very familiar or less known about the nature and environmental impact of fossil fuels.

Another study displayed that one-third of the respondents were knowledgeable about climate change and its impact on human life. Whereas, 40% of them had little knowledge about climate change and their effects on human beings. Lack of climate change knowledge and awareness led to insufficient recommendations from the respondents on climate change mitigation. The results showed that Dammam residents had a moderate understanding of climate changes, causes, its impacts, as well as inadequate remedies to tackle the problems. Its insufficiency is due to their reliance on traditional sources of climate change knowledge. A significant issue of this source is that it has little effect on respondent's attitudes or conduct because their level of education does not take into account [Pabón-Caicedo et al., 2020]. This study showed that most of the Dammam study participants do not know that their activities were impacting the climate. The primary reason that most people cannot access climate change knowledge is because of their use of traditional resources to obtain climate information. Traditional data resources are associated with education level as well as reading and writing skills [Ning et al., 2020]. Modern forms of communication, such as social media and YouTube, can help the less educated people to obtain their desired knowledge. Moreover, Saudi Arabia's government and other stakeholders must work together to make the people more knowledgeable about climate change. As the number of experts rises, weather complications and environmental degradation can be handled easily.

4. CONCLUSION

The people of the Dammam City of Saudi Arabia had impartial knowledge of the causes and consequences of climate change and were aware of it, and this is because they have little background information regarding pollution, global warming, and habitat conservation. These findings help to reduce negative impacts on climate change during decision-taking procedures. Stakeholders will understand which areas people can choose from and learn about the connection between people and the climate. More research must be done in other Saudi Arabia regions to determine the proportion of people aware of climate change issues. In future, the further study will also need to measure the perception, consciousness and knowledge of various communities, such as farmers. This study gives a public picture of Saudi Arabia citizens' level of climate change knowledge, perception and awareness. The study should broaden its scope to obtain a complete image of the environmental awareness of the entire Saudi Arabia population.

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Impact of Onshore Construction Activities on Sea Water Turbidity

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ABSTRACT

Turbidity in water is particularly defined by the presence of suspended particles. Moreover, the increased number of construction and development activities these current times is resulting an increase of sediments in water, which plays a significant role in turbidity. Sunlight is frequently absorbed by turbid water, resulting a rise in the water's overall temperature and a decrease in its dissolved oxygen concentration. All these events put aquatic life under stress. The primary focus of the research is on sedimentation and suspension turbidity which is more likely to occur as a result of onshore construction activities. In the study, samples were collected from various locations of one of Qatar's onshore construction sites and analyzed for turbidity using a portable turbidity meter and a spectrophotometer. Following that, a graphical comparison of the obtained data to Qatar's Ministry of Municipality and Environment (MME) standards was conducted. The results indicated a significantly increased turbidity in a few of sample locations i.e., at the inlet point of sedimentation tank, dewatering pipeline, and open excavation of the project site. The study also suggested the use of sedimentation tanks and silt traps in an onshore construction project to prevent turbid water from being discharged into the sea.

Keywords: Dewatering; Ministry of Municipality and Environment (MME) Qatar; Onshore Construction Activities; Sedimentation Tank; Silt Trap; Turbidity

1. INTRODUCTION

Turbidity is an indicator of water transparency. The greater the number of embedded granules present in the water, the more turbid it is, therefore leading to higher turbidity values. Sediment is the main cause of turbidity, which itself originates from construction and development practices [1]. High sediment concentration interferes with the light penetration in water, thus reducing the amount of light that reaches the aquatic vegetation. Likewise, turbid water often absorbs sunlight, which increases temperature and decreases the amount of dissolved oxygen in water. As a consequence, it stresses or kills life in water.

Therefore, as a summary it can be said that high particulate matter concentration in water impact ecosystem sustainability, leisure values and make lakes fill faster. Particulates in the water also includes a category of fasteners for other contaminants, in particular metals and bacteria. Building/construction works such as grading and renovation create sediment which can escape from the site, thus, causing harm to the water resources [2]. When it floods, water washes off the loose dirt from the building site and goods that are kept outdoors. These turbidity related issues are of major concern in the marine projects since they disturb the quality of the sea ecosystem.

2. MATERIALS AND METHODS

The study investigated the effect of onshore construction activities on the turbidity of sea water. Sampling was conducted along the coastline of an artificial island of Qatar. The samples were collected, and turbidity readings of few of the samples were taken onsite using a calibrated portable turbidity meter, while the rest were analyzed in the laboratory using spectrophotometer. The model of the used portable turbidity meter was Extech-TB 400 while that of the spectrophotometer was HACH DR6000. The instruments were calibrated by standard procedures before usage.

2.1 Sampling Sites

The samples were collected in the following order; (a) from the construction site, a groundwater sample was collected at the depth of -5 meters, (b) second sample was again taken from the construction site at a depth of -3 meters, (c) the third sample was taken from dewatering hose, (d) the fourth and the fifth one from sedimentation tank (inlet and outlet of the tank), (e) the sixth sample was collected from the discharge point and the last four samples were collected from the sea at a distance of 20 meters from the discharge point (before the silt trap) and the rest after the silt trap at a distance of 30, 50 and 100 meters from the discharge point.

3. RESULTS AND DISCUSSION

The turbidity values obtained from sampling are given in Table 1.

Table 2: Turbidity Monitoring Data

Sr No.	Method	Location	Unit	Results	MME Standard Qatar – [NTU]
1	Laboratory Sample	Groundwater		4.79	5
2	In Situ (Turbidity Meter)	Open Excavation		38	5
3	In Situ (Turbidity Meter)	Dewatering Pipeline		36	5
4	In Situ (Turbidity Meter)	Sedimentation Tank Sample 1 (Inlet Point)		21	5
5	Laboratory Sample	Sedimentation Tank Sample 2 (After Settlement)	NTU	3.86	5
6	In Situ (Turbidity Meter)	Discharge Point		3	5
7	In Situ (Turbidity Meter)	(Discharge Point) 20 meters away		2.8	5
8	In Situ (Turbidity Meter)	30 meters (After Silt Trap)		2.3	5
9	In Situ (Turbidity Meter)	50 meters (After Silt Trap)		2.9	5
10	Laboratory Sample	100 meters (After Silt Trap)		3.77	5

The analysis of the data confirmed the hypothesis that the water quality of samples taken from various points on an onshore construction site varied significantly, with the highest turbidity values found for the excavation point, dewatering pipeline, and sedimentation tank inlet. It was revealed that the aforementioned points with high turbidity readings even showed significant deviations from Qatar's MME standard of 5 NTU, implying a major impact of construction activities on the island's sea water [1], [3], [4]. Sedimentation tank and silt trap aided in reducing the turbidity. Therefore, the turbid water needs to be well treated before its discharge into the sea, in order to prevent marine ecosystem and comply with the standards defined by the state.

4. CONCLUSION

The purpose of this study was to determine the effect of construction activities on the selected island's sea water turbidity. The study was conducted by collecting water samples from various locations of an artificial island construction site and analyzing them using a portable turbidity meter and spectrophotometer. The study then compared the results for various sampling locations with Qatar's MME. The comparison revealed significantly higher turbidity values at the inlet point of sedimentation tank, dewatering pipeline, and open excavation. Additionally, the study emphasized the importance of using sedimentation tanks and silt traps to prevent turbid water from being discharged into the sea, and such precautions must be taken in any onshore construction project.

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Prospects for the Global Helium Industry Development

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ABSTRACT

The article is devoted to a comprehensive analysis of the global helium industry. The article discusses the current state of the world production and consumption of helium. Russia possesses the largest reserves of helium in the world, most of which are concentrated in the fields of Eastern Siberia and the Far East. With the development of large-scale production of natural gas containing helium in the east of the country, Russia can become the main producer and supplier of helium to the world market. The paper also analyzes the current state of the production and consumption of helium in the world with the identification of the main helium producers (USA, Qatar, and Algeria). The main factors influencing the production and consumption of helium have been determined. Based on retrospective and factor analysis, the authors have constructed a forecast for the production and consumption of helium in the world until 2040 according to three scenarios. An assessment was made of the possibility of transporting helium from Russia to the world market until 2040. In addition, the authors considered options for creating storage facilities for helium concentrate on the territory of Eastern Siberia.

Keywords: Helium industry, Gas Processing Plant, Russian market, factor analysis, trend analysis.

1. INTRODUCTION

Helium is used in many industries and its reserves are depleted [1; 2]. In this connection, there is an annual increase in helium prices. At the same time, a number of scientists suggest that the issue of lack of helium in the future is not so acute. Thus, in the work of Cai et al. [3], on the basis of a system-dynamic approach, a forecast of world helium reserves up to 2060 is presented and it is shown that there will be no problems with an increase in helium reserves in the world. Glowacki et al. [4] changed the input parameters in the model and showed that the global helium production will peak in 2030. The main growth in demand will be observed from the countries of the Asia-Pacific region [5; 6]. There is currently no consensus on the development of the global helium market. Thus, the purpose of this article is to forecast of volumes of production and consumption of helium in the world, taking into account the development of the helium industry in Russia.

2. MATERIALS AND METHODS

The authors use scenario simulation of long-term energy development as the basis for forecasting world production and consumption of helium. An assessment of the helium production and consumption was carried out on the basis of the retrospective dynamics and the main assumptions and scenarios regarding the development of this indicator in the long term. A detailed analysis of the main factors influencing the level of production and consumption of helium in the world is presented.

3. RESULTS AND DISCUSSION

Based on a review of the literature, the authors identified the factors influencing the production and consumption of helium.

The main factors influencing the level of helium production:

- Resource base of helium-containing gas;
- Prospects for the implementation of gas production projects;
- Geopolitical factors (sanctions, restrictions on the extraction, processing, transport and sale of helium).

The main factors influencing the consumption of helium in the world:

- GDP dynamics and the level of economic activity. A regression model was predicted comparing the GDP growth rate and the level of helium consumption, based on the US economy. As a result, a high dependence was obtained between the factors under consideration;
- Changes in the structure of the economy (industrial, post-industrial). The reduction in the basic industrial sectors of the economy leads to a reduction in helium consumption (cryogenic applications, welding). The growth of high-tech areas (the production of semiconductors, fiber optics) and the simultaneous growth of the service sector (primarily in the field of medical care) leads to an increase in helium;

- Development of technologies that stimulate both the consumption of helium and substitute goods (argon, nitrogen).

Based on regional forecasts of helium consumption, the authors of the work compiled a scenario world forecast. Compared to 2018, according to the moderate forecast scenario, the global helium consumption will grow by 15% by 2040, according to the baseline – by 34%, and according to the maximum – by 54%.

4. CONCLUSION

The analysis showed that there is a regional differentiation between the centers of production and consumption of helium in the world. Thus, the world centers of helium production are the USA, Qatar and Algeria, and the centers of consumption are the Asia-Pacific region, the USA and Europe. There will be no rapid development of helium markets. In developed countries, stagnation will be observed, and in developing countries (APR) – an increase in accordance with the rates of economic growth.

The main factors determining current and long-term demand for helium will continue to be GDP growth and economic activity; changes in the structure of the economy (industrial, post-industrial); development of technologies that stimulate both the consumption of helium and substitute goods (argon, nitrogen). In accordance with this, the value of world demand by 2040 will vary from 187 to 250 million cubic meters.

The main factors for maintaining sustainable production of helium in the world are the resource base of helium and helium; prospects for the implementation of gas production projects; geopolitical factors (sanctions, restrictions on production, processing, transport and sale).

The development of the helium industry in the east of the country will allow Russia to become the largest supplier of strategic raw materials to the world market and create prerequisites for the development of new high-tech industries in the country (microelectronics, cryogenics, fiber production, etc.).

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Investigation of B20 Preheating Effectivity in Single Cylinder Compression Ignition Engine Performance

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ABSTRACT

The purpose of this study is to investigate the effectivity of B20 preheating in single cylinder compression. Characteristic of fuel viscosity for some variant heating temperatures are explored. Engine performance was also carried out for measuring the impact of preheating the fuel. Cylinder pressure and emission of engine in some preheating fuel temperature conditions are measured. The heating B20 in range temperature $30 - 50^{\circ}C$ show the viscosity characteristic that full fill the ASTM 6751 and EN14214 standard. The engine performance shows the significant improvement when the B20 was heated at $40^{\circ}C$ prior to CI engine injector. The B20 preheating at $40^{\circ}C$ are the highest cylinder pressure, a lower specific fuel consumption, a lower carbon monoxide, the lowest carbon dioxide, the lowest oxygen content compared to ambient and others fuel temperature.

Keywords: Biodiesel, emissions, viscosity, preheating, performance

1. INTRODUCTION

A poorer biodiesel combustion quality compared to diesel has led a low cylinder pressure of compression ignition engine, increases the fuel consumption and reduce the fuel efficiency [1]. A higher viscosity and surface tension of biodiesel generated slightly larger droplet size compared to diesel, that influences the spray and atomization behaviour [2, 3]. Geng, Wang [2019] reported that when the fuel temperature and ambient air temperature are high, the fuel can create a high-quality mixture with air [4]. Therefore, in this study, the investigation of 20% palm oil biodiesel in diesel fuel (B20) preheating effectivity prior to injector single cylinder compression engine are carried out. The B20 are commercial fuels for many countries in existing diesel engine operate without engine modifications. Characteristic of fuel viscosity in some variant heating temperatures are explored. Engine performance such as cylinder pressure and emission were carried out for measuring the impact of preheating the fuel.

2. MATERIALS AND METHODS

This study considers three main aspects; fuel preparation, fuel characterization and engine performance test. The B20 was characterized by based on its viscosity at some temperature conditions such as $30,35,40,45$ and $50^{\circ}C$. The engine performance test was carried out in the bench test a cylinder direct injection engine. The fuel was preheated prior to engine injector by a heater. During the test, engine speed was maintained at 1200 RPM. The engine was connected to an eddy current dynamometer (Schenck W-70), fuel consumptions were measured by gravimetric.

3. RESULTS AND DISCUSSION

3.1. Fuel characteristics

The fuel chcaracterization shows viscosity decrease when the temperature increase. By heating up the B20 until $50^{\circ}C$, it decreases the fuel viscosity gradually but still in ASTM 6751 and EN14214 range that are $2.0\text{-}4.5$ mm^2/s. The gradually B20 viscosity reducing by increasing temperature caused by the breakdown of biodiesel intermolecular forces and adhesion between molecules [5]. In this study, it shown the B20 preheating at 30-50 $^{\circ}C$ are compatible for fuel viscosity conditioning. Decreasing of viscosity influence Reynold number in nozzle flow and atomization in chamber [6]. A lower viscosity the fuel can create a high-quality mixture with air and improve the atomization process [4].

3.2. Engine Performance

Generally, the cylinder pressure increases by load increases. However, the increasing of cylinder pressure is not linear to fuel temperature increasing. The highest cylinder pressure shows at $40^{\circ}C$ of fuel temperature compared to others. A higher cylinder pressure resulted a higher power of engine.

The exhaust gas temperature (EGT) are increase as the engine load increase for all the fuel preheating temperature. It was mainly due to the increasing amount of energy released at higher loads. When the load increases, the amount of fuel burning increases are injected to meet the extra power requirement to take the additional load; hence more heat rejection to the exhaust gases and increased the EGT [5]. The fuel at ambient temperature

obtained the highest EGT at 92% engine load. Increasing the B20 preheating temperature reducing the combustion and EGT temperature. It has confirmed by Chen, Guo [2016] that reported when the fuel temperature raising, the combustion temperature curves leave backward and peak combustion temperature decrease. However, in this experiment shows the EGT at the 40°C B20 preheating is higher compared to others. Which one these phenomena are attributed to peak combustion temperature.

The maximum CO_2 was obtained at full engine load. The CO_2 emissions are decrease as the increasing fuel preheating temperature. A high temperature corresponds with the low density of fuel which leads to the reduction of injection rate and high compressibility which result in both the delay of combustion and increasing injection duration [7]. The pre-ignition reaction rate slows down and flame speed reduces in presence of CO_2 [8]. The experiment result shows a higher carbon monoxide (CO) content at fuel ambient temperature compared to 40°C fuel temperature. A high CO in exhaust gas indicated the incomplete combustion [9]. Thus, the combustion quality B20 by preheating at 40°C is better compared to ambient temperature. This argument supported by a lower oxygen content in exhaust gas combustion by preheating at 40°C compared to the ambient fuel temperature. In fact, all of B20 preheating prior to injector resulted the lower CO emissions and O_2 compared the ambient temperature.

The B20 heating prior to injector increase the NOx in all load conditions. A higher NOx emissions resulted as a higher combustion temperature, a higher oxygen content and the residence time at elevated temperatures in the cylinder [1, 10]. In this study, the B20 oxygen content in all experiment assumed were same, because the fuel during the test were using the same fuel. Hence, the dominant root caused of NOx increasing are impact of temperature. More over, the lower NOx show at 40 - 50 °C B20 preheating conditions compared to 30-35 °C. However, the fuel heating decrease the smoke content of engine.

4. CONCLUSION

The investigation of B20 preheating effectivity prior to injector single cylinder compression engine had been carried out and resulted some conclusion. First, the heating B20 in range temperature $30 – 50$°C show the viscosity characteristic full fill the ASTM 6751 and EN14214 standard. The engine performance shows the significant improvement when the B20 was heated at 40°C prior to CI engine injector. The highest cylinder pressure, the lowest specific fuel consumption, the lowest carbon dioxide, the lowest oxygen content compared to ambient and others fuel temperature. The B20 heating prior to injector increase the NOx in all load conditions.

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Performance Analysis of Photovoltaic Inverter System for Predicting Energy Yield

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ABSTRACT

The paper aimed to explore the model that investigates the environmental factors affecting energy yield based on the photovoltaic inverter system. We employ the multiple regression analysis for predicting the energy yield from the data collected through the Net ECO system database at the Prince of Songkla University, Surat Thani Campus. The results showed that the maximum level of energy yield was in July, followed by May and June. The results of the amounts of energy yields positively correlated with the irradiance factor. The irradiance factor could explain variation in energy yield, which can predict the effectiveness for 96.49%.

Keywords: Energy yield, Irradiance, Multiple regression analysis, Temperature

1. INTRODUCTION

Nowadays, COVID-19 has declared a pandemic, causing the organizational measures to activate working from home. Also, labor termination, including closing down of the business affected by this widespread disease, could be observed in every occupation, especially office staff or regular employees of various companies. Of course, The majority impact happened with employees. When working from home, it is not easy to check whether the photovoltaic (PV) system works all the time. So, the tool developed for determining the actual effects of PV output is necessary.

This paper focuses on the relevant factors of environmental characteristics and energy yield in the university. These consist of rain, dust, temperature, and solar radiation as the energy output with the efficiency of the solar cell system [1], [3]. We assume that one approach to reporting the energy yield loss. Therefore, this current study explored the predictive model of energy yield performance analysis of the PV system to ascertain a fault condition. We use the existing data produced by applying multiple linear regression (MLR) to determine variables and predict energy yield for model analysis [2].

2. MATERIALS AND METHODS

The structure of the system from the solar cell series has energy storage details as follows: Solar Cells: Multicrystalline 156 x 156 mm. Cell Orientation: 72 cells. Module Dimensions: 1956 x 992 x 40 mm. and the dataset used in the analysis comes in a total of 1,100 solar panels, in which each panel can store up to 320 W. Inverter series has details as follows: Recommended max input Power (Ppv) 42, 12 kWp. and Number of solar cells per inverter: 120,128 cells.This study used weather factors including temperature, rainfall, and wind speed from the Meteorological Department in Thailand. We collected the energy yield and irradiance 125 records from May 2019 to Dec 2019 with the NetEco system database at the Prince of Songkla University, Surat Thani Campus. The weather and system data were enabled the data analysis, as shown in Fig.1.
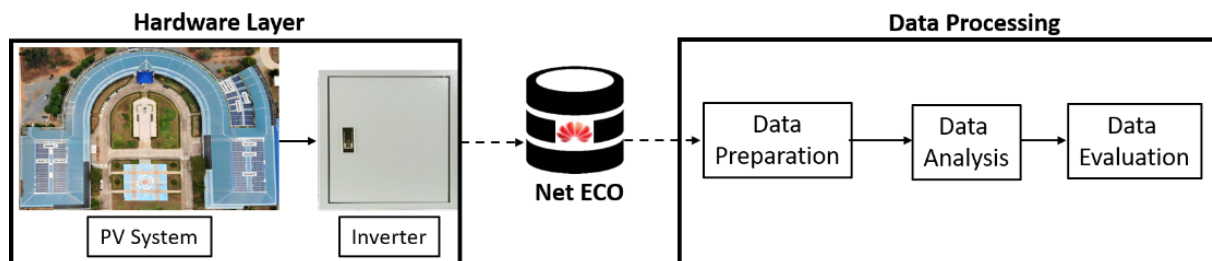

Fig.1. Overall system for gathering data.

The descriptive analysis in this paper was mean and standard deviation. Pearson's correlation coefficient and stepwise multiple regression analysis estimated the factors relating to the candidate predictor variables of energy yield. We implemented using R programming for all data processing part.

3. RESULTS AND DISCUSSION

The averages of energy yield, rainfall, irradiance, temperature, and wind were 1190.10 ± 291.33 kWh, 7.08 ± 7.57 mm, 15577 ± 4151.89 W/m^2, 28.32 ± 1.45 °C, and 14.04 ± 5.79 knots, respectively. The maximum level of energy

yield was in July ($\bar{x}$ = 1370.36 kWh), followed by May ($\bar{x}$ = 1366.44 kWh) and June ($\bar{x}$ = 1263.01 kWh). The results indicated that irradiance and temperature factors were significantly positively associated with the energy yield, with r = 0.982 and 0.670, respectively, at the statistically significant level of 0.05 as shown in Fig.2(a). The stepwise multiple regression analysis showed that the irradiance factor could explain variation in the energy yield at PSU Surat Thani, predicting the effect for 96.49% with the statistical significance at the 0.05 level. Moreover, it showed that when the irradiance dropped, the energy yield decreased. The relationship of irradiation with energy yield using linear regression was showed in Table 1. The performance of the MLR model was compared against the measured data, as shown in Fig.2(b).

Table 1. Regression model for predicting energy yield

	Estimate	Std.Error	t-test	p
Intercept	116.482	19.109	6.096	1.2×10^{-8}
Irradiance	0.069	0.002	58.132	2.0×10^{-16}

The finding from this study agreed with previous studies [4] in terms of the phase lag between the solar radiation and temperature cycles. Hassan et al. [5] found that the nature of the surface cover, cloud cover, and the time of day were related to the local air temperature and radiation balance. This study contrasted with previous results, no relationship between temperature conditions and energy yield were found.
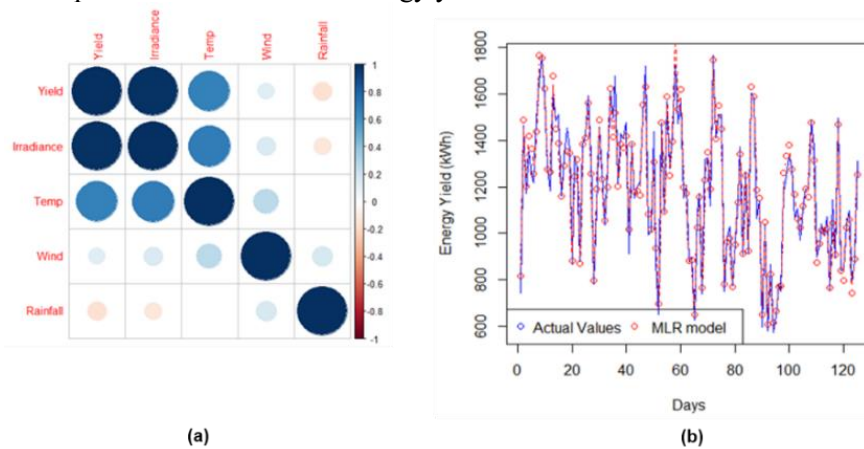
Fig.2. (a) Pearson's correlation of factors and (b) Performance of the MLR model with the measured data.

4. CONCLUSION

The results showed that irradiation and temperature were significantly related to energy yield trivially. By examining the prediction of energy yield by MLR, we found the irradiation could account for approximately 96.49% of the variation in energy yields. The research also underscores the value of the model that can be used to predict energy yield. The model can be used to create a system automatically tracking and notifying the energy yield based on the measured environmental factors. A web application can be developed to send a notification to alert the users about the energy yield via email or messaging.

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Selection of Working Fluid for Organic Rankine Cycle Used in Low Temperature Geothermal Power Plant

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ABSTRACT

In this paper, subcritical saturated steam cycle is selected as the key research object for low-temperature geothermal organic Rankine (ORC) power generation system. The mathematical and physical model of thermal process of ORC cycle is established. Five kinds of organic working fluids are selected to analyze the change trend of ORC cycle system performance and economic performance with the increase of geothermal water temperature. The simulation results show that R245fa is the best working fluid for PPH.

Keywords: Low temperature geothermal; ORC；Working fluid selection; system optimization

1. INTRODUCTION

Geothermal energy, a kind gift from nature to human beings, is a huge natural energy harboring inside the earth and has become one of the renewable energy that must be regarded in the energy development of the new century and one of the most realistic and competitive resources in renewable energy [1]. According to a preliminary estimate, the thermal energy contained by geothermal resources within 2000 m depth in our country equals 25 billion tons of standard coal, and a conservative estimate can be developed for 20% of them [2]. Stability and continuity are the biggest advantages of geothermal energy relative to other renewable energy resources. In 2007, in the contrasting figures for renewable energy generation given by the United Nations world energy evaluation report, geothermal generation has an utilization factor of approximately 72% - 76%, which is significantly higher than those for renewable energy generation such as biomass (52%), wind (21%), and solar energy (14%) [3].

2. CONSTRUCTION OF ORC CIRCULATION SYSTEM MODEL

The thermal cycle of ORC geothermal power generation system is shown in Fig. 1 and Fig. 2. The whole cycle system is mainly composed of evaporator, screw machine, condenser, working fluid pump, hot fluid pump, cooling water pump and some pipes.
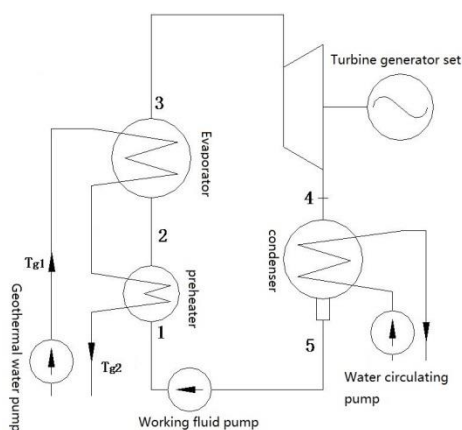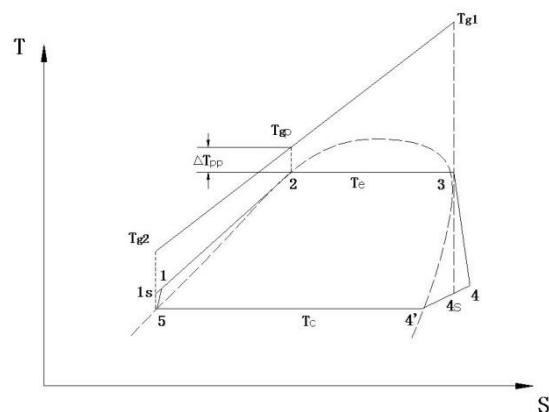

Figure1 Subcritical saturated steam ORC

Figure 2 Subcritical saturated steam ORC cyclecycle system thermodynamic process

3. SELECTION OF WORKING FLUIDS FOR ORC

Orc cycle uses low boiling point organic matter as working medium, collectively referred to as organic working medium, and the available organic working medium includes hydrocarbon and HFC. For the selection of organic working medium, the consideration should be focused on the net power generation, heat exchange performance, environmental safety and thermal stability of ORC cycle, and low boiling point and moderate saturation pressure must be also required.

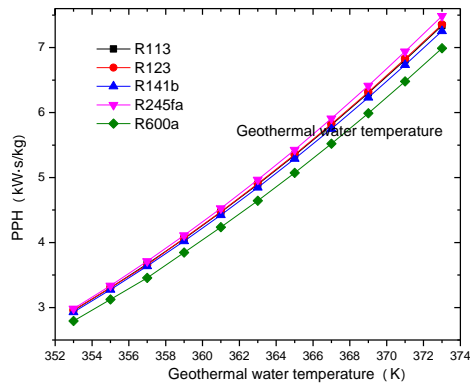## 4. INFLUENCE OF DIFFERENT WORKING FLUIDS ON SYSTEM PERFORMANCE
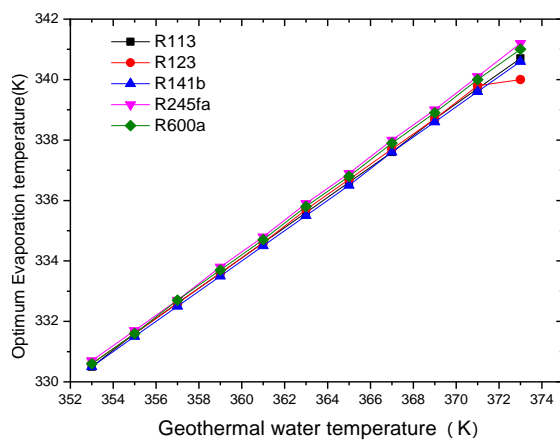

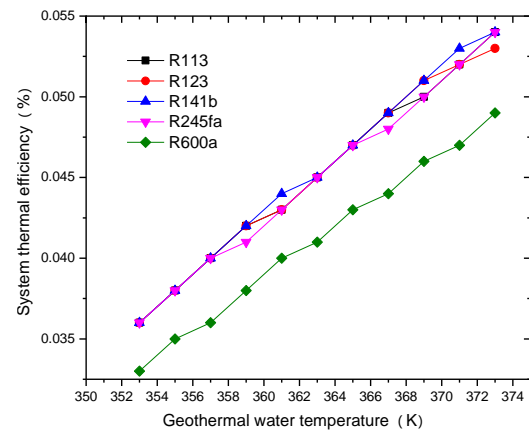Fig. 3 Variation curve of PPH for different

Fig. 4 Variation curve of thermal efficiency of organic working fluidsdifferent organicworking fluids
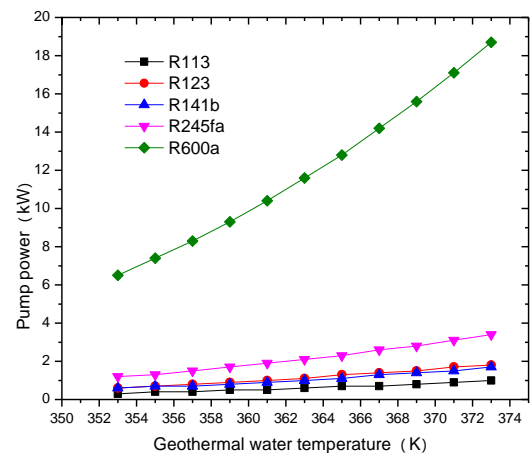

Fig. 5 Variation curve of optimum evaporation

Fig. 6 Variation curve of working fluid pump

5. CONCLUSION

When the geothermal water temperature is 80-100 ℃, the PPH difference of five organic working fluids is very small, and R245fa is slightly dominant, which makes the turbine more powerful.For relatively low temperature geothermal water, R600a has the lowest efficiency, R141b has higher thermal efficiency than other organic working fluids, but the difference is not big. The optimal evaporation temperature not only depends on the initial temperature and condensation temperature of geothermal water, but also closely related to the thermophysical properties of organic working fluids.The pump work of R600a is obviously higher than that of other organic working fluids.The APR of R600a was significantly higher than that of other refrigerants, and R113 was the best.

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Decomposition Analysis of China's Carbon Emissions Based on LMDI Approach

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ABSTRACT
Since China announced at the Paris Climate Change Conference in 2015 that it will achieve a carbon peak around 2030, how to achieve carbon emission reduction has become a key issue of concern. Based on the logarithmic mean Divisia index (LMDI) approach, this study selected four driving factors: population, economic development level, energy intensity, and carbon emission intensity to analyze China's carbon emissions from 2000 to 2016. Research results show that, China's carbon emissions are mainly driven by economic growth. As economic growth slows down after 2011, the growth rate of carbon emissions has also stabilized, dropping from 10.6% to 0.79%. Among the four drivers, declining energy intensity is the largest contributor to China's carbon emission reduction, followed by declining carbon emission intensity. Steady population growth has increased carbon emissions slightly. In general, the results of the study indicate that China has transitioned from rapid economic development to a sustainable development model, and China's low-carbon transition has achieved significant results.

Keywords: Carbon emissions; China; Decomposition analysis;LMDI

1. INTRODUCTION
Increasing carbon emissions have brought severe challenges to human survival and development. As the issue of carbon emissions has attracted widespread attention, the research on the drivers of changes in carbon emissions has become one of the focuses of studies on carbon emission reduction[1]. Studies have shown that the drivers for changes in carbon emissions include population, economic development level, urbanization, energy structure, industrial structure[2], etc. Many empirical studies have found that population, economic development level, energy intensity and carbon emission intensity will all have a significant impact on changes in carbon emissions[3].

Carbon emission drivers affect CO_2 emission in different ways. This study analyzes China's carbon emissions changes from 2000 to 2016 based on the logarithmic mean Divisia index (LMDI) approach, and selects population, economic development level (represented by GDP per capita), energy intensity, and carbon emission intensity as four drivers to clarify how these drivers affect China's carbon emissions in 2000-2016.

2. MATERIALS AND METHODS
2.1 LMDI
Based on the LMDI method, this study decomposes China's CO_2 emissions into four drivers: population, GDP per capita, energy intensity and carbon emission intensity, and calculates the contribution value and contribution rate of each driver over various time periods. The decomposition formula of LMDI is as follows:

$$C_t = \sum_i \sum_j \sum_k P \times \frac{G}{P} \times \frac{E_k}{G_k} \times \frac{C_{ijk}}{E_{ijk}} = p \times g \times e \times c \qquad (1)$$

where C_t is the CO_2 emissions at time t; P is the national population; G_k is the GDP of province k; E_{ijk} is the total energy consumption by fuel type i of sector j in province k; and C_{ijk} is the carbon emission produced by fuel type i of sector j in province k.

2.2 Data sources
Due to the lack of official carbon emissions data published by China, this study uses carbon emissions data from CEADs (China Emission Accounts & Datasets)[4]. Data on GDP and population comes from *China Statistical Yearbook*. Data on total energy consumption is from *China Energy Statistical Yearbook*.

3. RESULTS AND DISCUSSION
3.1 Four drivers of China's CO₂ emissions
Based on LMDI method, this study analyzes the contribution of four drivers-population, GDP per capita, energy

intensity and carbon emission intensity-to China's CO_2 emissions. First, the economic development level ΔC_g has the largest contribution rate in all time periods, but it gradually decreases in following stages. This shows that increase in carbon emissions is mainly driven by economic growth. With the slowdown of China's economic growth, the growth of CO_2 emissions stabilizes. Second, the contribution rate of energy intensity ΔC_e became negative in 2004-2008, and continued to decline in the last two stages, reaching -39.89% in 2012-2016, and becoming the biggest contributor to carbon emission reduction. This shows that improved energy efficiency brings energy saving and emission reduction effect in China. Third, the contribution rate of carbon emission intensity ΔC_c reached its maximum (which is 14.24%) in 2004-2008 but dropped in the last two stages, reaching -9% in 2012-2016. This may be because, after the economic growth period of 2000-2012, China began to enter the stage of industrial structural transformation in 2013. By increasing the proportion of clean energy and adopting advanced energy-saving and environmentally friendly technologies, the amount of CO_2 emission per unit of energy consumption has been reduced to achieve emission reductions. At last, the population's contribution to CO_2 emissions is almost stable at around 3%, with small fluctuations.

3.2 Discussion

According to the results of LMDI, it can be concluded that due to the slowdown in economic growth, reduced energy intensity as well as reduced carbon emission intensity, the growth rate of China's CO_2 emissions has dropped from an average rate of 10.6% in 2000-2011 to 0.79% in 2011-2016. China's carbon emissions are mostly driven by economic development, and with the slowdown in economic growth after 2012, carbon emissions have also stabilized. In addition, the reduction in energy intensity has become the largest contributor to China's carbon emission reduction, which is consistent with the research conclusions of Zheng et al. (2019)[1]. The reduction of energy intensity indicates that, China has transitioned to a sustainable development model, paying more attention to the development of green economy and ecological protection. Furthermore, the decrease in carbon emission intensity has also contributed to CO_2 reduction, which indicates that the proportion of clean energy consumption such as consumption of wind power and hydropower has increased, and the energy structure has been optimized in China. In summary, we can recognize from the results that China has made some progress in low-carbon transition in recent years.

4. CONCLUSION

The results show that China's carbon emissions are mainly driven by economic development, and the slowdown in economic growth in the new normal phase is the main reason why carbon emissions have stabilized. The decline in energy intensity is the biggest contributor to carbon emission reduction. The decline in carbon emission intensity also contributes to carbon emission reduction. In general, the results proved that China has transitioned to a sustainable development model and achieved carbon reduction by improving energy efficiency and using more clean energy.

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Thermogravimetric Analysis of High-Density Cork Granules Using Isocoversional Methods

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ABSTRACT

In the present work thermogravimetric techniques were used to study the thermal degradation of high-density cork granules. Pyrolysis experiments were carried out for four heating ramps (10, 15, 20 and 25 °C/min), using nitrogen as the carrier gas. From the differential thermogravimetric (DTG) curves it was seen that degradation mainly occurs from 220 °C to 525 °C for the main components of cork (suberin, lignin, cellulose, and hemicellulose). It was also observed that for temperatures higher than 525 °C and up to 900 °C, lignin continued to decompose. Activation energies were calculated using the data obtained and the two isoconversional methods Kissinger-Akahira-Sunose (KAS) and Flynn-Wall-Ozawa (FWO). For the KAS method, and for degrees of conversion between 0.10 and 0.85, the activation energies varied between 232.2 and 353.0 kJ/kg. Using the FWO method and for the same degrees of conversion, the activation energies were in the range of 230.0 to 346.6 kJ/kg. These values agree with data provided by other authors, for different lignocellulosic biomass.

Keywords: cork granule, kinetic analysis, pyrolysis, thermogravimetric analysis

1. INTRODUCTION

At the present time there is increasing concern over the use of fossils fuels, their future reduction in nature, and the environmental problems created by their continuous utilization. For these reasons there is a tendency to introduce renewable energy sources, such as energy from biomass.

Biomass conversation into energy can be achieved by pyrolysis, a thermochemical process where it is heated in the absence of oxygen and decomposes into volatiles and biochar. Several authors investigated the pyrolysis of different types of biomass using thermogravimetric analysis (TGA). Using this technique, the variation of the mass of a fuel sample was tracked against time or temperature, in an inert atmosphere, for a specific heating rate. These data together with kinetic models allowed the calculation of kinetic parameters, including the activation energy (E), pre-exponential factor and the order of reaction [1, 2, 3, 4].

Of the various kinetic models developed to mathematically represent the decomposition of the biomass, isoconversional methods consider that the rate of reaction for a given degree of conversion (α) is only dependent on the temperature (T) [5]. Yuan et al. provided the equations for the Flynn-Wall-Ozawa (FWO) and Kissinger-Akahira-Sunose (KAS) isoconversional models [3].

The objective of this work was to study the thermal degradation of high-density cork granules in an inert atmosphere, using TGA techniques. The experiments were carried out at four heating rates (β = 10, 15, 20 and 25 °C/min), using nitrogen as the carrier gas. Using two kinetic models (FWO and KAS methods), E was calculated for different degrees of biomass conversion.

2. MATERIALS AND METHODS

The high-density cork granules were supplied from a manufacturer located in the North of Portugal. The TGA experiments were performed in a thermal gravimetric analyser type Netzsch STA 449 F3 Jupiter. The runs were carried out using nitrogen as the carrier gas, at a flow rate of 50 mL/min. The temperature was varied from 50 to 900 °C, using heating rates of 10, 15, 20 and 25 °C/min. The data was treated using Proteus software.

3. RESULTS AND DISCUSSION

The differential thermogravimetric (DTG) curves of the decomposition of cork granules, for heating rates of 10, 15, 20 and 25 °C/min, are presented in Fig. 1. Fig. 2 shows the variation of the activation energies calculated *versus* the degree of conversion for the FWO and KAS methods.

The DTG curves show several stages. The first, for temperatures lower than ~200 °C, was mainly due to loss of humidity. The second stage at temperatures up to ~525 °C, was where the components of cork residues (hemicellulose, cellulose, suberin and lignin) suffered pyrolysis with the release of volatiles. From 525 °C and up to 900 °C, lignin continued its slow decomposition.

The data obtained from the TGA were used to calculate the activation energy of pyrolysis for temperatures in the range of 220 °C to 525 °C and for several degrees of conversion. The methods of FWO and KAS were used to treat the data. For the FWO method and for $0.1 < \alpha < 0.7$ the values of E were almost constant, varying from

230.0 to 246.0 kJ.mol^{-1}. For $\alpha = 0.8$ and $\alpha = 0.85$, the activation energies were 318.6 and 346.6 kJ.mol^{-1}, respectively. With the KAS method, E remained almost constant up to a degree of conversion of 0.7 (between 232.2 and 250.3 kJ.mol^{-1}) and then increased to 323.9 and 353.0 kJ.mol^{-1} for $\alpha = 0.80$ and $\alpha = 0.85$, respectively. The zone of constant activation energy probably corresponds to the decomposition of hemicellulose, cellulose and suberin, which occurs at lower temperatures. For $\alpha = 0.80$ and $\alpha = 0.85$, the degradation of lignin becomes predominant, needing a higher activation energy to breakdown its chemical bonds.
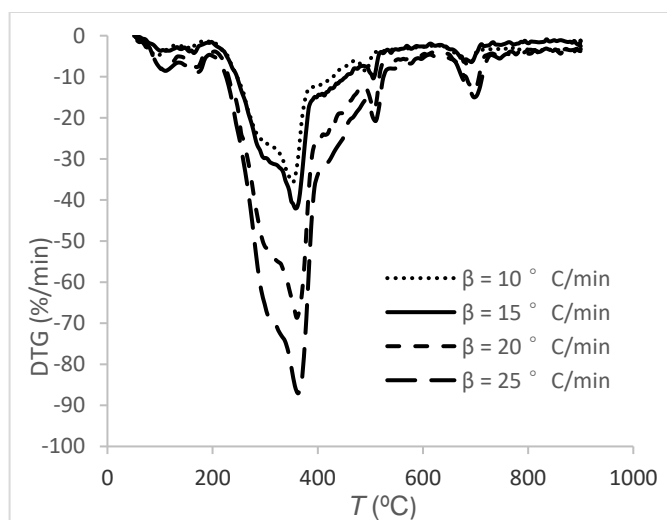
Figure 1 – DTG curves for the degradation of cork granules using nitrogen as carrier gas.
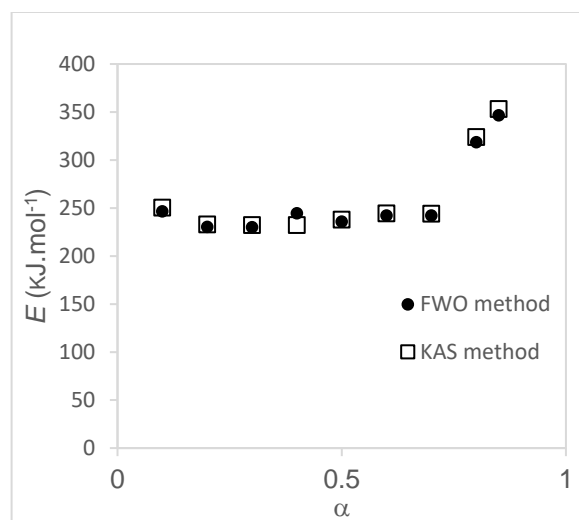
Figure 2 – Variation of E versus α for the FWO and KAS methods

4. CONCLUSION

The TGA results show that the degradation of high density cork granules occurs in several stages, linked to humidity loss and thermal decomposition of hemicellulose, cellulose, suberin and lignin. The energies of activation calculated from kinetic analysis of the data using the FWO and KAS methods are in agreement with results obtained by other authors, for different biomass residues.

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Designing a Qualitative Pre-Diagnosis Model for the Evaluation of Radon Potential in Indoor Environments

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ABSTRACT

In a very early stage of implementation of a comprehensive experimental campaign for indoor radon assessment, a pre-evaluation selection of the variables that play a leading role in influencing expected results must be insightfully assessed. Hence, a practical methodology for variable selection based on an analysis of historic data plays a key role concerning radon potential assessment. Given the circumstances, this work is focused on the design of a qualitative pre-diagnosis model for the evaluation of radon potential in indoor environments, for different energy efficiency scenarios, by considering a set of relevant variables carefully selected to characterize occupants´ risk exposure. A prior survey was done to identify all relevant characteristics that most affect Indoor Air Quality (IAQ), mainly concerning local geology, built environment performance, and occupancy schedules. The selected parameters will be afterward weighted and combined into performance indicators through an evidence-based literature review. In the current early stage, the requirements to drive the software development are presented, together with a software architecture proposal. Finally, it is expected that this pre-diagnosis model will allow a more refined sample selection for indoor radon assessment, by choosing the most susceptible variables that influence radon potential in a given scenario.

Keywords: Indoor Radon Assessment, Radon Performance Indicator, Radon Potential, Energy Efficiency

1. INTRODUCTION

Radon is a noble radioactive gas found freely in the natural environment, odorless, colorless, and tasteless. It arises through the decay of uranium and is prominent on granite and schist soils and substrates, rocks, and even in borehole water. Though in smaller concentrations, radon is also present in some specific building materials such as concrete, brick, and aggregates [1]. In normal environmental conditions, such as those that exist on the earth's surface, radon exhalation from the soil occurs in the gas form, presenting in outdoor environments low concentrations of approximately 10 Bq.m-3 with reduced known impact on human health [2]. However, the accumulation of radon gas in indoor environments poorly ventilated, which is approximately 8 times denser than air [3], represents a known public health problem, extensively reported by the World Health Organization (WHO), given the established relationship between high indoor radon concentration levels and the prevalence of respiratory diseases, mainly lung cancer [1]. Previous research works have been carried out to highlight the correlation between high indoor radon concentration, and the lack of air renovation [4]. However, an extensive analysis including other influencing parameters is yet to be done. This pre-diagnosis model will incorporate the most influencing variables previously selected by the Rn potential methodology. A pre-diagnosis assessment is a form of pre-assessment where the radon potential of a certain site can evaluate a building's tendency concerning indoor radon exposure. With this form of assessment, a meaningful and efficient experimental campaign can be implemented, without spending unnecessary time and resources on measuring buildings with low radon indoor risk exposure.

2. RELATED WORK

High radon potential is consensually attributed to geosites underlying constructions [5]. Most authors emphasize that the territory is endowed with high geodiversity, namely: residual; granitic; tectonic; fluvial; wind, and geocultural geoforms, therefore increasing the tendency for increasing radon exposure. On the other hand, indoor radon concentration tends to be reduced by natural ventilation [6, 7]. A pre-diagnosis model concerning radon potential assessment must include the analysis of several variables. Previous research found a correlation between the indoor radon concentration and several factors, that can be external or internal to the building. The external factors are related to the building localization and the climate conditions: geology and lithology, region, elevation above sea level, location on a hill or slope, Air pressure difference, outdoor temperature, and total atmospheric moisture. The internal factors are composed of the foundation type, the existence of a basement, the building materials, the story (distance from the ground), ventilation system, heating system, thermal retrofit, and indoor

relative humidity.

3. MATERIALS AND METHODS

The first step in the design of a qualitative pre-diagnosis model for indoor radon potential evaluation is the selection of a set of relevant variables correlated with indoor concentration level. In parallel, the research team will gather systematic data on radon concentration measurements and complete this data with these three categories of characteristics. Then, it will be assessed the correlation and relative weight of each variable concerning the radon to select the set of the most relevant characteristics or factors. Based on that set of variables, it will be developed a qualitative pre-diagnosis model for the evaluation of radon concentration potential in indoor environments through the possible use of classification and regression trees. The pre-diagnosis model aims to measure the level of risk so that the necessary measures can be taken, after confirmation by assessment, to mitigate the problem and consequent monitoring.

4. EXPECTED RESULTS AND CONCLUSIONS

The goal is to provide a software tool to support the first step of a broader approach to public health problems. After this stage is concluded, a short-term radon concentration measurement will be implemented whenever a user gets a high-risk estimate. And, if the short-term measurement confirms the high risk, a further long-term radon concentration measurement should be carried out. At last, after the long-term measurement confirms the high risk an in-situ remediation program will be implemented to reduce indoor radon exposure. Recently retrofitted buildings play an important role in the current model development since well-insulated walls, windows, and roofs with high energy efficiency performance can lead to air renovation reduction, designed to optimize winter thermal comfort. Nevertheless. the ventilation strategies are essential to improve Indoor Air Quality and reduce indoor radon potential. Radon mitigation strategies should accomplish a good trade-off between Indoor Air Quality and energy efficiency in order to improve indoor air quality with low impact on energy efficiency.

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A Statistical Review of A Decade of Residential Energy Research in Egypt

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ABSTRACT

To alleviate burdens to the Egyptian national electricity grid, there have been growing research efforts throughout the previous decade to reduce building-associated energy consumption. In the present contribution, a systematic literature review is undertaken, focusing on studies seeking to improve energy-efficiency in Egyptian residential buildings. Identified articles are analyzed by breaking them down into five categories describing variables manipulated, types of analyses, methodology and types of analyses, performance objectives, study locations and residential case studies analyzed, with the aim of unravelling key research trends and making pertinent gaps evident. The review indicates significant overlaps in the scope of enquiry; results highlight a simulation-based methodology, scenario analysis and exploration of energy performance, excluding economic and environmental performance objectives are repeatedly undertaken in 75% of articles. Based on these results, operational guidelines are proposed to support future research and broaden the scope of enquiry of Egyptian residential energy research.

Keywords: Egypt; Energy-efficiency; Literature review; Residential building stock.

1. INTRODUCTION

Residential buildings comprise 70% of Egypt's building stock [1] and consume 60% of the country's total energy [2], most of which was, until recently, generated from fossil fuel and subsidized for the entire population [3]. Subsidization coupled with lax environmental standards has vastly propagated energy-intensive activities, corresponding to a construction boom in the residential building sector [1], most of which tend to overlook prevailing climatic conditions. Since energy demand began exceeding supply in 2010, solutions are mostly focused on the supply side of the energy equation. However, another way to alleviate the burden is to reduce energy demand from the building industry by transitioning toward a more sustainable, energy-efficient building stock. There is a growing body of scholarly work concerned with improving energy-efficiency in Egyptian residential buildings, which this work aims to systematically and statistically review.

2. MATERIALS AND METHODS

A statistical, systematic literature review and quantitative content analysis was undertaken. A systematic search of databases relevant to building energy performance was undertaken using combinations of keywords related to the residential context and energy use. The search term 'Egypt' was added to ensure contextual relevance. This search strategy yielded over 6,000 records. After removing duplicates, article titles and abstracts were reviewed, and only 269 were deemed eligible for full-text assessment based on a series of pre-defined inclusion criteria. Content of eligible articles was coded into a series of categories (area of application, methodological approach, objectives and performance measures, location and case study typology) and associated sub-categories, with the aim of underlining key trends, advances in the field and existent gaps.

3. RESULTS AND DISCUSSION

Results of the review show notable overlaps within all five categories explored; possibly indicating dominant research trends in the Egyptian residential energy sector and, by association, potential 'blind spots' that may have been insofar overlooked. For example, in almost 60% of articles, building envelope components and windows and shading elements are manipulated, compared to only 19% of articles querying the impact of building design components and only 2% questioning how appliances and lighting affect performance. A methodological dominance is also observed; in 75% of articles a simulation-based approach is undertaken, mostly using the EnergyPlus simulation engine. While recommentations in methodological literature for empirical valiation to reduce errors exist [4] this is only found in 11% of the dataset. Similarly, residential building performance is evaluated mainly in terms of energy performance (76% of articles) whereas economic and environmental performance are evaluated minimally by comparison (16% and 8% respectively). Moreover, few works interrogate these three performance objectives in conjunction, despite assertions reporting the inter-relationship between energy, economic and environmental performance in the literature [5], suggesting that reduced energy consumption does not necessarily equate to a heightened performance overall. Moreover the review highlights

that state-funded social housing and/or residential buildings using conventional construction systems, in the form of multi-family residential buildings, are the housing type on which the literature set focuses, while other housing typologies and phenomena are under-represented. Overwhelmingly, in over 30% of works, simple-box models, highly-simplifed versions of a housing unit, are simulated to explore performance, raising questions regarding results' interpretation and reliability, as single-zone models do not account for across-zone interactions. Finally, case studies analysed are mainly fixated on existing urban contexts, in over 60% of the literature set. Moreover, out of 27 Egyptian governorates, residential energy research over the past decade has been undertaken in only 18. In addition, through this method of analysis, Egyptian climatic zones in which residential buildings' performance is under-studied is identified; these are the Highlands Climatic Zone, the East Zone Climatic Zone and the Northern Upper Egypt Zone, highlighting the need to investigate the performance of residential buildings in these climatic zones in particular in future research.

4. CONCLUSION

This work presents a systematic and statistical literature review of 124 academic publications seeking to improve energy-efficiency in Egyptian residential buildings, with the aim of unravelling latent content in this field over the previous decade. By classifying articles based on areas of application, methodological approach, objectives and performance measures, location and case study typology, dominant categories are identified in each of these. Results highlight a simulation-based methodology, scenario analysis and exploration of energy performance, excluding economic and environmental performance objectives are repeatedly undertaken in 75% of articles. Based on these results, the following recommendations are proposed as guidelines to support future research abd broaden the scope of enquiry. Researchers and policymakers are encouraged to focus on the impact of understudied areas of application on whole building performance; i.e. HVAC systems and appliances and lighting systems installed. Greater methodological reliance on field measurements and empirical validation of BPS results is proposed. Moreover, the results point toward the importance of conducting research in each of the three climatic zones and nine Egyptian governorates in which residential energy studies are largely absent, and exploring case study typologies that represent archetypal housing types in each of the study locations under investigation.

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Supercritical CO₂ Mixtures Optimization for Brayton Power Cycles: The Case Study of COS, H₂S, and SO₂

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ABSTRACT

This article investigates the chemical composition of the Brayton cycle working fluid as a design-key issue in the new generation of concentrated solar power plants. Four Brayton power cycle configurations are considered: recompression (RCC), recompression with reheating (RCC-RH), recompression with main compressor intercooling (RCMCI), and recompression with main compressor intercooling and reheating (RCMCI-RH). The supercritical Brayton cycle performance parameters are optimized through optimization algorithms (SUBPLEX, NEWUOA, and BOBYQA). As the main conclusion, the thermal efficiency is improved by adding high-molecular-weight substances (COS, H₂S, and SO₂) to pure s-CO₂. A rise in the RCC cycle thermal efficiency of 2.44% has been getting using $CO_2 = 46\%$, $COS = 10\%$, and $H_2S = 44\%$ mole fractions for $UA_{total} = 20$ MW/K and CIT = 333.15 K. The RCMCI-RH configuration achieves the best performance and an improvement of cycle efficiency equal to 1.43% using $CO_2 = 70\%$, $COS = 15\%$ and $H_2S = 15\%$ mole fractions for $UA_{total} = 20$ MW/K and CIT = 333.15 K.

Keywords: Brayton cycle; fluid mixture; solar plant; supercritical CO₂.

1. INTRODUCTION

The next generation of concentrated solar power (CSP) plants are likely to be founded on supercritical carbon dioxide (s-CO₂) Brayton power cycles coupled to concentrated solar collectors. In parallel, the latest research on supercritical Brayton power cycles has focused on defining the optimum chemical composition for the supercritical working fluid [1, 2]. The ever-increasing necessity to reduce the environmental impact of industrial and urban energy conversion processes has led engineers to consider using s-CO₂ mixtures as working fluid for thermodynamic power and refrigeration cycles [3], reducing emission and energy production costs.

The primary purpose of this study is to compare the advantages of ternary s-CO₂ based mixtures (s-CO₂/COS/H₂S, s-CO₂/COS/SO₂, and s-CO₂/H₂S/SO₂) used in Brayton power cycles coupled with line-focusing solar power plants. In the direction of the recent publications, four complex Brayton cycle configurations have been studied: recompression (RCC), recompression with reheating (RCC-RH), recompression with main compressor intercooling (RCMCI), and recompression with main compressor intercooling and reheating (RCMCI-RH).

2. METHODOLOGY

The supercritical concentrated solar power plant (SCSP) software [4] is used for the simulations of the performance of the Brayton cycle configurations using pure s-CO₂ and s-CO₂ mixtures. This software has been developed in the Energy Engineering Department at the Technical University of Madrid. This program is based on the software core developed by J.J. Dyreby in his doctoral thesis [5]. SCSP sets a constant heat recuperator total conductance (UA_{total}) for the performance calculation methodology. The exchangers' conductance is considered a constant parameter because the conductance is directly related to the design size, that is, to the cost of the exchangers. SCSP uses optimization algorithms (SUBPLEX [6], NEWUOA [7], and BOBYQA [8]) to determine the optimal s-CO₂ mixture that increases the cycle performance. The solar power plant reference power is 50 MW. The compressor inlet temperature (CIT) is from 318.15 K to 333.15 K. The turbine inlet temperature is set at 823.15 K. The turbine inlet pressure is set at 25 MPa. The overall conductance of the low- and high-temperature recuperators vary from 2.5 MW/K to 15 MW/K. The compressor inlet pressure (CIP), the split fraction, and the composition of the s-CO₂ mixture are optimized. The simulation's results are presented as a function of the heat recuperator total conductance and compressor inlet temperature.

3. RESULTS

Considering that the best performance among the four-cycle configurations studied in this work is the recompression with main compressor intercooling and reheating Brayton cycle, the results of this cycle are shown in Fig. 1. The maximum efficiencies obtained are close for the three mixtures. But there is a slight distinction above the others for the mix of sCO₂/COS/H₂S.
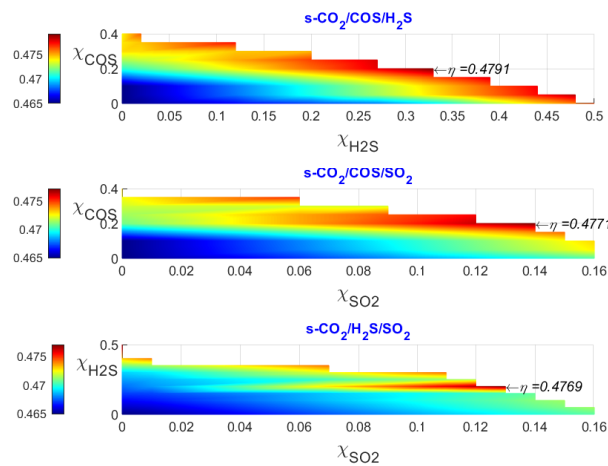
Fig 1. RCMCI-RH cycle efficiency vs. a concentration of s-CO$_2$ mixtures, CIT = 333.15 K and UA$_{total}$ = 20 MW/K.

4. CONCLUSIONS

An analysis of the influence of the s-CO$_2$ mixtures has been done in this work. It has been obtained as the main conclusion that the s-CO$_2$ mixtures with substances studied (COS, H$_2$S, and SO$_2$) have a beneficial impact on CSP efficiency.

A rise in the RCC cycle thermal efficiency of 2.44% has been getting because of s-CO$_2$ mixtures as the working fluid. With a composition of CO$_2$ = 46%, COS = 10% and H$_2$S = 44% mole fractions for UA$_{total}$ = 20 MW/K and CIT = 333.15 K.

The RCMCI-RH configuration achieves the best performance and an improvement of cycle efficiency equal to 1.43% using CO$_2$ = 47%, COS = 20%, and H$_2$S = 33% mole fractions for UA$_{total}$ = 20 MW/K and CIT = 333.15 K.

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Macro Modelling of Electricity Price Towards SDG7

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ABSTRACT

Energy is a very important issue to achieve Sustainable Development. Energy availability and affordability are key aspects for ending poverty and giving access to base commodities. In addition our daily lifes rely on electric appliances and gadgets to perform inumerous tasks so electricity price is a crucial issue due to its economic, environmental and social impacts. In this work it was studied the correlation of electricity price with the electricity mix from the several sources, GDP, energy productivity, electricity consumption per capita, fossil fuel reserves, and diesel price using Spearman correlation. The Kruskal-Wallis test was then applied considering the significant correlations and the macro variables that presented statistically significant differences were used to model electricity price. The logarithmic and linear model based on energy productivity to predict electricity price were the best models. The models were applied to the data and the average deviation was 10.3% and 11.7% which is satisfactory. Millions of people in the World are affected by electricity price and it is important to have models to predict electricity price to help in the decision-making process and in management.

Keywords: Energy; Electricity price; Sustainable Development Goals; Regression models

1. INTRODUCTION

Depletion of natural resources and pollution problems are major concerns that are linked to a rising World population and unsustainable consumption patterns. Humanity demand for resources and services in a given year exceeds Earth capacity of regeneration. For many countries the Earth Overshoot Day day falls already in the first six months of the year [1]. The Sustainable Development (SD) requires a new paradigm that is living well within the limits of Earth. The Sustainable Development Goals (SDG) adopted by the United Nations in 2015 are a measure to achieve several global aims [2]. SDG are very important and have been addressed by several authors [3]. The seventh SDG (SDG7) is related to affordable and clean energy since this is fundamental to have a good quality of life. An effort is being made to increase the share of renewables and there are many studies that address that subject [4,5,6] and the second target of SDG7 reflects this concern since it aims to increase substantially the share of renewable energy by 2020. The third and last target of SDG7 intends to double the rate of improvement in energy efficiency by 2030. Electricity is a form of energy that is fundamental in daily life because of the rising number of appliances and gadgets. Thus, in this work it was studied the relation between electricity price and some macro variables such as GDP, energy productivity, electricity consumption per capita, etc. It was used correlation analysis to find significant correlations, Kruskall-Walis test to analyse the effect of variables on electricity price, and linear and nonlinear regression to study models that can be used to predict electricity price. The existence of simple models that can predict the electricity price with more global scale can be very relevant to politicians and decision makers.

2. METHODS

The first step was to select variables that could potentially affect electricity price, specificaly: percentage of electricity produced from fossil fuels (FF), percentage of electricity produced from renewable sources (R), percentage of electricity produced from nuclear (N), gross domestic product (GDP), energy productivity (EnP), consumption of electricity per capita (CEC), fossil fuel reserves (FFR) and diesel price (DP). To assess the relationship between variables, different methods can be used. Spearman's correlation was used since it does not require a normal distribution being a nonparametric method. To assess normality the Shapiro-Wilk test was used in all data sets. The Kruskal-Wallis nonparametric test was then applied to the variables that present a significant correlation either positive or negative with electricity price as a confirmation process to determine if there were statistically differences between groups of a categorical independent variable on a continuous dependent variable. Finally, linear regression and nonlinear regression was applied to study possible models to predict electricity price. The Software used was SPSS Statistics 26.

3. RESULTS AND DISCUSSION

After applying Spearman's correlation it was possible to conclude that there are four significant correlations between electricity price (EP) and some of the macro variables namely with GDP, energy productivity (EnP), Consumption of electricity per capita (CEC) and diesel price (DP), all of them positive, which means the higher the value of the variables the higher the price of electricity.

The Kruskal-Wallis test was then applied considering these variables and for each variable 3 groups were considered. With this methodology it was found that only energy productivity, consumption of electricity per capita and diesel price present significant results since the p value is less than 0.05. This means that there is evidence that there is a significant difference between the electricity price across the three groups of each variable. These three variables were then used in linear and nonlinear regression in 21 models analysing the sum of squares of residuals, the R square and the corresponding coefficients. The best models found to predict electricity price were logarithmic and linear model of energy productivity. Applying the models the average deviation was 10.3% and 11.7% which is satisfactory.

4. CONCLUSION

European countries present still many differences in many important aspects. Electricity is produced using different sources, with a few countries having almost all electricity production based on renewables and the others on fossil fuels. The consumption of electricity per capita is also different and only a few countries present high GDP and most countries need to improve energy productivity. Most European countries do not own fossil fuel reserves [7] and at last, but not the least electricity price that varies substantially across European countries.

In this work several variables that can potentially affect electricity price were selected and a correlation analysis was performed. GDP, EnP, CEC and DP presented positive significant correlations with electricity price. Afterwards, a Kruskal-Wallis test was applied to these variables and it was possible to conclude that EnP, CEC and DP present significant differences and GDP does not. These three variables were then used in linear and nonlinear regression applied to 21 models. The best models were logarithmic and linear model of energy productivity to predict electricity price. Applying the models to the data, the average deviation was 10.3% and 11.7% which is reasonable.

It is relevant to analyse correlations between variables such as energy productivity, GDP, etc. and electricity price and to have good models to help in the decision-making process and in management.

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Dynamic Remuneration of Electricity Consumers Flexibility

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ABSTRACT

This paper proposes a decision support model to define electricity consumers' remuneration structures when providing consumption flexibility, optimized for different load regimes. The proposed model addresses the remuneration of consumers when participating in demand response programs, benefiting or penalizing those who adjust their consumption when needed. The model defines dynamic remuneration values with different natures for the aggregator (e.g. flexibility aggregator or curtailment service provider), which depend not only on the preferences of the aggregator and of the consumer in terms of prices, but also on the variation of the generation at each moment and the incentive to participate in programs taking into account the elasticity of each consumer. The validation is performed using real data from the Iberian market, and results show that value of remuneration increases when the elasticity increases and decreases when renewable generation increases, being an automatic way to stimulate the participation of consumers in times of greater need for flexibility and at the same time to guarantee a fair remuneration for both the participants and the aggregators.

Keywords: Data mining, Decision support systems, Demand response, Dynamic pricing

1. INTRODUCTION

The energy system paradigm has changed completely with the massive introduction of renewable energy sources [1]. The uncertainty brought by renewable energy sources' dependency on natural factors requires the system to use consumers' flexibility as a crucial means to balance the variation from the generation side [2]. However, adequate remuneration schemes for consumers' flexibility are lacking, which is delaying the widespread implementation of demand response programs to incentivize consumers participation. New models are needed to attract both consumers and aggregators to market transactions. Important developments can be widely found in the literature [3]; however, these are mostly directed to players market participation and energy management models, while neglecting flexibility remuneration models that are fair to both consumers and aggregators, while considering the system needs. This paper introduces a methodology for dynamic definition of remuneration for consumers' flexibility, benefiting or penalizing those who adjust their consumption. An optimized remuneration method is proposed, considering the potential economic benefit for both the aggregator and the consumers. The proposed model also considers the characteristics of the consumers (consumption volume, elasticity, previous participation in demand response programs) and the needs from the system, such as the volume of generation from renewable sources.

2. MATERIALS AND METHODS

The proposed model is directed to the demand response management from an aggregator. In a first step, the aggregator creates groups of consumers according to their similarity, so that the remuneration process is done according to players' characteristics. Clustering models are used to determine the optimal consumer groups [4]. The formulation is summarized as follows. (1) represents the remuneration for each consumer. CDR_c represents the remuneration of the consumers, obtained through the proposed methodology. The $Factor$ consists in several components and influences the variable CDR that represents the cost of reduction (when the consumer is paid to reduce consumption). In (2) P_RTPDR_MAX represents the maximum value of reduced energy per consumer, $P\_RTP\_initial$ represents the initial consumption of each load, Gen is the system production and Elast represents the elasticity of each consumer. w, x, y, z influence variables with different weights, to enable representing the relative importance of each variable to the remuneration calculation.

$$CDR_c = CDR \times Factor \tag{1}$$

$$Factor = w \times P_{RTPR_{MAX}} + x \times P_{RTP_{initial}} - y \times Gen - z \times Elast \tag{2}$$

The formulation presented in (3) is used to represent the income associated at each consumer after applying the remuneration methods. CDR_c represents the value of remuneration obtained by applying the proposed model, $Product\_RTPMAX$ represents the maximum consumption reduction for participation in Real-Time Pricing (RTP) demand response programs.

$$Income_{(€)} = CDR_{c(u.m./kWh)} \times Product\_RTPMAX_{(kWh)} \tag{3}$$

3. RESULTS AND DISCUSSION

This illustrative example shows the results that can be achieved using the proposed methodology for remuneration definition, considering five groups of clusters, previously defined and submitted to a normalization process for three and four clusters, with different weights for the influence factors (*w, x, y* and *z*). The clusters definition is performed using the *k*-Means clustering algorithm [4]. The calculation of the remuneration (CDR_c) is carried out by applying different forms of remuneration. The first three methods, for baseline results, consider as remuneration values, the maximum, minimum and average initial cost of consumption reduction, according to all players that compose each cluster/group of consumers. The fourth method refers to the proposed remuneration approach.

The chart presented in Fig. 1 A) shows that, when compared with the *CDR*, the calculated CDR_c have the expected behavior, when it is calculated using the minimum cost value from the cluster, the remuneration is lower compared to *CDR*, when calculated by the maximum, it is greater and when we use the average values, they are equal to the base *CDR*. From Fig. 1 B) it is important to analyze the remuneration values obtained since the influence factors *w, x, y* and *z* affect the outcomes in several ways. When assigning different weights to the components, we intend to analyze how there is an adjustment in the remuneration, related to the changes in the system (renewable generation at each time) and the consumers' characteristics.
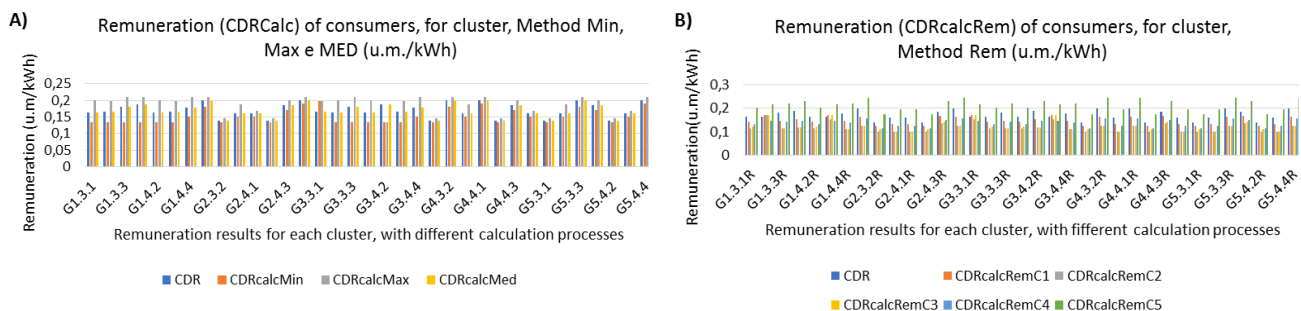

Figure 1. Remuneration values obtained with A) Method Min, Max and Med and B) Method Rem.

4. CONCLUSION

The decision support model proposed in this paper enables attracting consumers to assume a more active role in the system, through fairer remuneration strategies, including consumer's characteristics, and the production of energy associated with the whole system. From a practical point of view, these results are useful for the aggregator (or the entity that defines the remuneration), since in this way it can manage the overall remuneration to be defined for the group, depending on its strategy and objectives, while guaranteeing a fair remuneration for the consumers according to their characteristics and participation, and also according to the needs from the system.

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Demand Response and Dispatchable Generation as Ancillary Services to Support The Low Voltage Distribution Network Operation

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ABSTRACT

The current power systems, namely the low voltage distribution networks, are suffering considerable changes in recent years. The growing trend of power generation by renewable sources has posed new challenges and new opportunities. Furthermore, the wide installation of "smart meters" and the interest in placing the citizens as core players into the future energy markets and systems operation improves the role of the distribution system operator. In this way, developing new and innovative methodologies to explore the potential of mechanisms for providing ancillary services in distribution networks becomes of great importance, namely in low voltage levels. This research paper proposes an innovative methodology to enhance the demand response participation of small consumers and dispatchable distributed renewable energy sources flexibility as ancillary services to mitigate the voltage and congestion issues in low voltage distribution networks. A realistic low voltage distribution network with 236 buses is used to illustrate the application of the proposed model. The results demonstrate a considerable voltage profile and congestion improvements.

Keywords: Ancillary services, demand response, dispatchable generation flexibility, voltage profile.

1. INTRODUCTION

Nowadays, through the large-scale integration of distributed generators based on renewable energy sources (RES), the conventional control and operation framework designed for passive distribution networks is being challenged. In this context, the loads can be supplied not only by traditional generation units at the upstream power systems but also by the distributed energy resources (DER) [1]. Additionally, DER based on RES are highly volatile and naturally intermittent, depending directly on environmental conditions. In this way, not only new challenges appear, but also opportunities, like the demand response (DR) participation of the consumers and the dispatchable distributed renewable energy sources (DRES) flexibility as ancillary services (AS) in distribution low voltage networks (DLVN) with high penetration of RES. Several works in the specialized literature have been investigating the AS in distribution level [2-5], but none of them have addressed the DR participation as was said before. Also, it is not enhanced the participation of small consumers in the DLVN operation to mitigate voltage and congestion issues. Comparing with the previous works, this research paper will fill these gaps by proposing a methodology to enhance the DR participation of small consumers and dispatchable DRES flexibility to mitigate the voltage and congestion problems in DLVN. For this, a heuristic working together with a tool for electric power system simulation and analysis – MATPOWER [6] will be used. To demonstrate the application of the proposed model, a realistic 400V low voltage distribution network with 236 buses and a total of 96 loads (residences) was used.

2. MATERIALS AND METHODS

About the methodology, two types of ancillary services have been defined: demand response (DR) service and generation service. First, the DR service consists of mapping the buses and lines that present issues during the network operation, i.e., voltage and congestion problems (by a Power Flow analysis using a tool for electric power system simulation and analysis, e.g., MATPOWER), and then making a service provider search in the surrounding area. After that, through a developed heuristic, the smallest number of necessary providers will be activated to correct the verified issues in the network. Second, the dispatchable generation service also aims to solve network voltage and congestion problems. It consists of activation the dispatchable generating units and working based on the adjustment of their active and reactive power delivered to the network. About the case study, a realistic low voltage distribution network has 236 buses, 235 underground cables, and 96 load points (residence consumers), resulting in 679.65 kVA of total installed power and explored radially. In addition, the network has 39 residence consumers with rooftop photovoltaic panels. A 10 kV/420V, 1000 kVA transformer carries out the network supply. Additionally, two biomass generators (located in buses 23 and 190) with 300kW of rated power each are considered as dispatchable DRES. The collected data sample corresponds to 90 days and is divided into 15 minute periods (8640 total).

3. RESULTS AND DISCUSSION

Two studies were conducted to demonstrate that the small consumers' participation in DR events and the dispatchable DRES flexibility can mitigate or remove the voltage and congestion problems in DLVN: 1) Demand response (Case 1); 2) dispatchable DRES flexibility (Case 2). Both cases are compared with a reference case where DR and dispatchable DRES flexibility are not considered. In case 1, for all periods, all voltage and congestion problems were removed. Period 4977 (period with the high demand) was used to carry out a more detailed analysis. It was observed that a considerable improvement in the voltage magnitude up to around 0.7% is obtained by applying the DR service. It is noteworthy that almost all consumers able to provide the DR service are activated (35 of 39). This denotes that the service is well dimensioned but working at the limit. In case 2, all voltage and congestion problems were also removed for all periods. Considering again the period 4977 (the high demand period), it is verified that in two lines/cables, the occupation rates have a strong decrease (94.14% and 98.87%). These two lines/cables feed considerable large areas, meaning that the downstream loads are mostly supplied by the dispatchable generators. Additionally, in critical situations, such as total or partial disconnection of these areas from the main grid, the areas could be temporarily supplied by these generators. Indeed, for this type of situation, all technical and operational requirements should be approved in advance.

4. CONCLUSION

This research paper presented a methodology to mitigate the voltage and congestion problems in distribution low voltage networks through the flexibility of dispatchable distributed renewable energy sources and demand response services participation of small consumers as ancillary services. For this, a heuristic working together with MATPOWER, an electric power system simulation, and analysis, is used. The proposed model was tested using a case study of a realistic distribution network compared with a reference case (no demand response needer dispatchable distributed renewable energy sources flexibility ancillary services available) to demonstrate the advantage of the former. The results suggest that the proposed methodology can be used as an efficient approach to deal with distribution low voltage network operational issues, namely in what concerns the voltage and congestion problems.

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Application of Distinct Demand Response Program During the Ramping and Sustained Response Period

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ABSTRACT

The environmental concerns around energy, namely electricity, have driven attention to innovative approaches to fostering consumers participation in the whole energy system management. Accordingly, the concept of demand response provides incentives and signals no consumers to change the normal consumption patterns to increase the use of renewables, for example. The problem is that such response of consumers has a large amount of uncertainty. This paper proposes a methodology in which different demand response programs are activated and deactivated during an event to cover the demand response deviations from the target. Even after achieving the response target, if the actual response of consumers is reduced to a critical level, additional programs are activated. The proposed approach considers consumers participating in an aggregate way, supported by an aggregator. The case study in this paper accommodates three demand response programs, showing how different consumers are activated and remunerated for the provision of consumption reduction. It has been seen that the proposed methodology is flexible as desired to accommodate the uncertainty of consumers' responses.

Keywords: Aggregation, Demand Response, Uncertainty.

1. INTRODUCTION

Demand Response (DR) is related to a set of incentives or electricity price signals to the consumers to induce a change in the normal consumption pattern due to economic or technical reasons. It has been proven to be very effective [1]. Several barriers are, however, identified in [2]. Adequate strategies are therefore required to optimize the use of DR and deal with the uncertainty of the consumers' response [3]. Price elasticity of demand parameter is a well-known approach to model consumers' response to changes in prices. However, this parameter has a linear nature that does not reflect consumers' contextual changes [4]. Aggregation of consumers providing DR is another way to handle uncertainty. An aggregator collects small amounts of DR, delivering it as a whole to the electricity market, to the distribution system operator, or another player [5].

During the DR event, a specific moment when the DR program is activated, consumers are called to provide demand reduction. According to [6], the aggregation concept can continuously adapt to the different consumers' responses during the event. In fact, in [7], the authors proposed a methodology to handle the activation of different DR programs during a DR event to collect the total amount of response required in real-time. The focus was given to the ramping period, where the consumers provide an actual response before the reduction deadline, so the required amount is fulfilled at this last moment. However, the sustained response period was not adequately addressed.

2. MATERIALS AND METHODS

The proposed methodology is devoted to managing DR programs by an aggregator in the context of a request by a network operator or an electricity market operator. The aggregator will request medium and small size consumers and producers to reduce consumption. Demand response programs will then be activated. DR programs are activated during both the ramping and the sustained response periods, aiming for a certain overall reduction target. Finally, the aggregator can use the proposed methodology to collect the small amounts of DR and deliver it to the electricity market, which is the final target of the aggregation process.

3. RESULTS AND DISCUSSION

The case study in this paper is based on the data in [7]. Facing a reduction baseline, which represents the amount of consumption reduction during the DR event, equal to 15 kW, we can have different options for demand reduction. The latter are the three DR programs implemented, namely DR1, DR2, and DR3, which have different capacities.

There are two critical periods where the use of DR1 and DR2 programs is not enough to keep the consumption reduction within the acceptable range, namely periods 28 to 45 and 152 to 165. Comparing the two DR event periods for the DR3 program, one can see that consumer C5 is very active in the first DR event but with a lower

contribution in the second DR event. Regarding consumer C1, it is very active in the second DR event but less active in the first DR event. Such differences are caused by the specific amount of reduction available in each consumer in each period and the respective remuneration prices.

4. CONCLUSION

Demand response programs are a valuable resource in the operation of power and energy systems, bringing benefits to consumers, the network operator, and the electricity market. Other players like an aggregator can have a great role in DR programs. The proposed methodology aimed to provide a way to address the uncertainty of consumers' responses in real-time to DR events. When the target reduction baseline deviation is critical, five distinct consumers are activated as needed, which belong to the same DR program. The remaining two programs are activated as blocks without the knowledge of individual consumers participating. It can be concluded that by selecting the available consumers in real-time, it is possible to overcome the uncertainty of response in DR programs treated as blocks during the sustained response period or the DR event. This implies that adequate remuneration must be provided and handled as dependent on the period of the day and other context variables.

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Energy Transition in Saudi Arabia: Giant Leap or Necessary Adjustment for A Large Carbon Economy?

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ABSTRACT

This paper provides a systematic view of the Saudi energy transition by highlighting drivers, sectors, targets and processes. It analyzes the progress with regard to lowering carbon emissions and consumption, as well as introducing ambitious new targets and solar energy projects. The energy subsidy reforms have delivered the needed funds for the energy transition and allowed for more participation in energy markets. Other aspects of the energy transition included low-carbon urban developments and energy efficiency measures in the building sectors. Besides, key energy-intensive industries such as petrochemicals and desalination are incorporating renewables and facilitating the use of clean energy. Overall, the Saudi energy transition is underway, and it holds significant and necessary adjustments to the most important economy in the Middle East region. It needs to be complemented by environmental awareness and sustainable lifestyles. Reforming the large carbon economy of Saudi Arabia towards more sustainability and environmental responsibility can have positive spillovers and powerful messages about the future of carbon-fuel exporting states.

Keywords: carbon footprint; low-carbon economy; energy transition; energy policy; energy subsidies; renewable energy; Saudi Arabia

1. INTRODUCTION

The Kingdom of Saudi Arabia (KSA) is an oil-rich country and the biggest economy in the Middle East, making it an interesting case of the energy transition in large carbon economies. It holds the second highest proven oil reserves worldwide. Besides, it has the highest production of oil (ca. 12 million barrels per day in 2017), and third highest natural gas production (ca. 111 billion cubic meters per year in 2017) in the region of Middle East and North Africa (MENA) [1]. For decades, Saudi Arabia has been known for obstructing climate change agreements, and for dominating the positions of the oil-exporting countries which feared the negative spillovers of the energy transition o n their carbon industries [2]. As the case of other countries of the Gulf Cooperation Council (GCC), there is lately an increased attention to renewable energies, energy subsidy reforms and the issue of sustainable development in general.

2. MATERIALS AND METHODS

Considering the Saudi influence and economic power, the consequences of the ongoing energy transition are quite significant for the MENA region in terms of reforming current fossil-fuel intensive economies. Therefore, studying the Saudi case enriches the energy transition literature in terms of motivation, instrument and repercussions of such transitions in large carbon economies. While academic literature on the Saudi energy transition is emerging, it often focuses on reviewing the progress and targets with regard to renewable energy [2]. Such targets have been changing rapidly due to the dynamic nature of the ongoing restructuring of the Saudi energy sectors. Therefore, there is a need for more comprehensive reviews of the energy transition in Saudi Arabia in order to understand the enablers, process, and sustainability of this transition. Using secondary literature and data from recent projects, the paper reviews the Saudi energy transition case by analyzing the drivers, instruments and involved sectors. It also contextualizes the Saudi case within the GCC and MENA regions and discusses potential implications.

3. RESULTS AND DISCUSSION
3.1. Drivers of the energy transition in Saudi Arabia

There are generally two categories of explanations for the energy transition in Saudi Arabia. First, Saudi Arabia is facing an economic energy dilemma due to the declining prices and demands for oil globally, and the increasing domestic energy demands. In academic literature, this dilemma is presented as the main driver behind the energy

transition in Saudi Arabia and the region. Second, there are several geopolitical and non-economic factors attached to the energy transition in the GCC region. Al-Saidi [3] explains the extrinsic values of sustainable energy in the region, and provides non-economic justifications such as prestige and modernity images attached to the development of large-scale renewable energy projects and the nuclear power. Besides, the economic reforms in Saudi Arabia, including the energy reforms, are often attributed to the rise of the Saudi Crown Prince Mohammed Bin Salman who is a part of a new reform-oriented generation of monarchs in the GCC.

3.2. Sectors, instruments and targets

First, with regard to cleaner energies, tangible progress can be observed. Above all, the share of natural gas in power generation has increased significantly, now accounting for more than half of total generation. The increased gas production is an important factor for the decrease in the carbon-intensity of the Saudi economy. Besides, with the commercial operation of the Sakaka plant in 2021, the share of renewable energy is expected to increase slightly. However, the bulk of the projects is still under construction, with a significant development registered in 2021. In 2021, Saudi Arabia has announced 7 new projects, with the tender of 600 MW Shuaibah project drawing the world record low price of $0.0104/kWh. It also declared a new and quite ambitious renewable energy target of 50% of power generation through renewables by 2030.

Second, with regard to energy subsidy reforms, these reforms have been significant in terms of both actual reductions and the resulting benefits for the state. the subsidy reforms constitute a key factor facilitating other aspects of the energy transition. First, the reforms will generate hundreds of billions of dollars of saved fiscal revenues in the upcoming years (ca. 40$ billion of saved spending in 2019 in comparison to the subsidization spending of 2014). These revenues can be reinvested in direct welfare benefits or in renewables' projects. Saudi Arabia has created the Saudi Citizens Account, which disperses direct benefit for eligible households as a way of compensation mechanism for the fiscal reforms such as the subsidy reforms or the introduction of the value added tax (VAT).

Third, with regard to the built environment, the introduction of energy certifications for buildings, district cooling systems and the construction of low-carbon megaprojects have been a popular instrument in the GCC region for ecological modernization and low-carbon development. nother area of great importance for the energy transition is clean transport. In this regard, Saudi Arabia has recently increased its investments in public transport.

Finally, the bulk of the industrial basis in Saudi Arabia depends on energy-intensive sectors such as petrochemicals, steel, aluminum, cement and mining. Therefore, there have been several efforts to improve energy use in these sectors. Another key industry for the energy transition is desalination, which represents a key supply sector, and one of the largest electricity consumers in the GCC region (up to 12% of electricity in some GCC countries). The efforts to decrease the desalination energy footprint consist of constructing more energy-efficient plants

4. CONCLUSION

This paper has highlighted key elements of the energy transition including the renewables development, the energy subsidy reforms, interventions in the built environment and interventions in energy-intensive industries. Key energy transition indicators show some success with regard to lowering carbon emissions and intensity as well as decreasing energy consumption, particularly the in the residential sector. There have been new and ambitious renewables projects, including an impressive target of generating 50% of power from renewables by 2030. The energy subsidy reforms have been significant and delivered the needed spending for renewables development. They also allowed more competition and participation in the energy markets. Other aspects of the energy transition include low-carbon cities and enhancing energy efficiency in buildings through certifications. Besides, energy intensive sectors such as desalination or petrochemicals are being supported to incorporate and facilitate the use of clean energy. Overall, the Saudi energy transition has been significant, necessary and more comprehensive than past efforts. It should be complemented through encouraging sustainable livelihoods and low-carbon lifestyles.

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Determining The Influencing Factors in the Residential Rooftop Solar Photovoltaic Systems Adoption: Evidence from a Survey in Qatar

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ABSTRACT

Renewable energy sources have developed rapidly, decreased in cost, and proven to have the potential in limiting global warming. Renewable energy in the form of solar energy can be collected through decentralized rooftop solar systems. Solar energy development in Qatar is still at an early stage. The abundance of solar radiation, high GDP, and plentiful access to rooftop spaces makes rooftop photovoltaic (PV) systems a suitable option. Unfortunately, the early development and adoption of residential rooftop solar PV systems are expected to face numerous constraints. This paper attempts to investigate the factors that impact the residential rooftop solar photovoltaic adoption in Qatar. Through analyzing the response of a general public sample, we hope to prove the hypothesized factors by aiming at testing their solar systems knowledge and awareness. The result of the study will provide insights on how the public perceives solar panels, along with factors the government needs to address to ensure successful public adoption of residential solar rooftop systems in Qatar.

Keywords: PV Adoption, Rooftop Photovoltaic, Survey, and Sustainable energy.

1. INTRODUCTION

It is estimated that sufficient energy is received from the Sun on Earth to cover the entirety of human demand for a year. Solar energy could dwarf the capacity of all other energy sources combined. Global warming, climate deterioration, and destabilization due to increasing emissions of greenhouse gases (GHGs) are becoming a serious threat. Shifting to solar energy systems for generating electricity no doubt has huge social impacts on communities, whether in developing or industrialized countries. The social acceptability of renewable energy technologies plays a very critical role while shaping the implementation. The social attitudes must be aligned with the governments' objectives to implement such technologies feasible. Qatar has one of the highest per-capita CO2 emissions, the government of Qatar recognizes its global responsibility to limit its contribution to the CO2 and greenhouse gas emissions by setting renewable energy goals. According to the General Secretarian For Development Planning report, the plan for Qatar by 2030 is to produce approximately 20% of the total electricity from solar energy. Although the technology is sustainable and cheaper to run, some other obstacles make it unfavorable. Public acceptance and awareness are key factors in determining the measure of success of solar energy adoption in the state of Qatar. Changing the culture and shaping new policies will move the country toward a more sustainable economy, better awareness for the public, and a cleaner environment. The scope of the study is to investigate public perception in implementing PV panels for residential buildings in Qatar through a survey. The survey has been developed to obtain valid feedback from the residential villa owners in the State of Qatar.

2. MATERIALS AND METHODS

The survey was developed to provide helpful feedback about the environmental, economic, and social impacts of photovoltaics in Qatar's residential sector after collecting and analyzing the data. A previous survey titled "U.S. Homeowners on Clean Energy: A National Survey" was utilized to design the best survey structure attractive to participants. The survey was provided in both the Arabic and English languages.   The survey was distributed to a network of friends and family through social media and WhatsApp. In addition, the survey was distributed to a network of academic teachers and staff in elementary and high schools in the State of Qatar.

3. RESULTS AND DISCUSSION

Data analysis is the systematic approach of cleansing, tabulating, and modeling raw data to identify hidden relationships and trends. The study is focused on examining the public perception of solar energy in residential buildings in Qatar. For this purpose, primary data have been gathered by utilizing a survey questionnaire from 263 members of the Qatar residential area. The breakdown of the respondent's demographic statistics is shown in Fig. 1.
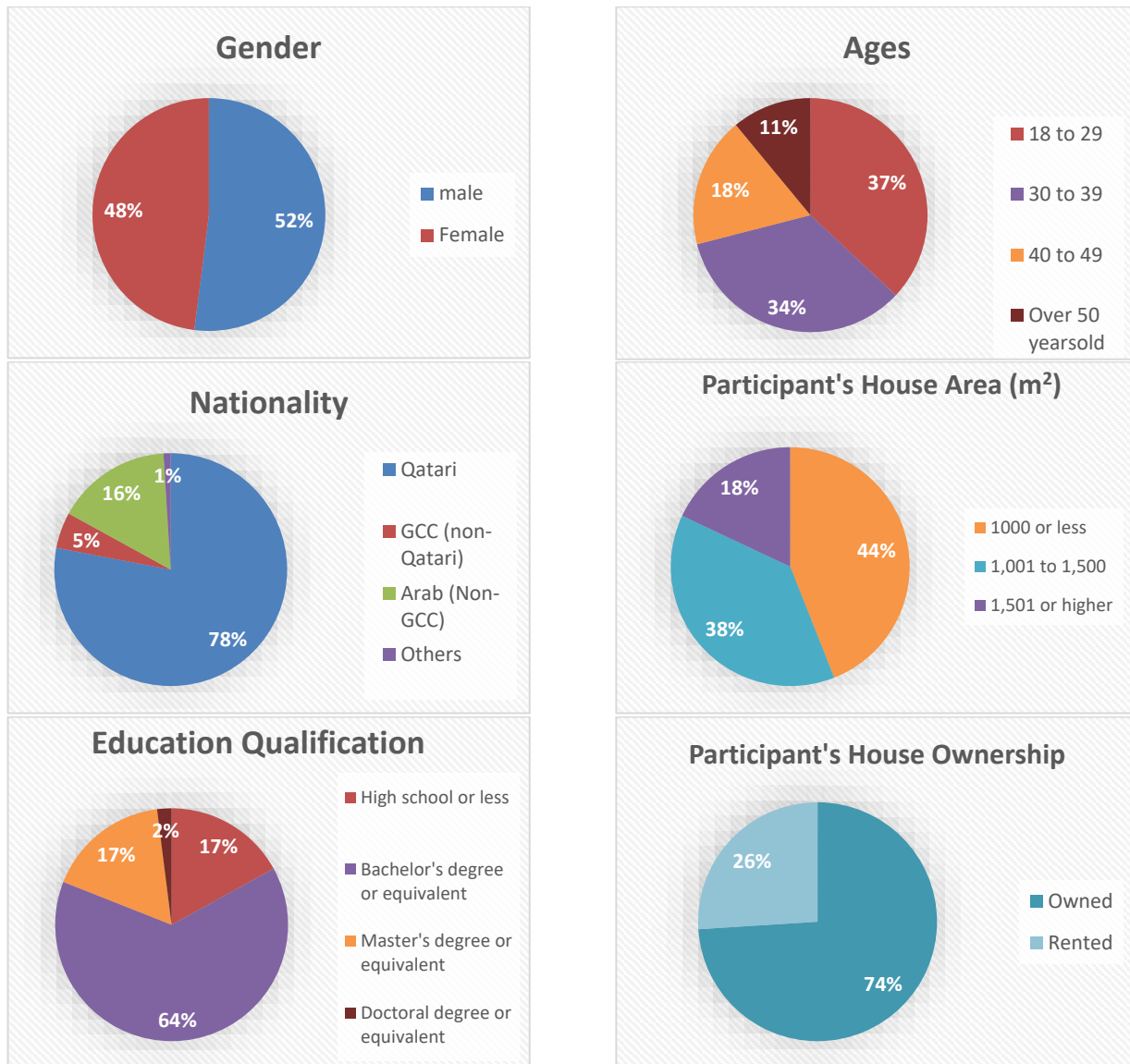
Figure 9: Demographic profile statistics of the research respondents

4. CONCLUSION

The goal of this paper is to examine the different aspects that determine public perceptions of PV implementation in residential buildings in Qatar. People's perspective is an important factor when implementing changes. The literature is rich with studies on PV efficiency, different policies, and the causes of climate change. It is important to address all of these aspects; however, policies are driven by social acceptance of an idea, and the level of acceptance will shape the strategy toward that change. Policy implementation will simply be ineffective if there is no cooperation from the public.

The Companies in the European Energy Sector: Hierarchical Tree Analysis

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ABSTRACT

The energy stock market is characterized by high returns and strong volatility, and little is known about possible interactions between these companies in the literature. We studied the time series of 18 European energy companies' daily stock prices during 2008-2018, including oil and natural gas prices. To analyze the relationship between the companies' stocks in the study, the Minimal Spanning Tree Method was used. Results pointed that companies like Engie and OMV, ENI, and Total possibly promote cooperation dynamics, namely clustering. Iberdrola, Total, and OMV companies play an essential role in the network, as an element of linkage and influence that can coordinate the information between the companies' stocks. Displaying the most relevant links and interactions between them is important for financial market investors and policymakers in terms of competitiveness.

Keywords: Energy Stock Market; European Companies; Minimal Spanning Tree

1. INTRODUCTION

This paper contributes to the existent literature by using individual quoted energy firms' closing prices and, in the interrelations, analyzed. Using the daily quotes of 18 European companies, the Minimal Spanning Tree (MST) model was used to analyze the Hierarchical Tree (HT) of the shares, displaying the most relevant links and interactions between them. It is important to study and know the influential stocks in energy markets because savings and investment decisions will depend on these interactions [1]. Understanding the causality and the behavior of each stock in the system is significant for predicting any significant interruptions. These will unfavorably impact the steadiness in the world, provided energy is an engine in the economic growth and development of any economy [2]. It would also give enough time to respond in accordance and provide resources for minimizing the impact in for example financial and economic crises, once stock markets are known as complex systems with huge interwoven interactions amid stock prices (part of the characteristics in dynamics of financial markets). Thus, investigating the structure of such connections among stocks will be helpful to optimize the portfolio of assets and for risk management purposes. Correlation network analysis may be analyzed in a variety of methods, like the Minimal Spanning Tree [3]. As far as we are aware, previous studies do not fully consider the properties of energy stock networks, at least for fossil fuel energy companies in European stock exchanges. Moreover, time series properties change through time, and they are not continuously explored as they should be. The only study exploring the energy stock markets network that we are aware of is that of [1] which have used MST applied in the energy market, but for renewable energy companies confirming that the solar sector in renewable energy is the dominant sector in America. Moreover, results demonstrated that the central hubs are Canadian Solar Inc. (CSIQ) from Solar and then Pattern Energy Group Inc. (PEGI) from Solar-Wind sectors. In financial markets, network analysis has been characterized as a very useful tool in characterizing their structural and market properties, and thus we propose a network analysis of 18 energy companies.

2. MATERIALS AND METHODS

For this paper, daily closing price data of 18 European companies were analyzed . Électricité de France, Engi, E. ON SE, National Grid, Hera, and RWE AG are companies belonging to the Multiline Utilities industry. The remaining companies belong to the Oil & Gas sector. The closing prices of the stocks are expressed in the currency of the country to which each company belongs and were taken from three websites: PT Stock Exchange, Investing.com, and Yahoo Finance. The choice of companies was based on the report on the top 100 of the world's leading energy companies according to the website of the multinational company Thomson Reuters. In this report, eight key pillars have been evaluated to rank the value of companies. Financial performance, management and investor confidence, innovation, legal compliance, environmental impact, social responsibility, reputation and risk, and resilience were the variables analyzed used a statistical model that follows a Bayesian logic. In this paper, 18 of the 100 largest European listed companies were selected (18% of the total available sample). Data

analysis was performed over 10 years from January 2008 to December 2018. Using the [3] approach, an analysis of similarities along stock returns will be performed through the Minimal Spanning Tree (MST) method to understand the hierarchical tree (HT) of the stocks.

3. RESULTS AND DISCUSSION

According to the degree of centrality, Total S.A. and OMV have a greater number of links with the other stocks. The same had been reported earlier with the MST analysis. The greater the number of links to one stock, the greater the influence of this stock on the others. As a result, Total S.A. and OMV are the two companies with the most influence, with values of 0.2941. These companies are followed by Iberdrola and Royal Dutch Shell. The other two most important stocks are Repsol S.A. and E. ON SE, where each company has centrality values of 0.1177. Regarding the degree of proximity, the higher it is, the faster stocks are influenced by the behavior of other stocks. Thus, the Spanish companies, Iberdrola and Repsol S.A., are the most influenced by the remaining stocks. The least influenced company is the German RWE AG (0.2208). The degree of intermediation expresses the "communication control", i.e., indicates the potential of each stock to influence the other stocks. Total S.A. and Iberdrola have the highest values (0.6250) in terms of the degree of intermediation. This indicates that the influence of most stocks on the remaining stocks goes through these two companies. Thus Total S.A. and Iberdrola play a crucial role in the network as a liaison that can coordinate information between stocks. The remaining four stocks with high intermediation values are Repsol S.A. (0.5294), OMV (0.5047), Royal Dutch Shell (0.3309) and E. ON SE (0.1177). According to [4] the Utilities sector, is the sector that presents higher values in the three centrality measures, while the energy sector presents lower values. [5] analyzed 300 European companies between 2005 and 2010 and found that Total S.A. is the most centrally located company in 2010, occupying the second position. Regarding the degree of intermediation, in the top 10, we highlight again the company Total S.A., but also the Dutch company Royal Dutch Shell. This suggests that the French Total S.A. is one of the most important, which is also verified in this paper through the results presented above.

4. CONCLUSION

The results of the application of MST and HT revealed the possible existence of clustering between the companies Engie-OMV and ENI S.p. A-Total S.A, given the strong correlation and the short geometric distance between them. Through the application of the 3 centrality measures (degree of centrality, degree of proximity, and degree of intermediation) it was found that the companies Total S.A. and OMV are linked to a larger number of companies. Thus, these companies exert a great influence on the other companies under study. On the other hand, the companies most influenced by the remaining stocks are Iberdrola and Repsol. Already Total S.A. and Iberdrola have higher values regarding the degree of intermediation, suggesting that the influence of most companies over the remaining, goes through these two stocks. In short, both Total S.A. and OMV, as well as Iberdrola, play an essential role in the network as a liaison and influence that can coordinate information between stocks.

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The Nexus Between Co₂ Emissions from Electricity Generation, Gdp and Energy Intensity Using A Complete Maximum Entropy Approach: the Case Of Iran

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ABSTRACT

This study examines the nexus between energy intensity (EI), gross domestic product (GDP) and carbon emissions from electricity generation (CEEG) in Iran, where energy intensity has been increasing during the last decades. Iran holds one of the world's largest fossil fuel reserves and its electricity sector is highly dependent on natural gas. In recent years, the empirical literature focuses on intensity and efficiency of energy due to global warming and climate change resulting from burning conventional fossil fuels. Therefore, finding the role and impact of energy intensity in an economy is assumed as a very important issue. The results of the current study show a positive impact of EI on CEEG, and no impact of EI on GDP. On the other hand, a nexus between CEEG and GDP is clearly identified in all the scenarios considered in the study. The generalized maximum entropy estimator is used to estimate all the parameters of the replicated models generated by the maximum entropy bootstrap for time series, which represents a novelty and an important improvement towards stability of the entire estimation procedure.

Keywords: Economic Growth; Environmental Policies; Info-Metrics; Time Series

1. INTRODUCTION

Energy intensity (EI) is an index that is measured as units of energy consumption measured in energy units per unit of gross domestic product (GDP), and it stands as a proxy for energy efficiency of the economy [1, 2]. In the economies with high level of energy intensity, the cost of converting energy resources to GDP is high, that means increasing one percent in economic growth requires more than one percent increase in energy consumption. Therefore, along with improving economic growth, the intensive energy use leads to more environment pollutant and greenhouse gas emissions (GHG) in poor countries [3]. Accordingly, improving the energy intensity index means more savings in natural resources, higher energy security, lower production costs and more protection of the environment [2]. To achieve sustainable development, economic growth must be accompanied by socio-economic and environmental targets. For this end, the economies should set targets to reach higher economic growth along with lower energy consumption, energy intensity and environmental degradation. Higher economic growth requires either more inputs or increased productivity and efficiency of inputs. To aim sustainable development, the most important factor is increasing energy productivity by improving technology and better energy conservation that lead to the reduction of the Energy/GDP ratio that measures energy intensity [3].

2. MATERIALS AND METHODS

The three variables in this paper are CO_2 emissions from electricity generation (CEEG) measured in million tons (Mt) per capita as a proxy for environmental degradation, gross domestic product (GDP) per capita measured in 2010 constant price US dollars as an indicator for economic growth, and energy intensity measured in megajoule (MJ) per unit of GDP in 2011 constant price US dollars that presents the ratio between total primary energy consumption and GDP.

This research applies the maximum entropy bootstrap to create 1000 replicates of the time series and generalized maximum entropy to estimate the parameters of the two models presented as

$$CEEG_t = b_1 + b_2 GDP_{t-m} + b_3 EI_{t-m} + e_t, \tag{1}$$

and

$$GDP_t = b_1 + b_2 CEEG_{t-m} + b_3 EI_{t-m} + e_t, \tag{2}$$

for the lags $m = 0, 1, 2, 3$, where $CEEG$ represents carbon emissions from electricity generation, GDP represents gross domestic product, EI represents energy intensity, e represents the noise component, and t

represents the time (year). The time period is from 1995 to 2015.

3. RESULTS AND DISCUSSION

An important result is that the null hypothesis $H_0: b_2 = 0$ is rejected at a low significance level, regardless the model considered, which reveals the nexus between CEEG and GDP for Iran in the time period from 1995 to 2015. And since both limits of the corresponding confidence intervals are positive, this means that, on average, a unit increase in CEEG (GDP) implies an increase (its magnitude depends on the model considered) in GDP (CEEG), *ceteris paribus*.

On the other hand, considering the model in (1), the null hypothesis $H_0: b_3 = 0$ is also rejected at a low significance level, which shows that energy intensity has a positive impact on carbon emissions from electricity generation in Iran (both limits of the corresponding confidence intervals are positive). Since the main source of electricity generation is fossil fuels, any increase in energy intensity causes more CO_2 and environmental degradation.

Table 1. Results from model in (1) for different lags.

		Estimate	CI 90%	CI 95%	CI 99%
$m = 0$	b_1 ***	-8.6196	(-9.9026, -6.9361)	(-10.2681, -6.4630)	(-10.7798, -5.3526)
	b_2 ***	1.1046	(0.8857, 1.2730)	(0.8080, 1.3092)	(0.6880, 1.3701)
	b_3 ***	0.1189	(0.0742, 0.1809)	(0.0676, 0.1957)	(0.0518, 0.2356)
$m = 1$	b_1 ***	-8.0343	(-9.6625, -6.0078)	(-9,9571, -5.5327)	(-10.5110, -4.3143)
	b_2 ***	1.0397	(0.7959, 1.2367)	(0.7262, 1.2803)	(0.5719, 1.3351)
	b_3 ***	0.1172	(0.0708, 0.1800)	(0.0645, 0.2000)	(0.0437, 0.2305)
$m = 2$	b_1 ***	-7.5788	(-9.3134, -4.8873)	(-9.6194, -4.4084)	(-10.3017, -3.1016)
	b_2 ***	0.9979	(0.6744, 1.2040)	(0.6084, 1.2425)	(0.4588, 1.3479)
	b_3 ***	0.1082	(0.0598, 0.1696)	(0.0507, 0.1880)	(0.0338, 0.2206)
$m = 3$	b_1 ***	-6.8694	(-8.8315, -3.6348)	(-9.2147, -3.0339)	(-9.9658, -2.0753)
	b_2 ***	0.9349	(0.5447, 1.1630)	(0.4711, 1.2155)	(0.3455, 1.2949)
	b_3 ***	0.0881	(0.0355, 0.1557)	(0.0270, 0.1707)	(0.0144, 0.1883)

Regarding the model in (2), the null hypothesis $H_0: b_2 = 0$, as mentioned above, is rejected at the usual significance levels (1%, 5% and 10%), which reveals the impact of CEEG on GDP in Iran. However, the confidence intervals for coefficient b_3 lead to different conclusions. The null hypothesis $H_0: b_3 = 0$ is not rejected in all the scenarios, except for lag zero and at the 10% significance level. (Results are not presented here due to space limitations but they are available upon request to the authors.)

4. CONCLUSION

During the last decades, energy intensity has been increasing in Iran, accompanied by higher carbon emissions and economic growth. Burning fossil fuel resources and low energy efficiency cause critical environment damages. It is worth studying the effect of growing energy intensity on GDP and carbon emissions from electricity generation in this country. Based on the obtained results, energy intensity and GDP affect CEEG, in all the scenarios considered. As expected, increasing EI and GDP lead to higher CEEG, which may be due to the natural gas-base electricity generating system.

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Posters

15:30-16:00 @ Meeting ID: 948 1336 4454

E006

Landslide Syusceptibility Assessment Using Expert Weightage

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ABSTRACT

Landslides are a significant problem in the hilly region. The landslide susceptibility maps are very effective and efficient tools for planning and management of infrastructure including energy infrastructure. Aim of this study is to prepare landslide susceptibility map of Almora district, India using expert weightage technique. The different causative factors considered in this study are slope, aspect, curvature, drainage density and distance from rivers. The causative factors are divided into sub factors and the weightage are given according to the expert opinion. The different causative factors and sub-factors are extracted in layer form in GIS environment. The expert weightage are based on the judgment of expert and the historical landslide data. The weighted layers are overlaid in GIS environment and the final output map shows the landslide susceptibility in increasing order. The landslide susceptibility index varies from 7 to 45 in the region. Lower landslide susceptibility index (LSI) shows lower probability of occurrence of landslides and hence higher suitability for development of new infrastructure projects. The results of the study can be used by the project planners and environmental engineers.

Keywords: landslide susceptibility mapping, geographic information system (GIS), expert opinion, remote sensing

1. INTRODUCTION

Landslide susceptibility maps are a very useful tool for planning and management of landslide disaster in hilly region. The landslide susceptibility maps are used by planners and risk managers to plan construction activities and installation of new infrastructure in hilly regions [1]. Almora district in India faces many landslide events throughout the year. So, it is necessary to prepare a landslide susceptibility map for the region for understanding the problem of slope failure. Aim of this study is to prepare a landslide susceptibility map for the study area using expert rating.

The methods of landslides susceptibility mapping can be classified in qualitative and quantitative [2]. The mathematical models for landslide susceptibility mapping establish a relationship among landslide probability and causative factors of landslides [3,4]. The expert based models are based on the subjective judgment of the experts. The weightage of the causative factors and sub-factors are based on the opinion of the expert. So, the decisions can be taken from the practical knowledge and field data. The expert based ranking method is easy to implement in GIS environment.

In this study, landslide susceptibility map of Almora district has been prepared with the help of weightage assigned by experts. The historical data of landslides helped the expert in deciding the weightage of causative factors and sub-factors.

2. MATERIALS AND METHODS

We have used expert rating method for landslide susceptibility mapping. The causative factors are extracted from the digital elevation model (DEM) and Survey of India maps. The digital elevation model (DEM) is obtained from Cartosat 1 data. The DEM is available freely. The weightage to each factor and causative factor is assigned by opinion of expert. The causative factors are overlaid in GIS environment to obtain a landslide susceptibility map which shows the cumulative effect of these factors.

3. RESULTS AND DISCUSSION

A landslide susceptibility map is obtained as final output. The final output map is based on the landslide susceptibility index which is a numerical index combining the impact of different causative factors. Landslide susceptibility index is given by following formula:

$$Landslide\ Susceptibility\ Index\ (LSI)$$
$$= w_1 * Slope + w_2 * Aspect + w_3 * Curvature + w_4 * Relative\ Relief + w_5$$
$$* Drainage\ Density + w_6 * Distance\ from\ Faults$$

Here w represents the weightage of different causative sub-factors. The landslide susceptibility index varies from 7 to 45. The lower values of landslide susceptibility index represents the lower susceptibility of region towards landslides and higher suitability for development of new projects. Figure 1 shows the landslide susceptibility map.
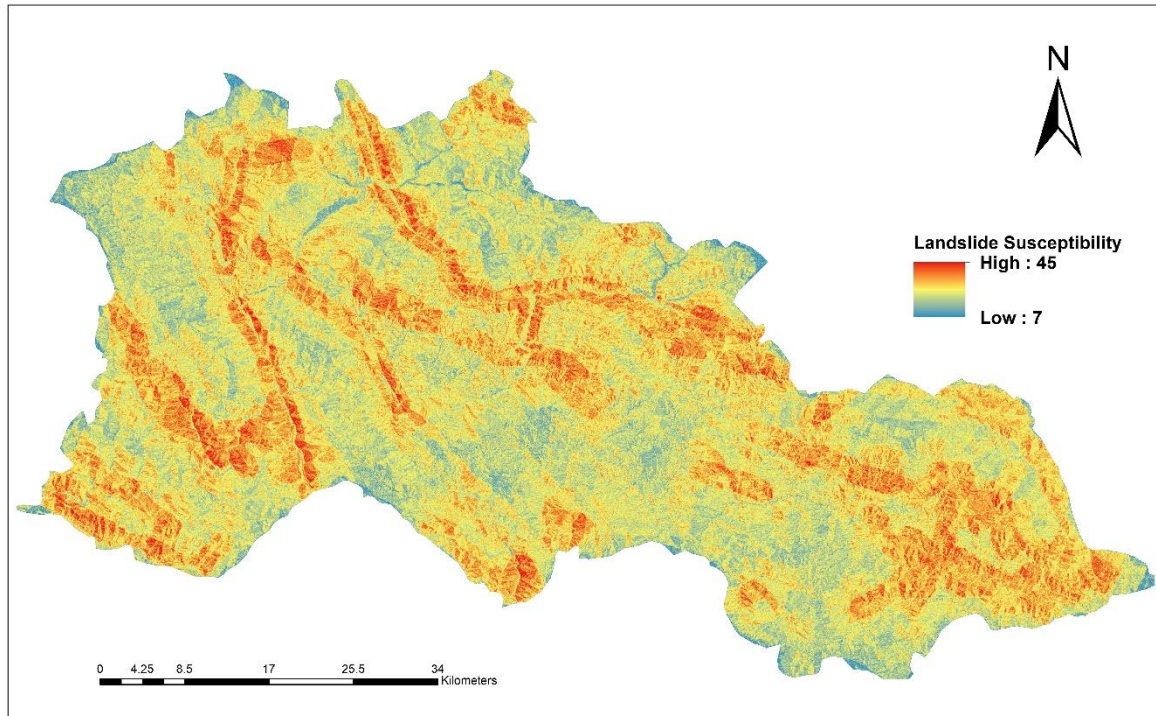
Figure 1. Landslide susceptibility map

4. CONCLUSION

The landslide susceptibility map for Almora district in India is prepared using expert weightage in this study. The expert weights given in this study depends upon the subjective judgment of the expert. However, landslide inventory is helpful in deciding the realistic weightage. The landslide susceptibility map is prepared at regional level and it will be helpful for planning purpose. The output of the study can be improved by considering more causative factors. Further, other qualitative models like analytic hierarchy process (AHP), fuzzy logic and neural networks can be applied for improving the output. The study can be extended to comparative analysis of different qualitative and quantitative models in future.

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E019

Key Factor Mining Method of Distribution Network Equipment Operational Efficiency Based on Apriori and CNN

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ABSTRACT

The paper proposed a mining method based on Apriori algorithm and convolutional neural network for main influencing factors of distribution equipment operation efficiency. Firstly, the possible affecting factors of operation efficiency are analyzed, then a method based on K-means clustering and Apriori algorithm is proposed to mine the main factors affecting the operation efficiency. Thirdly, quantitative measure of the relationship between the operation efficiency and the main influencing factors based on convolutional neural network is developed. Finally, the paper is tested on GEFCom match data. The simulation results show the feasibility and effectiveness of the proposed algorithm.

Keywords: operation efficiency; key factors; apriori algorithm; convolutional neural network

1. INTRODUCTION

Identifying the key factors of operation efficiency for power equipment in distribution network helps to propose improvement measures. Research on operational efficiency is mainly concentrated in other fields [1-3], there are few studies on operational efficiency distribution network equipment. [4] puts forward an equipment efficiency evaluation model based on the annual load duration curve, considering the security and economic requirements of the equipment. [5] proposes a new exploitation capacity index to measure the efficiency of a distribution network.

The quantitative relationship between operating efficiency and key factor is helpful to forecast future operational efficiency and guide subsequent planning and construction. The traditional fishbone diagram can clearly list all the influencing factors of operation efficiency, but it cannot find out the main factors. Pearson correlation coefficient can be used to mini the factors highly correlated with operation efficiency. The coefficient simply compares correlation strength due to nonlinear distribution. It is failure to provide objective evaluation criteria for key factors.

2. MATERIALS AND METHODS

In the paper, a mining method based on Apriori and CNN is proposed to identify key factor and quantitatively measurement the relationship between operation efficiency and key factors. The remainder of this paper is organized as follows: In Section 2, mining method of key influencing factors of operation efficiency will be provided. Section 3 describes the process to quantitatively measurement the relationship between operation efficiency and key factors. The proposed method is examined and discussed through the utilization of test system in Section 4.　Finally, conclusions are drawn based on the experimental results.

3. RESULTS AND DISCUSSION

The error of the operating efficiency prediction value considering all influencing factors is 1.03%; while the prediction error considering only the main influencing factors is 0.84%. Both have high prediction accuracy and can predict the operational efficiency value very well. The difference shows main influencing factor plays a decisive role in the prediction model, while the other influencing factors have little relationship with the operating efficiency and even play a disturbing role in the CNN prediction.

The training time of CNN only considering the main influence factors is 687.6s, while prediction time of inputting all influencing factors is 881.54s, the CNN model considering only the main influencing factors saves nearly 22% of the time. The prediction error was calculated to be 1.76% when using the BP neural network for operational efficiency. the prediction error of the CNN neural network was about 1/2 of that of the BP network.

4. CONCLUSION

This paper finds out the key influencing factors of operational efficiency and the quantitative relationship between the key influencing factors and distribution equipment based Apriori and CNN. The advantages of this method are as follows:

(1) The process of finding the main influencing factors is logical and clear, and the finding method reduces many artificial subjective guesses and is more objective.

(2) The quantitative relationship analysis is conducted after the key influencing factors are found, which maintains the calculation and prediction accuracy while speeding up the calculation speed.

(3) CNN method is used to find the quantitative relationship between operational efficiency and the main influencing factors, compared with the traditional multivariate statistical analysis without giving a specific function for it to fit, the accuracy is higher, the scope of application is wider and more practical.

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E028

Studies on the Performance of Distributed Combined Cooling, Heat and Power System Under Off-design Conditions Based on Exergy Analysis

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ABSTRACT

This paper adopts the exergy analysis method of second law of thermodynamics to analyze the characteristics of off-design conditions of distributed combined cooling, heat and power system. The research results show that cooling capacity declines more slowly than generating capacity. When the gas turbine load drops under 60%, the distributed combined cooling, heat and power system may not save energy. The biggest loss of system exergy occurs in combustor and high-pressure producer.

Keywords: Combined cooling, heat and power system; Characteristics of off-design conditions; Distributed; Exergy analysis

1. INTRODUCTION

Distributed energy is a kind of energy supply method set up on the user side, and an energy system characterized by the comprehensive and gradient use of energy and combined cooling, heat and power supply. It has received wide attention worldwide for its excellent energy-saving, reliable, economical and environment-friendly nature [1-4]. This research is a simulation study of distributed cooling, heat and power system in all conditions. It proposes the simulation method of gas turbine distributed system in all conditions, establishes and verifies the off-design condition model of main unit equipment such as small gas turbine, exhaust gas dual-effect lithium bromide absorption refrigerating machine, and exhaust gas hot water heat exchanger.

2. THE ANALYSIS OF CHARACTERISTICS OF COOLING, HEAT AND POWER SYSTEM UNDER OFF-DESIGN CONDITIONS

The performance of energy levels of gas turbine under off-design conditions. Fig. 1 shows the exergy loss distribution of gas turbine under off-design conditions. Fig. 2 shows the pattern behind the load rate changes of energy releasing side and receiving side in the air compression process. Fig. 3 shows the pattern behind the grade difference changes of energy receiving side and releasing side with the changing of load rate in the turbine. Fig. 4 shows the changing characteristics of grade differences in the combustion process. Fig. 5 and Fig. 6 show a comparison between experimental value and simulation value of Capston C30 gas turbine efficiency and exhaust gas temperature.
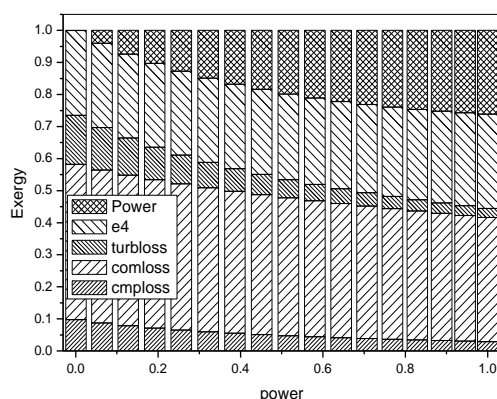
Fig. 1 Exergy loss distribution of gas turbine under off-design conditions
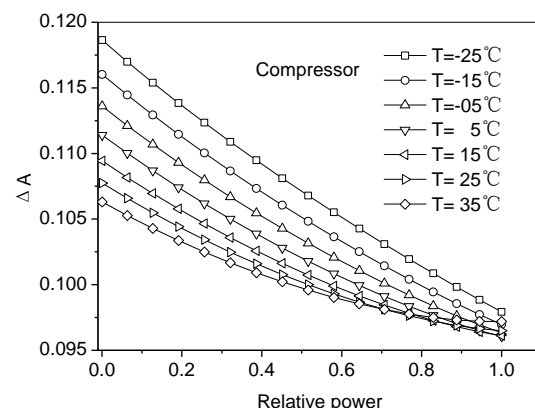
Fig. 2 The changes of energy levels difference of compressor under off-design conditions
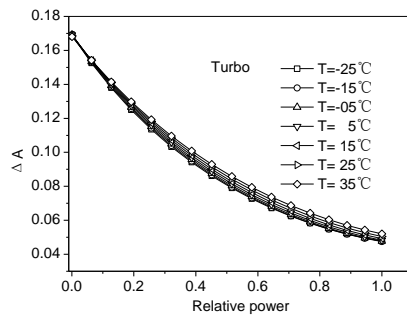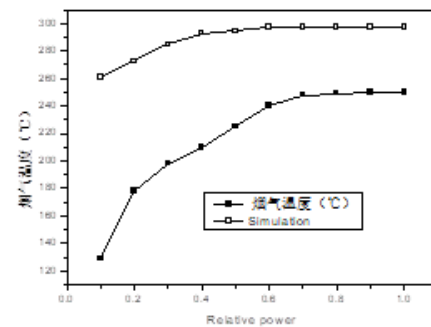
Fig. 3 The changes of energy levels of turbine under off-design conditions.
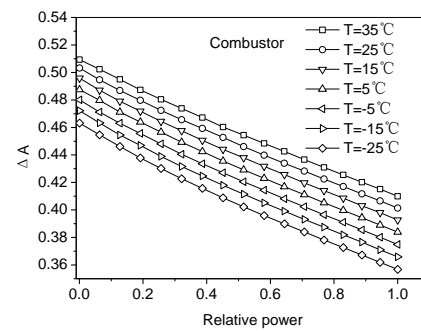
Fig. 4 The changes of energy levels of combustor under off-design conditions.
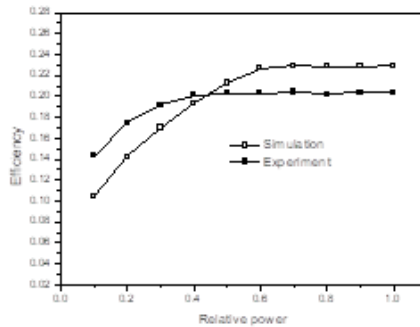
Fig. 5 Comparison between experimental value and simulation value of generating efficiency.

Fig. 6 Comparison between experiment value and simulation value of exhaust gas temperature.

3. CONCLUSION

Based on the analysis and research on the performance of gas turbine and absorption refrigeration unit under off-design conditions, this paper studies the off-design conditions of distributed power supply system. Under off-design conditions, the generating capacity and refrigerating capacity of the system reduce as the load decreases, but the decrease of refrigerating capacity is slower than that of generating capacity. When the system only has cooling and power supply, without generation or use of hot water, and the gas turbine operates under full load, the system has a relative energy saving rate 16%. When the system generates and uses hot water, it has a relative energy saving rate of 25%. As the gas turbine load decreases, the relative energy saving rate declines faster. When it declines to a certain level, it will no longer be energy-saving. If the low-grade waste heat in the system can be utilized, it will significantly improve the energy saving rate under off-design conditions.

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E036

Governance Quality and Environmental Policy on Emergent Resource-Rich Economies: the Case of Brazil

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ABSTRACT

In this paper we analyze the role of governance quality on environmental policy in Brazil regarding natural resources exploration, particularly oil. Governance quality is reflected in five indicators following the approach of the World Bank: political stability, regulatory quality, government effectiveness, rule of law, and control of corruption. We highlight the main governance challenges faced by this country which can hinder environmental policy, particularly when they can influence oil exploration. The first problem detected is the political interference on environmental management. As governments change, so do environmental priorities, which raises immense costs. The second problem is that, despite the good environmental regulation, its effective implementation is hard. This happens due to low government effectiveness levels. Finally, the lack of political independence of environmental agencies increases the risk of corruption. Hence, it appears necessary for Brazil to carry out a self-assessment of its environmental policy and trace independent paths for technical and political resources management.

Keywords: Governance quality; Environmental Policy; Natural Resources; Oil

1. INTRODUCTION

Resource abundant countries often utilize resources inefficiently which has been referred in the literature as the "natural resources curse" [1]. Simultaneously, and partly due to poor resource management, developing countries frequently struggle with enforcement of environmental quality. In reality, these countries frequently face political and institutional instability which has a dramatic impact on governance institutions. The relationship between governance indicators and environmental quality is being increasingly studied in recent years [2]. One prominent branch of this literature concerns proper fossil fuels management given the negative environmental impact of the exploration of these resources [3]. This problem is particularly relevant in developing, resource-rich countries such as Brazil, where there is evidence that institutions play a significant role. In these countries, governance quality can impact environmental policies particularly through natural resources management.

Some authors have studied the impact of governance quality on environmental quality. For example, Gani [4] studied the effect of several governance variables on CO_2 emissions for a vast set of developing countries, including Brazil, and found that maintaining a stable political environment, strengthening the rule of law and fighting corruption were particularly important aspects. Dasgupta and Cien [5] reviewed the literature on this topic showing, for example, that democratic countries tend to have a better environmental performance and that corruption can lead to environmental degradation. Mavragani et el. [6] showed, for a panel of 73 countries including Brazil, that each of these indicators had a positive impact on environmental quality.

We contribute to the literature by analyzing the role of governance quality on the environmental policy, particularly concerning natural resources exploration in Brazil. We focus on the particular case of oil exploration, given its high importance for the country. To our knowledge, the analysis focusing on natural resources management has never been done.

The structure of this article is as follows: after this introduction, in section 2, we cover the main indicators of governance quality with special focus on Brazil, and in section 3 we draw some conclusions and policy implications.

2. MATERIALS AND METHODS

We use the approach of the World Bank described in Kaufman et al. [7] focusing on the following governance indicators: political stability, government effectiveness, regulatory quality, rule of law, and control of corruption. These indicators are not only and directly related to environmental policy and resource management. However, given their macroeconomic importance, they will inevitably influence all major political paths in the country, including the ones related to the environment. The analysis of governance quality indicators highlights the main problems, challenges, but also opportunities faced by Brazil regarding environmental policy and oil exploration. We also analyze the evolution of oil production and CO_2 emissions in the considered period to infer if there is a connection between the several indicators.

3. RESULTS AND DISCUSSION

Our analysis shows common behaviors for the governance quality indicators under analysis, namely worsening in the periods from 2004 to 2008, improving afterwards and having extremely lower values in 2018 or 2019. Political stability is the indicator with the strongest oscillations, which could be reflected in changes regarding environmental and resources policies. Government effectiveness also presents oscillations indicating the difficulty to properly implement the existing environmental legislations. Regulatory quality, despite decreasing, is relatively good in Brazil, indicating that good laws exist but are not always implemented due to economical and political reasons. It is interesting to notice that since 2014, this indicator achieved its lower values, falling below the world median. This can be related to the political scandals that occurred in Brazil. Contrarily to the other indicators, the Rule of Law overall increased in the period under analysis. This happened due to the construction of a stronger judiciary system over the last decades. Finally, Control of corruption strongly decreased after 2012. This factor could risk the proper resource management since big lobbies may gain too much power and risk resource and environmental sustainability with their reckless practices.

4. CONCLUSION

Our analysis shows no evidence of a strong connection between the behavior of the government quality indicators and oil exploration and CO2 emissions. Still, the qualitative analysis of the challenges in for environmental and resource policies indicates several aspects that require improvements. Namely, increased stability in the institutions and regulations of the sector, need for a strong, stable, democratic and autonomous state organizations to apply legislations as well as need for coordination between different levels of government institutions and active participation of civil institutions. It is also key to ensure that the existing good legislations are properly and effectively enforced.

One of the most important challenges is the strategic role played by oil for economic growth in Brazil. To guarantee better environmental performance, the country needs to ensure the independence and political impartiality of environmental agencies. In this way economic interest will not be prioritized over the environment.

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Offshore Wind Resource Mapping in Cambodia: Sensitivity Assessment of the Weather Research and Forecasting Model

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ABSTRACT

The objective of this paper is to assess the model's sensitivity to three parameters: nesting with nudging options, planetary boundary layer (PBL) options, and nudged variable options for the Cambodian territory. Three tests are set up and carried out, and each of the test, intended for each parameter, is comprised of several experiments. The same 15-day simulation is done for all experiments. Then the outputs of the weather research and forecasting (WRF) model are validated with measured wind data from four meteorological stations at 10 m above the ground level. The results show that the WRF is unlikely influenced by the nesting choices but more sensitive to the PBL options for wind speed simulation. In term of wind direction, the model is insensitive to any of the tested parameters. Through statistical and graphical analyses, the best experiments are found to be the two-way nesting with gridded nudging from test 1, MYNN2.5 scheme for PBL from test 2, and nudged wind components from test 3. With these optimal configurations, the model is then applied for simulations of higher vertical-level wind and for mapping the offshore wind resource in Cambodia.

Keywords: Nesting; Nudging; offshore wind; Planetary boundary layer; Weather Research and Forecasting; Renewable energy

1. INTRODUCTION

Cambodia, a country in Southeast Asia, has recently allowed the integration of renewable energy into its national grid to reduce the reliance on fossil fuels and hydro power. Beside high potential in the solar source, Cambodia has not realized its offshore wind power resource yet despite a few studies on the onshore wind potential assessment such as [1,2,3]. Due to unavailability of offshore wind measurement in Cambodian sea, the study on offshore wind potential is viable with numerical weather predictions (NWPs). The well-performed NWP for evaluating wind resource has been claimed to be the WRF [4]. The model has been found to be sensitive to a number of parameters including domain, numerical, and physical configurations. Among them, PBL choice is a site-specific and key parameter for a near-surface wind simulation. The nudging options are also site-specific and have been recommended for further study [5]. Moreover, it is still difficult to locate a study evaluating the effect of all nudged variable combinations. Therefore, in this work, the WRF sensitivity to the three parameter options, specifically PBL, nudging options, and nudged variables, is examined for the location of Cambodia

2. MATERIALS AND METHODS

To investigate the model's sensitivity to the above three parameters, three subsequent tests, namely test 1 (T1) for checking nesting and nudging options, test 2 (T2) for PBL options, and test 3 (T3) for nudged variable options, are carried out. The tests are related because the best results in the prior tests are used in the subsequent ones. Each test is comprised of several experiments. All tests are simulated for the same length of 17 days (from 29 November to 15 December 2019) with the first two days discarded as a spin-up. The simulated outputs of the experiments are validated against the measured wind data from the four automatic weather stations (AWS) including Kampot station (KP), Koh Kong station (KK), Kampong Speu station (KPS), and Takeo station (TK), at 10 m above ground level (AGL). The hourly observed data are collocated with the hourly modelled wind vectors retrieved from the domain 03, the innermost domain with the highest horizontal resolution of 1.66 km, at the nearest grid points to the four AWS locations. The best experiment of each test is selected based mainly on Taylor diagrams from statistical indexes. With these optimal configurations, the model is applied for simulations of higher vertical-level wind for mapping the offshore wind resource in Cambodia.

3. RESULTS AND DISCUSSION

Six experiments were conducted in T1. The results showed that two-way nesting with gridded nudging (2GN) was the best experiment. Additionally, based on the statistical analyses, it was figured out that one-way and two-way nesting did not seem to affect the model performance. Rather, the nudging choices showed much influenced

on the model simulation of wind speed. These findings were also highlighted by [6,7].

In T2, the MYNN2.5 PBL scheme was selected for the best experiment. This optimal scheme still widely overpredicted the observed wind speed at all stations. This may be because of the model's overestimation tendency when simulated at very near surface wind (10 m AGL) as reported in [4]. Furthermore, it may be contributed by the model's inappropriate representation of the actual topography. This cause was also emphasized by [8].

Among seven experiments in T3, the nudged-wind-component experiment (V) marginally led others at KK and TK. It also became the second-best experiment at KP. According to the results, nudging V was chosen for the optimal configuration for nudged variable option.

In term of wind direction, all experiments of the three tests underestimated the in-situ data at all stations. There was seemingly no noticeable difference among the experiments, but, among the stations, KP had the largest MBE and STDE (> 100 degrees). It could mean that neither all tests nor experiments had an influence on the WRF performance. Moreover, the wind direction was affected more by the topographical representation in the model than the physic parameterizations [9].

4. CONCLUSION

In this study, the WRF sensitivity to nesting with nudging options, PBL schemes, and nudged variable options for Cambodia is evaluated. The results show that two-way nesting with gridded nudging, MYNN2.5 PBL scheme, and nudged wind components are the suitable options for the parameters tested in T1, T2, and T3, respectively. Moreover, for wind speed, it is found that the model is likely insensitive to the nesting choices though they are tested along with the nudging options. PBL schemes seem to significantly affect the WRF behavior. However, for wind direction, it is not influenced by the choices of the tested parameters but rather sensitive to the topography. Despite overestimation of in-situ wind speed at the four sites at 10 m AGL, the results of WRF simulation can be further used to estimate the offshore wind resources for possible offshore wind power generation in Cambodia.

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E053

Spatial Organization of Arctic Mineral Resource Centers

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ABSTRACT

The Arctic zone has a significant raw material base of hydrocarbons; the significance of their development is recorded in the strategic documents for the development of Russia and other Arctic countries. The authors carried out a study to assess the effectiveness of investments in the spatial organization of the mineral resource center. The work systematized data on the state of the mineral resource base of hydrocarbons in the Arctic zone, developed a scheme of spatial organization and assessed the economic efficiency of investments. Calculations have shown that the effectiveness of the spatial organization of the Arctic mineral resource center exists due to the creation of a multi-level transport system. The organization of an Arctic mineral resource center will not be economically viable. However, the feasibility of its organization is associated with a multiplier effect at the national and corporate levels. The authors proved that the need to develop the resource potential of the Arctic territories is due to a special geopolitical status and the elimination of imbalances in spatial development – an increase in the socio-economic level and infrastructural security of the Arctic.

Keywords: Arctic region, mineral resource centers, transport system, spatial organization, oil export, Northern Sea Route.

1. INTRODUCTION

Currently, the development of the Arctic is of key geopolitical, economic, social importance for the Arctic countries. The region contains the main reserves and production of gas, nickel and cobalt, apatite concentrate, as well as significant reserves of oil and a number of other minerals [1]. Comprehensive development of the mineral resource base on the principles of rational environmental management, including the stages of exploration, production, processing, transport infrastructure, is a driver of economic development in the Arctic regions [2-4]. There is a need to develop an integrated approach to the spatial development of the Arctic zone, to carry out a fundamental study of rational subsoil use in the resource regions of the Arctic, taking into account the possible socio-economic effects of development and the practice of combining national and corporate interests [3; 4].

2. MATERIALS AND METHODS

The work uses a set of methods, including systemic and economic analyzes, economic and mathematical forecasting, investment project assessment, as well as relevant research used to assess natural resources.

For the further effective use of the resources of the Arctic MRC, the author developed a methodology for a comprehensive assessment of the effects of spatial development of the Arctic region, consisting of three main blocks:

I block. Algorithm for forecasting hydrocarbon production at the fields of the Arctic MRC to determine the long-term possibilities of hydrocarbon production.

II block. Assessment of the investment efficiency of the spatial organization of the Arctic MRC, including a multi-level communications system, production and processing infrastructure.

III block. Substantiation of the multiplier effect of the spatial organization of the Arctic MRC at the national, regional and corporate levels [4; 5].

3. RESULTS AND DISCUSSION

The spatial organization of the Arctic mineral resource center in accordance with the developed conceptual scheme is achieved through the creation of a multi-level communications system, the basis of which is investment in the construction of port, processing and transport infrastructures.

Indicators were obtained that characterize the inefficiency of the Arctic mineral resource center, including the development of the resource base and the implementation of communications necessary for the stable functioning of all production and transport processes [3; 6]. However, the organization of the Arctic mineral resource center is economically beneficial for the state. So, the accumulated value of taxes paid to the budgets of all levels for the period under review 2021-2050. is 696.4 billion dollars.

The spatial organization of the Arctic mineral resource center in a strategic perspective is based on the

coordination and interaction of national and corporate priorities for the development of the regions of the Arctic zone - this approach allows to ensure a multiplier effect on the development of related industries and regions [7].

4. CONCLUSION

The spatial organization of the implementation of the Arctic mineral resource center is of strategic importance for Russia from the point of view of the development of the Arctic zone, the construction of engineering and social infrastructure, as well as the loading of the Northern Sea Route.

Despite the high level of required investments, the Arctic mineral resource center generates a large volume of revenues from the sale of oil and gas, which practically pays off capital investments. Undoubtedly, the economic efficiency from the implementation of such a large-scale project depends on many factors, including the exchange rate of the national currency and the sale price of hydrocarbons on the international market. Therefore, with a change in the price environment in the world market, the Arctic mineral resource center may develop and have a risk of loss.

At the same time, it should be noted that the organization of the Arctic mineral resource center provides not only economic benefits to the subsoil user and the state, this project is national and important in the development of the region, increasing its socio-economic significance and spatial organization.

FUNDING

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E059

Towards Sustainable Water and Food Security in Qatar Under Climate Change and Anthropogenic Stresses

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ABSTRACT

Qatar is a hyper-arid peninsula with minimal water resources. Over the last two decades, the country's population has risen fivefold, the built environment has doubled, and water consumption has reached an unprecedented rate. The Qatar National Food Security Program (NFSP, 2018–2023) aimed to ensure national food security, which lead to rapid expansion in agriculture (depends entirely on groundwater). These factors together amplified the pressure on the already deteriorated aquifers. The presented study revisits the Qatar NFSP in light of climate change and human needs challenges. Our analysis showed that current legislations had overlooked climate change and anthropogenic impacts, making the country experience growing groundwater depletion. The study recommended considering managed aquifer recharge and treated sewage effluent to face the climate change impact and clearing the uncertainty in anthropogenic projections.

Keywords: climate change; food security; population growth; Qatar; urbanization; water sustainability

1. INTRODUCTION

Qatar has minimal freshwater resources. Several anthropogenic factors have recently increased the pressure on Qatar aquifers. The groundwater abstraction has risen from 160 Million Cubic Meters (Mm^3) per year in 1993 to 250 Mm^3 in 2010, whereas the annual safe groundwater yield did not exceed 60 Mm^3 [1]. Besides, the built environment in metropolitan Doha grew 60 times in only half of the century, expanding by 213% between 1987 and 2013 [2]. Current activities tell extra urban development before 2030. The combined effects of these factors (climate change and anthropogenic activities) pressurized the country's aquifers.

Qatar aquifers had severe water shortages and high deteriorations in quality. Schlumberger Water Services [1] has reported a decline in the water table of greater than 10 m in several areas. The seawater intrusion advanced several kilometers inland in some regions, and the groundwater became saline in general—several wells are abandoned every year due to their high salinity. As stated by [3], the salinity in Qatar's aquifers increases significantly with time. Accordingly, the current research highlights the main aspects of protecting and sustainably managing Qatar's aquifers under the projected changes in climate and human needs. The study also suggests several mitigation and management schemes to manage and replenish the aquifer.

Agriculture in Qatar is entirely dependent on groundwater [3]. As a result of the National Food Security Program (QNFSP, 2018–2023), agriculture activities expanded rapidly in Qatar [4]. Although the impact on water resources has yet to be documented, these expansions appear to amplify the pressure on aquifers.

2. RESULTS AND DISCUSSION

Climate and anthropogenic changes are expected to have a complicated and dynamic influence on water resources, which should be considered when planning for Qatar's water and food nexus. Below are two pillars of this influence:

(1) previous records of temperature and rainfall during 1984-2014 at Doha International Airport station are shown in Fig. 1. Temperature is increasing while rainfall is decreasing. The trend of precipitation is complicated and cannot be generalized across Qatar. While rainfall is decreasing at Doha International Airport station, this might not represent the whole country. Results showed a severe spatial variation in the average annual and monthly rainfall, an increase in winter precipitation, a decrease in spring precipitation, and non-meaningful trends in most other indices. Another study observed a disruption in the Arabian Peninsula seasons characteristics, especially during the last three decades [5]. Climatic parameters—especially rainfall had, therefore, a complex impact on Qatar water resources.
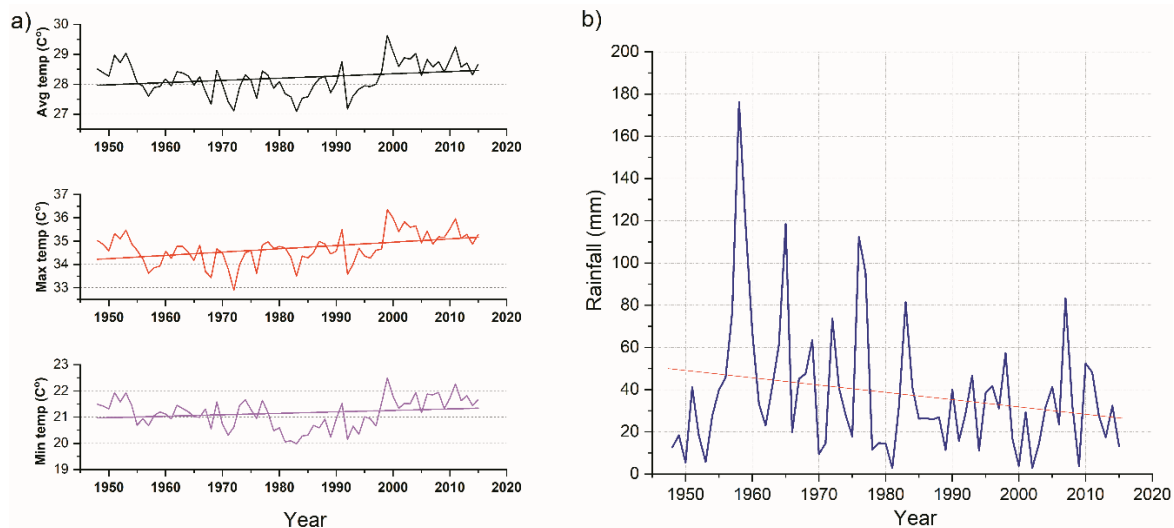
Fig. 1 (a) The minimum, maximum, and average monthly temperature and the (b) annual precipitation at Doha International Airport station during 1984-2014.

(2) Qatar experiences dynamic anthropogenic changes recently. These changes include rapid growth in population, water consumption, and industrial development. The rapid population growth can increase Qatar's food demand significantly, increasing irrigation needs. The land use and land cover changes can accelerate the already high climate warming. Even though the temperature trend in Doha is in line with the regional heat-up of recent decades, the recent human impact, represented by the high increase in Doha's population and urbanization after 1990, has intensified the rapid pattern in warming [6].

3. CONCLUSION

There is a dire necessity for involving an integrated sustainable water resource management in Qatar. This management should understand aquifers' response to anthropogenic and climatic changes: a topic that did not receive adequate attention in Qatar during the last five decades. The challenge is to stop the enduring depletion and to manage and augment aquifer storage while at the same time meeting QNFSP demands. Previous strategies did not address the latter challenge adequately. The Qatar National Vision 2030 was published in July 2008. Decision-makers may look for managed aquifer recharge and wastewater reuse to resolve the problem [7]. The climate change impact also increases evapotranspiration losses and increases irrigation wants [7,8]. Without a comprehensive approach to managing and augmenting the aquifers, one cannot guarantee the success of such strategies. Managed aquifer recharge and utilizing the treated sewage effluent might be feasible solutions to augment and sustainably manage Qatar aquifers.

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E062

Analysis of the Influence of Solar Cycles on the Meteorological Variables of the Central Inter-Andean Valley of Peru Period 1986-2019

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ABSTRACT
Solar activity transmitted in energy reaches the Earth, affecting atmospheric temperature and other global weather variables. This research aims to analyze the relationship between solar cycles and meteorological variables in the Central Inter-Andean Valley during the period 1986-2019. Sunspot data were obtained from the Royal Observatory of Belgium for solar cycles 22, 23 and 24, and the meteorological variables of the National Service of Meteorology and Hydrology of Peru from five stations that are distributed in the Valley. For the correlation of the variables, the nonparametric Spearman statistical test with a third degree polynomial regression was applied. The results show that there is a decrease in the number of sunspots in cycle 24, and that the temperature varies by 3.85°C in the study period. Of the five stations analyzed, four of them show that there is no relation between the variables and only in the station Viques there is an inverse relation for α0.05 referring to the variables of maximum temperature and sunspots, obtaining a coefficient of determination of $R^2=0,619$. Therefore, solar activity does not influence the climate variability of the study valley, and this is due to climate change due to the effects of anthropogenic activities.

Keywords: solar activity; solar cycles; solar energy; precipitation; temperature

1. INTRODUCTION

The main source of energy for our planet is the Sun, due to its energetic emission and its magnetic field that vary over time. Studies have shown that the number of sunspots correlates with solar radiation at the global level, which depend on the solar activity that is affected by solar cycles [1]. Sunspots are concentrations of magnetic fields that occur on the solar surface and are characterized by a dark zone in the central part and a less dark one in the outer part [2]. Astronomer Henrich Schwabe discovered in 1843 that the duration of solar cycles is 11 years thanks to the sunspot records observed up to that time. From the middle of the 17th century to the beginning of the 18th century there were no sunspots and at the same time there was a drop in temperature that lasted the same time, since then there is a suspicion that the solar cycle has influence on the Earth's climate [3]. Besides the fact that 99% of the energy of our planet comes from the Sun, it is a very logical idea to say that a very small variation in solar cycles and in the energy emitted by the Sun has a great influence on the climate of the earth [4]. Many scientists argue about the causes of climate change, including anthropogenic activity. Similar research on solar activity and climate change in different geographical areas has been carried out so far, but not in Peru, which is quite limited to know the impact of solar activity on climate variables since Peru is one of the most affected by climate changes [5].

2. MATERIALS AND METHODS

The study area is the Mantaro Valley, an inter-Andean valley that is located in the Junín region, in the Andes Mountain Range, in the central highlands of Peru and has a geographical space between the provinces of Jauja, Concepción, Chupaca and Huancayo with an average altitude of 3300 meters above sea level. For the meteorological variables, daily data were obtained from five stations, which are distributed in the Mantaro Valley: Jauja, Ingenio, Huayao, Santa Ana and Viques. The data were acquired from the Historical Data platform of the National Service of Meteorology and Hydrology of Peru (SENAMHI), for a period of 33 years. In the case of solar cycles, 12 416 daily sunspot data were obtained from the Sunspot Index and Long-term Solar Observations (SILSO), data belonging to the Royal Observatory of Belgium-Brussels, for which annual data from 3 solar cycles were analyzed: 22 (1986-1997), 23 (1998-2008) and 24 (2009-2019). For the processing of meteorological variables and sunspots, interferential statistics were applied with a third degree polynomial regression, obtaining the coefficient of determination (R^2). To analyze the correlation of the variables, the nonparametric Spearman statistical test was applied, since they do not have a normal distribution, at a confidence level of α= 0.05.

3. RESULTS AND DISCUSSION

In the analyzed solar cycles it is observed that there is a decrease in the amount of sunspots, in which the solar cycle 22 is the one that has a greater amount of sunspots and the solar cycle 24 the one that presents less. Graphs

showed that the minimum temperature variation ranges from 1°C to 3°C and the maximum temperature variation ranges from 1°C to 4°C throughout the period.

In the correlation analysis of the variables of precipitation, minimum temperature and solar cycles, they indicate that there is no significant relationship in the five stations because they have a significance $\alpha > 0.05$. With respect to the maximum annual temperature in the 4 stations, they show that there is no significant correlation, except in the Viques station that a significant indirect correlation was found p-value=0.013, with a coefficient of determination of r=-0,787; R^2= 0,619.

According to Useros [6] solar radiation is the determinant of Earth's temperature, but global warming of the atmosphere and melting of ice sheets is likely not to be due to natural factors, but to anthropogenic forcing; this idea is reinforced by the results of this research where it is determined that the relationship between solar activity and temperature is inverse, suggesting that man could be one of the main causes of the increase in Earth's maximum and minimum temperatures. The climate vulnerability of Peru is manifested through the retreat of glaciers, there is a loss of 51% of the surface of glaciers, including the snowy mountains of the Central Inter-American Valley, with climate change being the main cause [7]. To reduce the effects of climate change, the energy system must be decarbonized. Renewable energy sources should account for the majority of the technologies supplied [8].

4. CONCLUSION

The last three solar cycles dependent on the number of spots occurring in them have no significant influence on the meteorological variables of temperature and precipitation in the Central Inter-Andean Valley of Peru, since the coefficients of determination are low and thevalues obtained are higher than the confidence level. However, it was found that the number of sunspots indirectly influences the maximum temperature only at the Viques station, because a high coefficient of determination R^2= 0.619, r=-0.787 and a p-value of 0.013 lower than the confidence level was obtained. The results at Viques Station vary due to the fact that in the last 20 years the highest temperatures have been recorded throughout the Valley. Climatic variations may be due to climate change as a result of anthropogenic activities.

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E073

Optimization of Low Temperature Geothermal Organic Rankine Power Generation System

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ABSTRACT

In this paper, for low temperature geothermal organic Rankine (ORC) power generation system, R245fa is used as the circulating working fluid, and the calculation program is compiled by using the engineering calculation software EES. The thermodynamic parameters and thermodynamic performance of the main state points of the cycle are calculated theoretically. The effects of narrow point temperature difference, evaporation temperature, geothermal water stabilityand condenser end temperature difference on the system performance are analyzed. The results show that the narrow point temperature difference has a significant effect on the performance of ORC cycle. For low temperature geothermal conditions, considering the system performance and economic cost, the ORC cycle system has the best narrow point temperature difference, which is in the range of 5-7k; The temperature difference at the end of the condenser is the same as that at the narrow point, and there is an optimum value in the range of 5-7k.

Keywords: Low temperature geothermal energy;System optimization;Organic Rankine

1. INTRODUCTION

Nowadays, energy depletion and environmental pollution are two important factors restricting the development of human society, so the development of clean renewable energy has become an urgent need for sustainable development. As one of the alternative energy sources, geothermal energy has been paid more and more attention. Geothermal power generation is an important way of geothermal utilization[1-5].

2. ANALYSIS OF ORC GEOTHERMAL POWER GENERATION SYSTEM

The thermal cycle of ORC geothermal power generation system is shown in Fig. 1 and Fig. 2. The whole cycle system is mainly composed of evaporator, screw machine, condenser, working fluid pump, hot fluid pump, cooling water pump and some pipes.
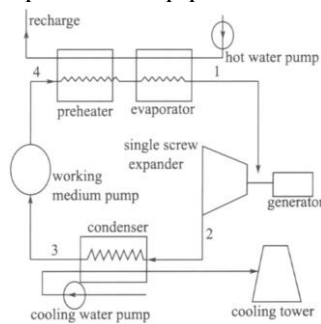
Fig.1 System schematic diagram
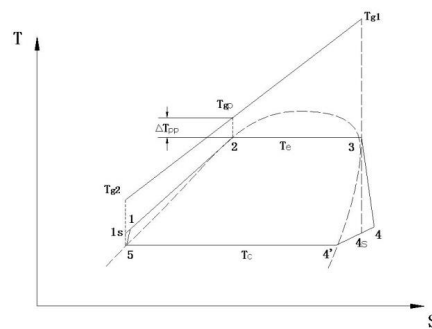
Fig.2 T-Sdiagram for ORC

3. RESULTS AND DISCUSSION
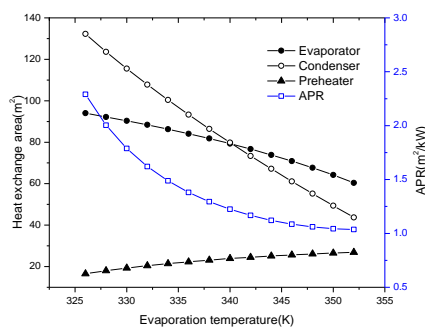
Fig. 9 variation curve of heat transfer performance of preheater and evaporator with evaporation temperature
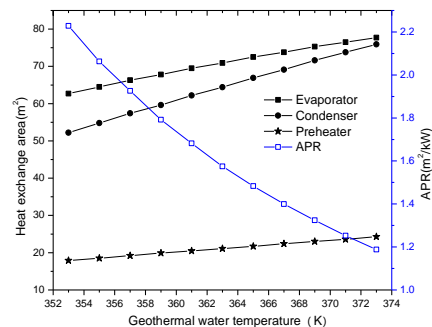
Fig. 14 variation curve of PPH and thermal efficiency with temperature difference at condenser end
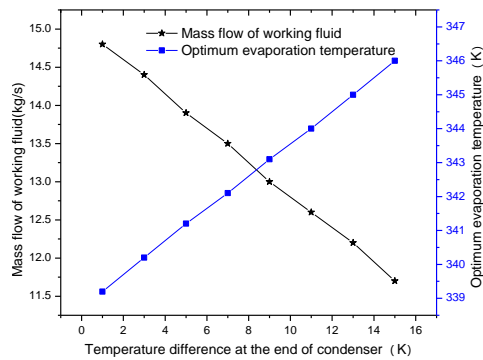
Figure 17 variation curve of working fluid flow rate and optimum evaporation temperature with temperature difference at condenser end
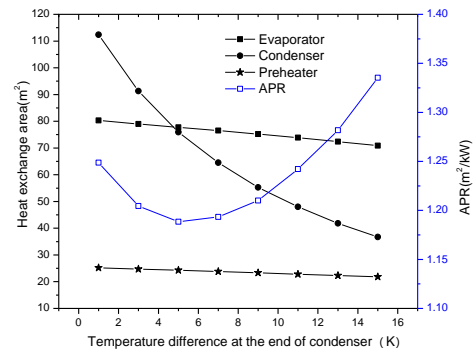
Figure 18 variation curve of heat exchange area and APR with temperature difference at condenser end

4. CONCLUSION

(1) The narrow point temperature difference has a significant effect on the performance of ORC cycle. For low temperature geothermal conditions, considering the system performance and economic cost, the ORC cycle system has the best narrow point temperature difference in the range of 5-7k;

(2) From the analysis of different organic working fluids, it can be concluded that the optimal evaporation temperature not only depends on the geothermal water temperature and condensation temperature, but also closely related to the thermophysical properties of organic working fluids;

(3) ORC cycle performance depends on the difference between geothermal water temperature and cooling water temperature. The larger the difference is, the higher the system performance is. The temperature difference at the end of condenser is the same as that at the narrow point, and there is an optimal value in the range of 5-7k;The Conclusion section should be 250 words maximum. It must contain the main findings.

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E083

Performance Analysis And Working Fluid Selection of Organic Rankine Steam Compression Air Conditioning Driven By Ship Waste Heat

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ABSTRACT

In order to effectively utilize the waste heat of ship flue gas and cooling water, the organic Rankine vapor compression refrigeration system is used for ship air conditioning. The thermodynamic model of the system is established. The system performance of six common working fluids R123, R134a, R245fa, R600, R600a and R290 is analyzed and compared, and the working fluids are optimized for the best system performance. The results show that R600a is the most suitable working fluid for both organic Rankine cycle and vapor compression refrigeration cycle, and for the whole system. The heat source temperature and condensation temperature have an important influence on the system performance. By changing the hot water flow, the hot water temperature can be controlled and adjusted to optimize the system performance. At the same time, the system performance, cooling water pump power consumption, heat exchanger area and system investment should be taken into consideration to determine the condensation temperature, so as to achieve the best overall performance of the system.

Keywords: Ship waste heat; air conditioner; Organic Rankine-vapor compression; Working fluid selection

1. INTRODUCTION

Most modern large ships are equipped with refrigeration and air conditioning equipment, but these equipment consume fuel or electric energy. For most small and medium-sized ships, there is no refrigeration and air-conditioning equipment due to low engine power [1,2]. At the same time, 30% ~ 45% of the heat generated by the combustion of the diesel engine is taken away by the exhaust gas, and the exhaust gas temperature is generally about 400°C or higher. In addition, the temperature of engine cooling water is generally between 60-100°C, and the heat dissipation of cooling water is about 30% of the heat generated by engine combustion. If this part of heat can be recycled for air conditioning of ships, it is of great significance [3,4].

2. SYSTEM DESIGN SYSTEM DESIGN AND WORKING FLUID SELECTION

Table 1 parameter values

Workingfluid	T_{crit}(°C)	ODP	GWP
R290	96.68	0	3
R600	151.98	0	20
R600a	134.67	0	20
R123	183.68	0.012	76
R245fa	154.05	0	820
R134a	101.1	0	1320
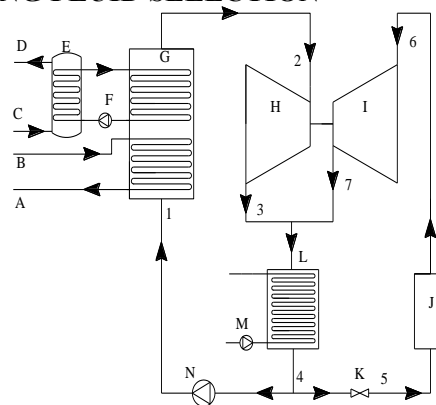
Figure 1 System schematic diagram

A- engine cooling water outlet, B-engine cooling water inlet, C-engine exhaust gases outlet, D-exhaust port, E-heat recovery boiler, F-hot water pump, G-generator, H-expander, I-compressor, J-evaporator, K-throttle valve, L-condenser, M- cooling water pump, N-working fluid pump

3. THERMODYNAMIC MODEL

In order to establish the thermokinetic mo
del, the following two assumptions are made
(1) The friction resistance and heat loss in the system are ignored;
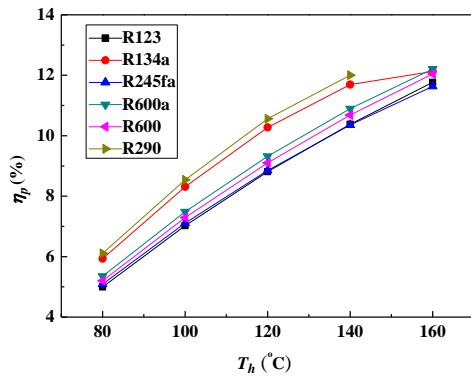(2) Ignore the power consumption of the condenser in the system.

4. RESULT ANALYSIS

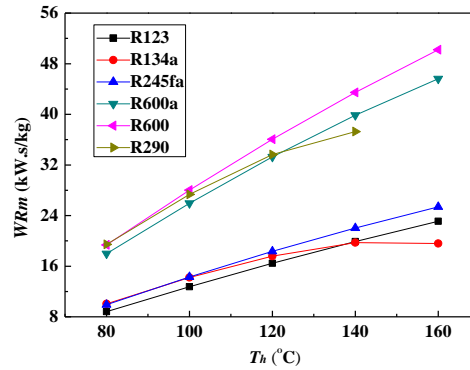Figure 2 Effect of heat source temperatureon ORC efficiency
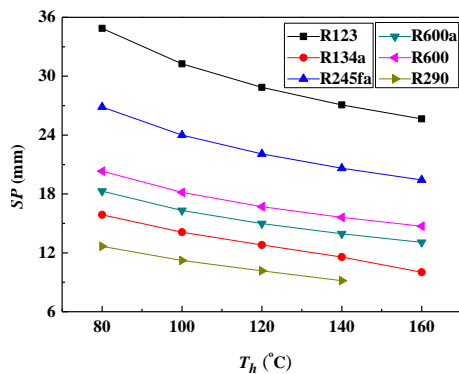

Figure 3 Effect of heat source temperatureon *WRm*

Figure 4 Effect of heat source temperatureon *SP*

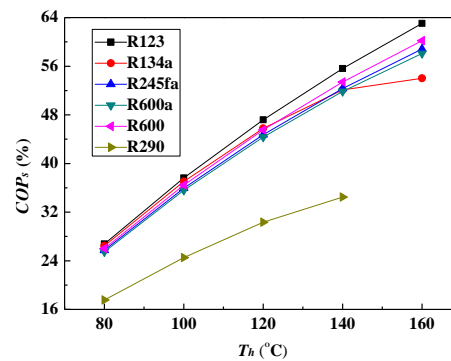

Figure 5 Effect of heat source temperatureon *COP$_S$*

5. CONCLUSION

(1) For organic Rankine cycle, R290 and R134a are suitable working fluids, but their system pressure is high, which leads to large investment. Considering the Rankine cycle efficiency, system pressure and work capacity of working fluid per unit flow rate, R600 and R600a are the most suitable working fluids;

(2) By comparing the COPc、 PRandCRPR of the five working fluids, R600a is the most suitable working fluid for vapor compression refrigeration cycle;

(3) Compared withηp, WRm, SP, COPc, PR, CRPR, COPS, CPRmA and N, R600a is the most suitable refrigerant for organic Rankine vapor compression refrigeration cycle;

(4) The heat source temperature and condensation temperature have an important influence on the system performance. By changing the hot water flow, the hot water temperature can be controlled and adjusted.

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E092

Activated Carbon Produced from Tanning Industry Residues Used to Remove Carbamazepine from Wastewater

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ABSTRACT

According to UNESCO, emerging pollutants are posing a threat to ecosystems and human health. These compounds can be either synthetic or natural chemicals or microorganisms, that are not usually regulated, and can be found in hospital wastewater, even after conventional treatment processes. Carbamazepine is a mood stabilizing drug and an anticonvulsant. Due to its persistence, carbamazepine is one of the most frequently detected pharmaceuticals in wastewater. Though there are many methods to remove such pollutants, adsorption is one of the most effective treatments. To remove carbamazepine from solution, an activated carbon prepared from leather residues and a commercial activated carbon were used as adsorbents.

The adsorption tests show that the leather residue derived activated carbons have higher specific surface area (> 1500 m^2/g) and higher adsorption capacity (q > 300 mg_{CBZ}/g) for carbamazepine when compared to commercial activated carbon (992 m^2/g and q < 180 mg_{CBZ}/g, respectively).

Keywords: Activated Carbon; Adsorption; Carbamazepine; Leather Residues

1. INTRODUCTION

As our world continues to develop, human activities lead to an increase in pollution on one of our most valuable resources, water. The elimination of water pollutants has been one of humanity's greatest concern. Compounds such as beta-blockers, antidepressants, anti-inflammatory and antiepileptics have been detected in hospital wastewater, even after conventional treatment processes [1].

Since pharmaceuticals were created to trigger a physiological response, their presence in an aquatic environment may pose risks to human and animal life [2]. Carbamazepine (CBZ; $C_{15}H_{12}N_2O$) is a mood stabilizing drug and an anticonvulsant. This pharmaceutical is mainly used in the treatment of epilepsy, trigeminal neuralgia, and bipolar affective disorder [3]. Activated carbon (AC) has been widely used in water purification, as it can remove dyes, heavy metals, and some pharmaceuticals. Although being an easy-to-use method, adsorption presents cost as a drawback [4]. Therefore, there is a necessity to produce cheaper adsorbents. Using waste materials as activated carbon precursors reduces the disposed waste quantity and pollution, giving added value to the waste material.

2. MATERIALS AND METHODS

Residues from leather tannery (wet white and finished leather shavings) were used as precursors and chemically activated at 900 °C with a 1:1 mass ratio (potassium hydroxide : carbonized precursor). The textural characterization of carbon materials was based on N_2 adsorption isotherms at 77 K using a Quantachrome Instruments Nova 2200e.

The carbamazepine solution used was prepared by dissolving carbamazepine (Alfa Aesar, powder, purity >98%) with methanol to obtain a concentration of 1000 mg/L. Then, this solution was diluted with demineralized water to prepare the required concentration for the adsorption tests.

Carbamazepine concentration was quantified by UV-Vis spectrophotometry using a Shimadzu UV-2101 PC spectrophotometer, at a wavelength of 285 nm. The evaluation of the adsorption capacity of wet white activated carbon (WWAC), finished leather activated carbon (FLAC) and commercial activated carbon Norit ROW 0.8 (ROW_0.8) was conducted by contacting different masses of the adsorbents (between 0.02 and 0.18 g) with a carbamazepine solution of known concentration, during 48 hours at 25 °C and 150 rpm. Three pH levels were tested, acidic (pH=3, addition of HCl solution), alkaline (pH=11, addition of NaOH solution) and neutral (pH=6/7).

3. RESULTS AND DISCUSSION

In this work activated carbons prepared from leather tannery residues were used for CBZ adsorption and compared to a commercial activated carbon. FLAC and WWAC were prepared by KOH activation and have a specific surface area of 1516 and 1584 m^2/g, respectively whereas ROW_0.8 had a specific surface area of 992 m^2/g.

To determine the effect of pH in the CBZ adsorption, WWAC and ROW_0.8 were used as adsorbents. From the

obtained results it was observed that solution pH did not significantly affect the AC capacities, thus FLAC was only tested at basic pH. Figure 1 shows the experimental adsorption isotherms on WWAC, FLAC and ROW_0.8 and the Langmuir and the Freundlich models fitting curves. The parameters values for each model and sum of squared errors (SSE) are listed in Table 1.
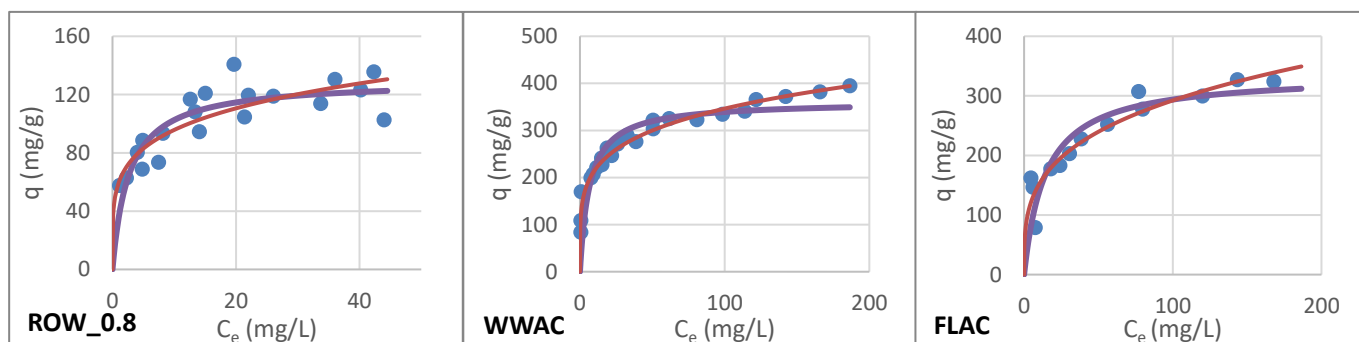

Figure 1 – CBZ adsorption isotherms at basic pH; points – experimental data, red line – Freundlich model, blue line – Langmuir model.

As it can be seen from Figure 1 and table 1, the activated carbons produced from leather residues have a higher adsorption capacity (q > 300 mg$_{CBZ}$/g) when compared with the commercial AC (ROW_0.8), being the highest adsorption capacity obtained with WWAC. It was shown that Freundlich model offers the best fit for the adsorption isotherms for WWAC and FLAC, since the values of SSE obtained are smaller, except for WWAC, at neutral pH.

Table 1 – Adsorption isotherm fitting results on activated carbons (Langmuir and Freundlich models)

	pH	Langmuir			Freundlich		
		q_{max} (mg$_{CBZ}$/g)	K_L (L/mg)	SSE (mg$_{CBZ}^2$/mg^2)	n	KF (L/mg)	SSE (mg$_{CBZ}^2$/mg^2)
ROW_0.8	Acid	177	0.182	17951	0.183	74.4	21057
	Neutral	133	0.395	2151	0.262	49.1	3017
	Basic	130	0.385	3044	0.207	59.4	3203
WWAC	Acid	384	0.156	39427	0.201	145	7374
	Neutral	380	0.265	28279	0.295	109	36434
	Basic	362	0.152	31263	0.208	133	5394
FLAC	Basic	336	0.0696	13226	0.286	78.4	7433

4. CONCLUSION

Residues from leather tanneries are good precursors to produce activated carbons. These carbons are better adsorbents for carbamazepine (q > 300 mg$_{CBZ}$/g) when compared to commercially available carbons (q < 180 mg$_{CBZ}$/g). The effect of pH is not significant for the adsorption of carbamazepine on these activated carbons.

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E103

Analysis of Biomass Potential within the Sector Coupling Concept

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ABSTRACT

The energy sector in the Czech Republic needs to be transformed in order to fulfill the European policy targets in decarbonization. However, replacing widely used domestic brown coal is not possible without the massive development of renewable energy resources including biomass. The Sector Coupling concept emphasizes direct and indirect electrification processes at end-users, where the carbon-free or low-carbon electricity is consumed directly or via storage technologies. Effective and sustainable usage of biomass for electricity, heat, or biofuel production, is also part of this concept. Biomass potential is influenced by many factors such as climate change, sustainability criteria, changes on the demand side, etc. Preliminary analyses show, for the case example of the Czech Republic, that gap between expected biomass contribution to the energy sector decarbonization and the real biomass potential reflecting all the agrotechnical, economic, and environmental constraints.

Keywords: Biomass potential; Energy branch decarbonization; Energy crop; Sector Coupling

1. INTRODUCTION

The energy policy of the European Union puts increasing emphasis on renewable resources as part of the energy mix within the "Clean Energy for All Europeans" concept [1]. The Czech Republic, as a member state, is being forced to increase the share of RES in order to fulfill the carbon neutrality targets by 2050 [2]. Renewable energy is one of the cornerstones of the EU's energy and climate strategy, both by the 2030 horizon and beyond with the long term goal of reaching climate neutrality until 2050 for EU territory. Biomass currently accounts for 60.5% of total RES in the contribution to primary energy sources in the total EU RES contribution as a whole, while in the Czech Republic it is reaching an even higher share - 90% of the total contribution of RES to primary energy sources [2]. The main purpose of this project is to analyze biomass potential in the Czech Republic within the expected transformation of the Czech energy branch with respect to the Sector Coupling concept [3].

2. MATERIALS AND METHODS

EU strategic documents defining decarbonization goals and transformation pathways of the energy branch (the Green Deal, European Climate Pact, and Regulation 2018/1999) are the starting point of the analysis. The analysis includes also the Czech strategic documents such as the National Energy Climate Plan (NECP), outputs of the Coal Commission, National Action Plan on Clean Mobility, etc.

Existing outlooks for biomass potential in NECP for the Czech Republic are based on current values of basic parameters defining the biomass potential. As a result of climate change, there are significant changes in the conditions for growing conventional and energy crops. At the same time, new restrictive conditions are emerging (e.g., soil erosion caused by heavy rainfalls, biodiversity problems, etc.), which have a significant impact on crop-growing conditions and consequently on biomass yields. Climate change also seriously impacted forests in Central Europe, namely in the Czech Republic. Massive development of bark beetle calamity [4] will result in a significant reduction of biomass potential from forestry in the next decades. Biomass potential is modelled using a model in GIS, where potential is derived from the soil and climate conditions on-site [4]. Structural changes in individual energy sectors and heat and electricity consuming sectors are analyzed based on EU and Czech strategic documents (see above) including a recent study on heating branch transformation [5].

3. RESULTS AND DISCUSSION

The impact of new restrictions on conventional agricultural production will reduce the potential of biomass from conventional agricultural production. In the Czech Republic, for example, this reduction can be estimated at 10-15%. [2] Higher reduction can be expected in the case of biomass from forestry - app. by 30-40% for the decades after 2030 [4].

Contrary to it, Czech NECP and transformation strategy of heating branch assumes relatively high contribution of biomass in substitution of fossil fuels - e.g. app. 20% of coal heating and cogeneration plants is assumed to be transformed into biomass burning plants.

These structural changes in the energy sector have already started - as one of the first EU countries, the Czech Republic, open calls for application for a new RES power plant and transformation of the heating branch (April 2021) from the Modernization Fund. Demand for biomass will be significantly influenced by technological changes esp. in the heating sector where the Sector Coupling concept assumes various technologies enabling utilization of excess electricity from intermittent RES power plant, utilization of waste heat, and decentralized RES technologies (e.g. solar thermal panels). Preliminary results of modelling (based on model reflecting changes on the biomass supply side and expected demand for biomass as the result of fossil fuel substitution) shows the gap between expected biomass contribution to the decarbonization of energy branch and demand for biomass namely for cogeneration and heat delivery to the district heating system and also for local space heating [5] [6] [7].

4. CONCLUSION

The role of Sector Coupling in the energy sector is unquestionable as well as biomass. Since the current share of coal both for power generation and heat production is high, it is necessary to search for alternative renewable sources where biomass plays its part.

Many biomass resources can be used in the Czech energy sector otherwise they would find no use. As an example, sewage sludge can be considered. This final product contains a high biomass portion that can be used as an energy raw material to cover the own consumption of wastewater treatment plants.

However, further development of biomass utilization for energy purposes should be viewed from the point of view of changing conditions and constraints for its collection and utilization. Sustainability criteria play an increasing role and also all relevant strategies should count with the impact of climate change. It is also necessary to reduce barriers to the development of new biomass concepts, such as agroforestry or agrovoltaics.

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E110

Studies on Homogeneous Photosensitized Oxidation Aiming Winery Wastewater Reuse

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ABSTRACT

A visible light-sensitized oxidation of winery wastewater pollutants in the presence of 3 photosensitizers (AlPcS4, ZnPcS4 and Rose Bengal (RB)) was studied. Influence of various parameters, such as initial sensitizer concentration and pH of the reaction solution was examined. It was found that ZnPcS4 is the photosensitizer with best performance with a COD removal of 40%, a phenol removal of 85% and a very low photodegradation. The change of the pH of the mixture and concentration of ZnPcS4 used in the study does not improve the effectiveness of the oxidation.

Keywords: oxidation, photosensitizer, winery wastewater

1. INTRODUCTION

Green chemistry is a strategy aiming to reduce environmental hazards by the use of safer solvents and raw materials from renewable sources and has multiple applications [(Foszpańczyk et al., 2019)].The wine sector is no exception - it is estimated that a winery produces 1.3 to 1.5 kg of residues per liter of wine produced, which of that is wastewater (WW) [(Ioannou et al., 2015)]. Removing contaminants and pathogens from water and wastewater is a concern that pushes for the development of new, effective, and low-cost processes. One of these solutions could be photosensitized oxidation [(Thandu et al., 2015)]. This process requires the presence of three major compounds: molecular oxygen, visible light, and a photosensitizer (PS). When PS is able to absorb the visible light, it transits to the excited singlet state (^{1}PS*). Then, through intersystem crossing, it can spin-flip into excited triplet state (^{3}PS*) of lower energy [(Gmurek and Miller, 2012)]. In this stage, PS transfers its energy to molecular oxygen, giving rise to reactive oxygen species (ROS) [(Thandu et al., 2015)]. ROS are cytotoxic in nature and can be used to degrade unwanted microorganisms like bacteria, fungi, phenols and recalcitrant compounds [(Thandu et al., 2015)]. The photodynamic action can initiate oxidation by two types of mechanisms. Type I involves the direct electron transfer from the ^{3}PS* to substrate molecule, yielding free radicals that can react with oxygen to form an active oxygen species. Type II generates singlet oxygen, which can oxidize water pollutants, through energy transfer between the PS in the triple excited state and triplet oxygen [(Thandu et al., 2015),(Gmurek and Miller, 2012),(DeRosa and Crutchley, 2002)]. The photosensitized oxidation occurs periodically until the PS suffers photobleaching. The aim of this study was to compare the effectiveness of Rose Bengal (RB), Aluminum phthalocyanine (AlPcS$_4$) and Zinc phthalocyanine (ZnPcS$_4$) in the photodegradation of pollutants from winery WW, along with the effect of pH and PS concentration.

2. MATERIALS AND METHODS

<u>Wastewater:</u> It was collected in a wastewater treatment plant (WWTP) of an industrial winery in the south of Portugal and, after chemical characterization, was stored at 4ºC in 5 L bottles.

<u>Chemicals and analytical methods:</u> Al (III) phthalocyanine chloride tetrasulfonic acid (a mixture of Regio isomers, Frontier Scientific), Zinc(II) phthalocyanine tetrasulfonate tetrasodium salt (Frontier Scientific) and Rose Bengal, were purchased from Fluka andused as received.

Chemical Oxygen Demand (COD) was determined by the 5220 D method (Closed Reflux) [(Tarigan, 2013)].The Biochemical Oxygen Demand (BOD) was carried out as established in the Standard Method 5210 B. 5-Day Test [6]. The Total Phenolic Content (TPh) was measured colourimetrically by the Folin–Ciocalteu procedure [7]. PS concentration was measured colourimetrically (515nm for RB and 765nm for AlPcS$_4$ and ZnPcS$_4$). A toxicity bioassay was conducted using two different species*: Aliivibrio fischeri* (bacteria) and *Lepidium sativum* (garden cress).

3. RESULTS AND DISCUSSION

Independent assays were performed under sun light to study different PS and the effect of variable conditions: (1) effectiveness of the three PS in the same conditions (pH and concentration); (2) pH influence using ZnPcS$_4$

and (3) concentration influence of ZnPcS$_4$.

Photosensitizers effectiveness (Fig.1): ZnPcS$_4$ is the photosensitizer with the best performance in COD and TPh removals. Photostability was verified by controlling PS concentration through time. The obtained results show that ZnPcS$_4$ and AlPcS$_4$ [5E10^{-6}M] are stable. On the contrary, RB [5E10^{-6}M] is unstable probably due to higher quantum yield of its oxygen singlet. The BOD$_5$ test, using ZnPcS4, presents the best results reaching 30% removal of the initial WW BOD$_5$ value. Due to these results, ZnPcS$_4$ was chosen for the following studies. pH influence (Fig.2): In this study, three pH values were used: 7, 8.1 (WW pH) and 9. No significant differences were observed in COD and TPh removals. Concentration influence: Using a higher concentration of ZnPcS$_4$ [1E10^{-4}M], a slight increase of COD (103%) was observed but the degradation of phenolic compounds was similar to the one obtained previously. Toxicity studies were conducted for the three PS and, again, varying pH and concentration for ZnPcS$_4$. With *A. fischeri*, was only observed an increase on the toxicity of the WW when using ZnPcS$_4$ at high concentrations (1E10^{-4}M). Whereas, with the *L. sativum*, all the assays using ZnPcS$_4$ (different pH and concentration) demonstrated an increase on the toxicity.
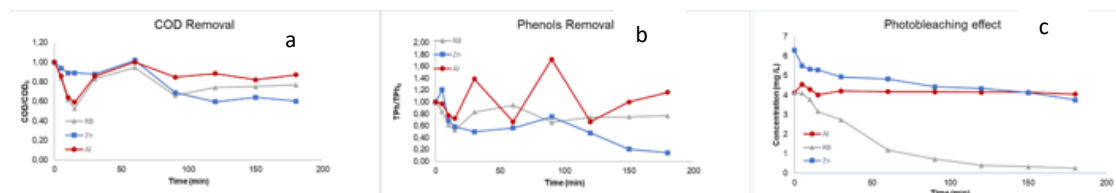
Fig. 1. Photosensitizers effectiveness. (a) COD/COD$_0$, (b) TPh/TPh$_0$ removal and (c) Photobleaching
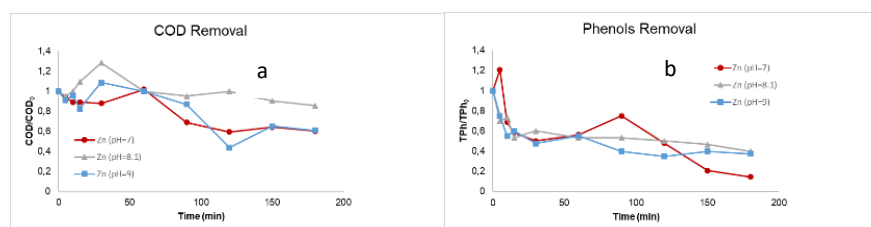
Fig. 2. pH influence. (a) COD/COD$_0$ and (b) TPh/TPh$_0$ removal.

4. CONCLUSION

The photosensitized oxidation by RB, ZnPcS$_4$ and AlPcS$_4$ as PS can be applied for photodegradation of pollutants in wastewater. The study shows that each of the sensitizers was able to degrade organic matter. The ZnPcS$_4$ revealed the best results, presenting high COD and phenols removals and a low photodegradation. In the process condition, the dependence of the pH in the range of 7 to 9 is not relevant.

This work presents a study of a homogenous system and the selection of optimum conditions of photosensitized oxidation. Studies on the possibility of using PS for degradation of water pollutants are essential for further research on heterogeneous systems. Based on our studies, ZnPcS$_4$ seems to be a suitable PS for the immobilization.

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E137

Quality of Seeds and Crude Jatropha Oil (Cjo) Based on Various Hybride of *Jatropha Cu*rcas L. as A Biodiesel Source

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ABSTRACT

Jatropha curcas L. is a woody shrub from the tropics that has extraordinary potency as a producer of biodiesel. This research was aimed to analyze the quality of seeds and CJO based on various hybrid of *J. curcas* as a source of biodiesel. The material was dry seeds from 4 genotypes of *J. curcas* hybrid from Kedung Pengaron, Pasuruan District, East Java, namely G5-A, G5-B, G6-A and G6-B. This research consisted 2 stages, started with observing *J.curcas* L. seeds quality (water and oil content),followed by CJO production and analyzed (acid number, Free Fatty Acid, saponification number, ester number, and water content). Completely Randomized Design with 3 replications were applied. The results defined that *J.curcas* hybrid was not significantly affect on the oil content, but gave significantly effect on the water content of seeds. Furthemore, *J.curcas* hybrid was also gave significantly effect on the acid number, FFA, and water content of CJO properties..

Keywords: free fatty acid, saponification number, ester number

1. INTRODUCTION

The biggest potency of biodiesel raw material for Indonesia comes from palm oil. The properties of palm oil was 314 ºC for ignition point, 88.6 (10^{-6} m^2 s^{-1}) for kinematic viscosity, 54.2 mg g^{-1} iodine number, 199.1 mg g^{-1} saponification number, Gross calorific value 39.54 (MJ kg^{-1}) [1]. *Jatropha curcas* L. is a tropical plant that also has potency as biodiesel raw material. Jatropha seeds contain about 35% oil that easy to convert as biodiesel [2]. Crude Jatropha Oil (CJO) commonly is obtained from extraction using a solvent, pressing, or a combination of both. The compression of Jatropha seeds that apply hydraulic presses at low temperature can produce 23−35 % oil in the seeds. Furthemore, extraction at high temperature (hot press), able to produce higher CJO about 75−80 % [3].

The quality of seeds and crude Jatropha oil greatly affects the quality of biodiesel produced. The saponification number is the amount of oil that can be saponified which defined the molecular weight. Achten et al. (2008) stated that the average of *J. curcas* saponification number ranged from 102.9–209 mg g^{-1}. The value of the water content of vegetable oil should not to be more than 2%. The high content of water and free fatty acids will trigger the formation of soap (saponification) and cause problems in the separation of glycerol [5]. The research aimed to identify the seed and crude jatropha oil quality of various hybrid *J.curcas* L. as a source of biodiesel.

2. MATERIALS AND METHODS

The research was conducted at the Chemistry Laboratory, University of Muhammadiyah Malang. Completely Randomized Design with *J.curcas* L. hybrid that consisted four level (G5-A, G5-B, G6-A, G6-B) [6]. The *J. curcas* L. seeds used as samples was collected from Kedung Pengaron, Kejayan Sub-district, Pasuruan, East Java, Indonesia. After the drying process, it followed seeds water content and oil content analysis. Furthermore, dried Jatropha seeds were pressed to obtain crude jatropha oil and analyzed acid number, free fatty acid, saponification number, ester number, and water content

3. RESULTS AND DISCUSSION

The treatment of several genotypes from the *J.curcas* cross did not significantly affect the oil content, and had a significant effect on the water content of the seeds (Table 1). The lowest water content of Jatropha seeds was in the G6-A, and the highest was in G5-B which was not significantly different from B5-A.

Table 1. Water Content and Oil Content ± Standard Deviation of *J.curcas* L. Seed Genotypes.

Seed Genotypes	Water Content (%)		Oil Content (%)	
G5-A	8.42 ± 0.06	c	26.69 ± 0.73	a
G5-B	8.54 ± 0.15	c	27.92 ± 0.83	a
G6-A	7.52 ± 0.13	a	25.75 ± 1.93	a
G 6-B	8.14 ± 0.09	bc	27.94 ± 1.24	a

Note: numbers followed by same letter in a column were not significantly different on Duncan Test 5%.

The various genotypes of *J. curcas* showed that there was no significant effect on the ester and saponification number of crude jatropha oil. Furthemore it gave significantly effect on the acid number, Free Fatty Acid and water content of crude jatropha oil (Table 2). The lowest acid number (3.70 mg KOH/g) was in the G6-A genotype. The lowest free fatty acid content was genotype G6-A (0.69%). Furthemore, the highest ester number (62.83 mg KOH/g) was in the G6-B genotype. The saponification range values was 65.12 mg KOH/g (G5-B) to 68.46 mgKOH/g (G6-B).

Table 2. Crude Jathropha Oil Properties

Treatment	Acid Number (mg-KOH g^{-1})		Free Fatty Acid (%)		Ester Number (mg-KOH g^{-1})		Saponification number (mg-KOH g^{-1})		Water Content (%)	
G5-A	4.22 ± 0.6	b	1.53 ± 0.16	b	63.14± 1.21	a	65.84 ± 0.55	a	0.43 ± 0.02	a
G5-B	4.22 ± 0.4	b	1.54 ± 0.16	b	60.90± 1.99	a	65.12 ± 1.61	a	0.50 ± 0.05	ab
G6-A	3.70 ± 0.5	a	0.69 ± 0.16	a	64.54± 1.21	a	66.24 ± 1.61	a	0.56 ± 0.06	b
G 6-B	5.63 ± 0.4	b	2.01 ± 0.15	b	62.86± 1.22	a	68.46 ± 1.60	a	0.63 ± 0.05	b

Note: numbers followed by the same letter in a column were not significantly different on Duncan Test of 5%.

4. CONCLUSION

The lowest water content of Jatropha seed (7.52%) was achieved by genotype G6-A, and the highest was at G5-B (8.54%). Various genotypes of *J.curcas* hybrid defined significantly effect on acid number, Free Fatty Acid and water content of crude jatropha oil, but unsignificant on the saponification number and ester number. In this study, the lowest acid number (3.70 mg KOH/g) was in the G6-A genotype. The lowest free fatty acid content was genotype G6-A (0.69%). The various genotypes of *J. curcas* was unsignificant affect on the ester number and saponification number. In this study the highest ester number (62.83 mg KOH/g) was in the G6-B genotype. The saponification range values was 65.12 mg KOH/g (G5-B) to 68.46 mgKOH/g (G6-B). The lowest average water content of CJO (0.43%) was in the G5-A

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Trainig and Sustainable Entrepeneurship

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ABSTRACT

Sustainable entrepreneurship is a concept that, in addition to the economic component or monetary benefits, implies protection and social development. Engineering degrees present competencies in entrepreneurship and sustainability that can be worked on together during the degree.

In recent years, through Entrepreneurial Promotion Programs (EPPs) both entrepreneurship and sustainability competence have been developed in different engineering courses. In this programs several face to face and online activities were developed and they were boosting by social media (Facebook or Twitter).

After several editions of these program, it has been observed that the ecological dimension of sustainable entrepreneurship is easily recognizable by students in companies, entrepreneurs or ideas. However, the social or economic aspects of the sustainability entrepreneurship are not easily recognized.

In this work, the results and main conclusions obtained in the EPPs developed by the University of Jaen (Spain) are analysed and new strategies for a better understanding of the concept of sustainable entrepreneurship in its global dimension are suggested.

Keywords: engineering students. engineering students. entrepreneurship, entrepreneurial promotion programs, sustainable development objectives.

1. INTRODUCTION

Sustainable development [1] is a concept that requires the integration of three objectives: environmental, social and economic. But this concept is not only limited to the current era, but is projected towards future generations [2]. In addition, it considers transparency and ethics in business, as they are necessary for the proper functioning of the market [3]. This concept is in accordance with the "Global Compact" that asks companies to practice values such as human rights, labor standards, the environment and the fight against corruption.

In 2015, the Sustainable Development Summit and elaborated the 2030 Agenda that contains the 17 Sustainable Development Goals (SDGs) to transform our world. The higher education can be a key tool to achieve Sustainable Development; which means that the university has to train professionals capable of using their knowledge, not only in a scientific context, but also to respond to social and environmental needs. The development and promotion of entrepreneurship education has been one of the key policy objectives of the European Union and the Member States for many years. The Spanish Universities, are developing numerous initiatives to promote the entrepreneurial culture. In the current context, these initiatives must be oriented towards sustainable entrepreneurship.

At the University of Jaén, the authors have been working on Entrepreneurial Promotion Programs(EPPs) in engineering studies since the 2015. In recent years, the generic competence on sustainability was incorporated into these EPPs as it is closely related with the SDGs.

In recent years, the generic competence on sustainability was incorporated into these projects given the importance it presents and its relationship with the SDGs. In this case, this competence focuses on the basic knowledge of technologies to protect the environment and the sustainability.

This paper explains the main results obtained after the incorporation of the sustainability competence for the promotion of sustainable entrepreneurship.

2. METHODOLOGYS

In the projects for the Promotion of Entrepreneurial Culture developed by the authors at the University of Jaén, a general work scheme has been maintained, which is shown in Figure 1. There have been face-to-face activities and online activities that have been energized by networks social (Facebook, Twitter ...). In the case of online activities, search topics have been indicated periodically and students have shared links, photos, files, etc. through the networks, in a closed group, specifically created for projects. Group activity was measured using Facebook's Grytics group analytics software.
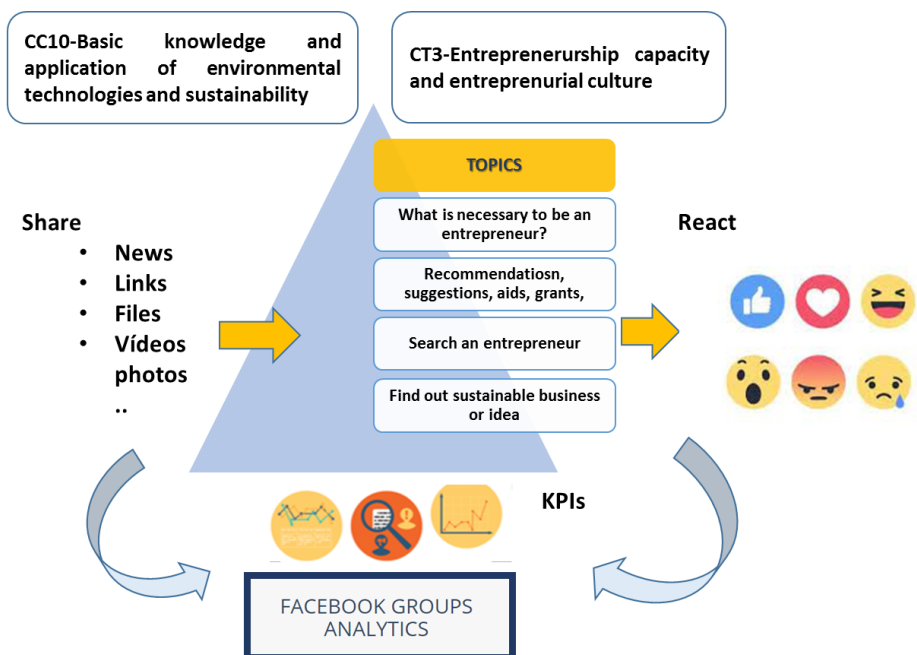
Fig 1. Methodology

During this course, the search for tools for a company to comply with the SDGs has been incorporated as a topic.

3. RESULTS AND DISCUSSION

During the 2020/2021 academic year, a specific topic related to the SDGs in companies has been incorporated. The publications that the students by networks social have shared are especially focused on 5 of the 17 Sustainable Development Goals: GOAL 7: Affordable and Clean Energy, GOAL 8: Decent Work and Economic Growth, GOAL 9: Industry, Innovation and Infrastructure, GOAL 13: Climate Action and GOAL 15: Life on Land.

The SDGs most addressed in this activity continue to be those related to ecological sustainability and to a lesser extent with social and economic apects.

4. CONCLUSION

This work shows the first experiences related to the promotion of sustainable entrepreneurship in engineering students. The results show that although the topic of the SDGs have been incorporated into the activities dynamized by Facebook, the students only consider the part related to the environment and not the social and economic component of the SDGs. It is suggested that it is necessary to delve into each of the SDGs in different subjects, as well as incorporate glossaries and wikis in the next EPPs.

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