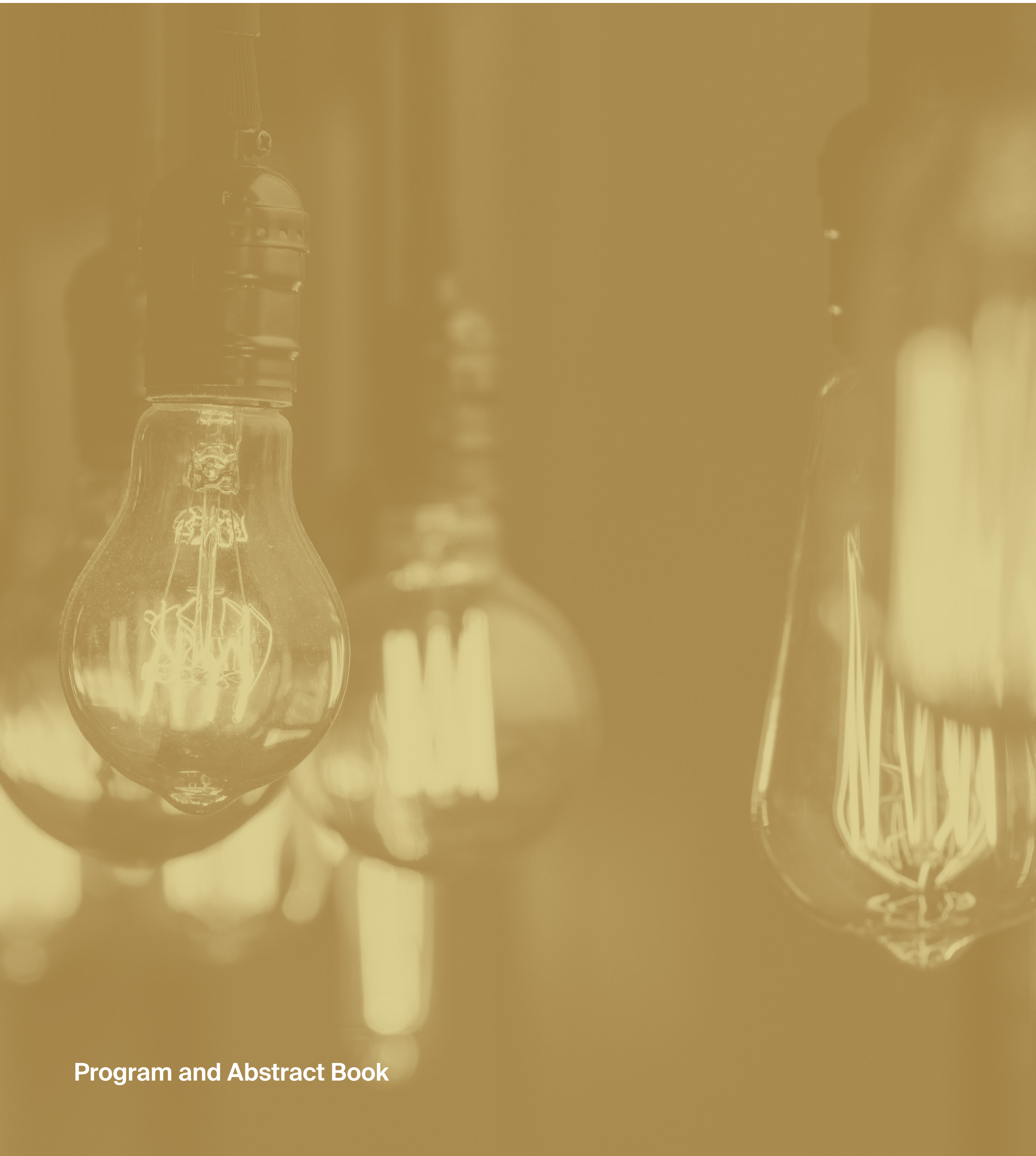
IOCIV
2026
Conference

The 1st International Online Conference on Inventions

25–26 June 2026 | Online



Program and Abstract Book

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The College of Electrical and Power Engineering, Taiyuan University of Technology traces its origins to 1918, when the Electrical Engineering Program was first established under the Western Studies Division of Shanxi University Hall (山西大学堂西学专斋).

The College currently comprises four departments—the Department of Electrical Machines, the Department of Automation, the Department of Thermal Engineering, and the Department of Energy Network Engineering (official English title to be confirmed)—as well as the Division of Electrical Engineering Fundamentals and the Electrical and Electronic Experimental Center.

At present, the College has 170 faculty and staff members, including 139 full-time academic staff, among whom 24 are doctoral supervisors. The College is home to one Member of the Chinese Academy of Sciences, two experts receiving the State Council Special Allowance, and one scholar recognized under both the National Science Fund for Distinguished Young Scholars and the Chang Jiang Scholars Program. In addition, the College has five scholars selected for the Shanxi Province Hundred Talents Program, two leading talents under the "131" Leading Talent Program of Higher Education Institutions in Shanxi Province, three Shanxi Province Academic and Technical Leaders, six Shanxi Province Distinguished Teachers, and twenty-two outstanding young and middle-aged innovative talents from higher education institutions in Shanxi Province.

The College hosts a number of prestigious research platforms, including one Key Laboratory of the Ministry of Education, one Discipline Innovation and Talent Introduction Base under the Ministry of Education and the Ministry of Science and Technology (the "111 Program"), one National and Local Joint Engineering Research Center, four Key Laboratories of Shanxi Province, one Shanxi Provincial Joint Graduate Training Base for Industry-Education Integration, one National Defense Innovation Engineering Center (official English title to be confirmed), and two Shanxi Provincial Engineering Technology Research Centers.

The College currently offers programs in three disciplines: a doctoral program in the first-level discipline of Electrical Engineering, a master's program in Control Science and Engineering, and a master's program in Power Engineering and Engineering Thermophysics.

At present, the College has a total enrollment of 2,680 students, including 1,948 undergraduate students, 702 postgraduate students, among whom 62 are doctoral candidates, as well as 30 international students.

The undergraduate programs in Electrical Engineering and Automation and Automation are both recognized as National First-Class Undergraduate Programs and have repeatedly passed engineering education accreditation. Thermal Engineering is recognized as a Shanxi Provincial First-Class Undergraduate Program.

Fore more details: https://dlxy.tyut.edu.cn/English/Home.htm

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Organizing Committee

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Prof. Dr. Eugen Rusu

Session Chairs
Dr. Said Al-Hallaj
Dr. Trilochan Bhatta
Dr. Zahid Ullah
Prof. Dr. El Manaa Barhoumi

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Conference Secretariat

iociv2026@mdpi.com

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Welcome from the Chair

Dear Colleagues,

It is with great enthusiasm that we announce **the 1st International Online Conference on Inventions - Energy Security and Sustainable Development (IOCIV 2026)**. The conference is organized by the MDPI open access journal *Inventions* (ISSN: 2411-5134; Impact Factor: 1.9) and will be held online from **25–26 June 2026**.

The conference offers a great platform to explore the latest advancements and future directions in the dynamic field of inventions. Scientists worldwide can share their research, exchange ideas, and collaborate to shape a better future. As a virtual event, it is convenient and provides an engaging international experience. Another advantage is that you do not need to travel to attend. You can take advantage of this opportunity from wherever you live.

The main topics and sessions of the conference are as follows:

Session 1: Energy transition, decarbonization and environmental policy;
Session 2: Advanced sustainable energy conversion systems;
Session 3: Energy system analysis and modelling;
Session 4: Advances and challenges in extracting offshore energy.

Registration for the conference is completely **free of charge**. All submitted abstracts will be reviewed by the conference committee before being published and displayed on the conference website.

To acknowledge the support of the conference's esteemed authors and recognize their outstanding scientific accomplishments, we are pleased to announce that the conference will provide **four awards** including **Best Oral Presentation Awards** and **Best Poster Awards.**

Lastly, we would like to express our sincere gratitude for your unwavering support and participation. We look forward to a successful and inspiring conference!

Kind regards,

Prof. Dr. Eugen Rusu
Conference Chair
Department of Mechanical Engineering, University Dunarea de Jos of Galati, Galati, Romania

inventions

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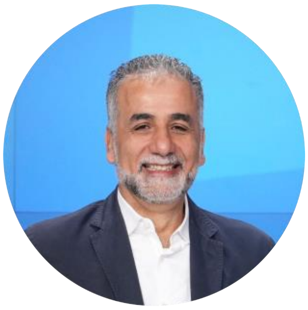
The journal *Inventions* is an international, peer-reviewed journal that publishes original scientific research of significance concerning innovation/invention, or patent-based/extended/reviewed research papers in all fields of science, engineering and product development processes. Also covered would be research concerning improvements of machines or products; new processes for creating an object; inventions in advanced technologies; and short technical reports regarding transferring technology. The journal Inventions aims to publish high quality papers concerning the discovery of completely unique functions or results, offering readers radical breakthroughs and novel contributions. We encourage authors to give special attention to patent-based/extended researches.

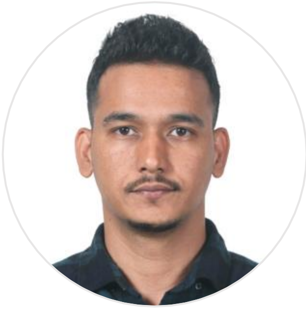
(ISSN: 2411-5134; Impact Factor: 2.4; CiteScore: 5.7)

Journal Webpage: https://www.mdpi.com/journal/Inventions

Session Chairs

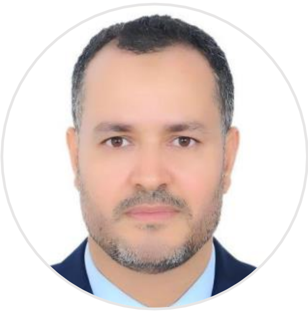


Dr. Said Al-Hallaj
Department of Chemical Engineering, University of Illinois at Chicago,
Chicago, USA



Dr. Trilochan Bhatta
Department of Electronic Engineering, Kwangwoon University, Seoul,
South Korea

Dr. Zahid Ullah
Department of Electronics, Information and Bioengineering,
Polytechnic University of Milan, Milan, Italy

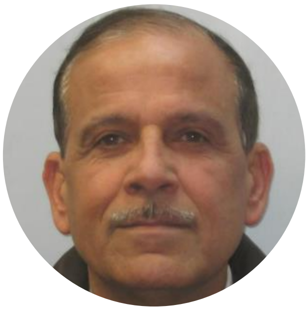


Prof. Dr. El Manaa Barhoumi
the College of Engineering, Dhofar University,
Dhofar, Oman

Keynote Speakers

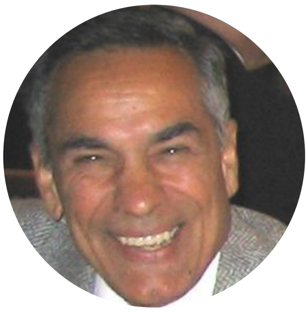
Prof. Dr. Achille Messac

Department of Mechanical Engineering,
College of Engineering and Architecture,
Howard University,
Washington, USA



Prof. Dr. Mohammed Farid

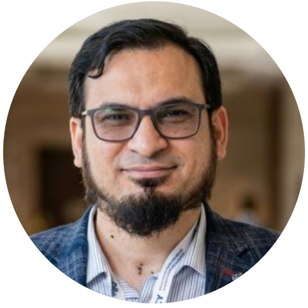
CTO, PhaseFoam Ltd,
Auckland, New Zealand,
Department of Chemical and Materials Engineering, The University of Auckland, Auckland, New Zealand



Prof. Dr. Om Malik

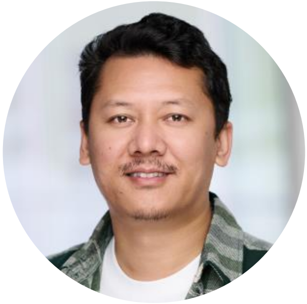
Department of Electrical and Software Engineering, University of Calgary,
Calgary, Canada

Invited Speakers



Dr. Bilal Khan

Department of Control and Instrumentation Engineering (CIE), King Fahd University of Petroleum and Minerals (KFUPM), Dhahran, Saudi Arabiay



Dr. Pukar Maharjan

New York University at Abu Dhabi, Abu Dhabi, United Arab Emirates

Prof. Dr. Fernando Coelho

Department of Environmental Sciences, Federal University of Alagoas, Maceió, Brazil

Prof. Dr. Mirela Panait

Department of Cybernetics, Informatics, Finance and Accounting, Faculty of Economic Sciences, Petroleum-Gas University of Ploiesti, Ploiesti, Romania

Program Overview

	25 June 2026	26 June 2026
Morning	Session 3. Energy system analysis and modelling	Session 4. Advances and challenges in extracting offshore energy
Afternoon	Session 2. Advanced sustainable energy conversion systems	Session 1. Energy transition, decarbonization and environmental policy

IOCIV 2026 Program

25 June 2026 (Thursday)

Session 3. Energy system analysis and modelling

Time: 09:00 (CEST, Basel) | 03:00 (EDT, New York) | 15:00 (CST Asia, Beijing)

Time in CEST	Speaker	Title
9:00–9:10	**Prof. Dr. Eugen Rusu** Conference Chair	**Opening Remark from Conference Chair**
9:10–9:15	**Prof. Dr. El Manaa Barhoumi** Session Chair	**Welcome from the Session Chair**
9:15-9:40	**Prof. Dr. Achille Messac** Keynote Speaker	Energy Systems Evolution: Multidisciplinary Design Optimization in the Age of Artificial Intelligence
9:40-10:00	**Chenjue Wang** Selected Speaker	Physics-Informed Reduced-Order Models for Air-to-Water Heat Pumps Coupled with Sensible and Latent Thermal Storage
10:00-10:20	**Angel Buendía-Esparcia** Selected Speaker	A Machine Learning–Enabled Energy Management Tool for Flexible Port Operations and DER Integration
10:20-10:40	**Tormi Lillerand** Selected Speaker	Causal Greedy Pair Scheduling for Residential Battery Storage under Day-Ahead Electricity Prices
10:40-11:00	**Lavinia Cretu** Selected Speaker	An evaluation of Black Sea wave energy dynamics
11:00-11:20	**Ahmad Mohsenimanesh** Selected Speaker	Techno-Economic Evaluation of Community-Scale EV–ASHP–PV Systems Using HOMER Grid: Case Studies in Three Canadian Provinces
11:20-11:40	**Ioannis Mozakis** Selected Speaker	Grid Resilience under Ultra-High Renewable Penetration
11:40-12:00	**Omar Dario Delgado Brito** Selected Speaker	MuLTEcast-Bandit: Sustainable and Energy-Aware Adaptive Multicast/Unicast Selection for Massive Event Streaming in 5G/6G Edge Networks
12:00-12:20	**Omar Mohsen Sayed** Selected Speaker	Comparative Techno-Economic Analysis of Offshore and Onshore Wind Farms in Zafraana, Egypt Using the System Advisor Model (SAM)

Session 2. Advanced sustainable energy conversion systems

Time: 14:00 (CEST, Basel) | 8:00 (EST, New York) | 20:00 (CST Asia, Beijing)

Time in CEST	Speaker	Title
14:00–14:05	**Dr. Said Al-Hallaj** Session Chair	**Welcome from the Session Chair**
14:05-14:35	**Prof. Dr. Mohammed Farid** Keynote Speaker	Innovative Use of Phase Change Energy Storage System in Cold-Chain and Building Applications
14:35-15:10	**Prof. Dr. Om Malik** Keynote Speaker	Automatic Tuning of Inverter Parameters for Sustainable Energy Sources
15:10-15:30	**Armand Pellja** Selected Speaker	Design, construction, and initial testing of a transportable mobile energy station with autonomous solar tracking
15:30-15:50	**Dasun Siriwardena** Selected Speaker	Hierarchical Ternary Carbon Nanocomposite on Stainless Steel for Low-Overpotential Hydrogen Evolution in Alkaline Water Electrolysis
15:50-16:10	**Fabian Velasquez** Selected Speaker	Design and Experimental Evaluation of a Biomass-Based Boiler for Sustainable Thermal Energy Supply in Rural Agroindustries
16:10-16:30	**Ravishankar Sathyamurthy** Selected Speaker	Experimental analysis of single slope solar still equipped with jute and nanoenhanced jute cloth for clean water production
16:30-16:50	**Abdelhafidh Benreguieg** Selected Speaker	Techno-Economic Feasibility of an Off-Grid Wind-Powered Hydrogen Microgrid for Green Hydrogen Production in Northwest Algeria: System Modelling by HOMER Energy
16:50-17:10	**María Jesús Millas Soria** Selected Speaker	Design of an Urban Solid Waste Management system for waste collection and recycling

26 June 2026 (Friday)

Session 4. Advances and challenges in extracting offshore energy

Time: 09:30 (CEST, Basel) | 03:30 (EDT, New York) | 15:30 (CST Asia, Beijing)

Time in CEST	Speaker	Title
9:30–9:35	**Dr. Trilochan Bhatta** Session Chair	**Welcome from the Session Chair**
9:35–10:00	**Dr. Pukar Maharjan** Invited Speaker	Powering Offshore IoT: Energy Harvesting from Water and Wave Motion
10:00-10:25	**Prof. Dr. Fernando Coelho** Invited Speaker	The sustainability of beach-cast seaweed biomass for biorefinery processes: calorific power heating studies with macroalgae
10:25-10:45	**Adriana Silion** Selected Speaker	Future Offshore Wind Potential and Turbine Performance in the Romanian Black Sea
10:45-11:05	**Mohamed Maktabi** Selected Speaker	Decay Analyses of Eight Floating Wind Turbines
11:05-11:25	**Roberto Adrian Dobri** Selected Speaker	An integrated techno-economic assessment of offshore wind energy potential in Romania’s Exclusive Economic Zone

Session 1. Energy transition, decarbonization and environmental policy

Time: 14:00 (CEST, Basel) | 8:00 (EST, New York) | 20:00 (CST Asia, Beijing)

Time in CEST	Speaker	Title
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14:05-14:30	**Prof. Dr. Mirela Panait** Invited Speaker	Corporate Social Responsibility of Energy Companies: Risks of Greenwashing and Opportunities for Impact
14:30-14:55	**Dr. Bilal Khan** Invited Speaker	Enhancing Grid Stability and Decarbonization through Physics-Informed Machine Learning Integrated Control for Electric Vehicle Integration
14:55-15:15	**Catalin Anton** Selected Speaker	The World’s First 700 TEU Pure Electric River–Sea Container Ships: Energy Architecture, Emissions Accounting, and Operational Feasibility
15:15-15:35	**Alina Mihalcea** Selected Speaker	Strategies for decarbonization and resilience - the path towards clean emissions transport on European coastal regions
15:35-15:55	**Alexandra Bujor** Selected Speaker	Enhancing Sustainability of European Floating Structures through Renewable Energy Integration
15:55-16:15	**Eyad Emad Abdelrahman** Selected Speaker	Techno-Economic Assessment of Green Hydrogen Production in El Galala, Egypt: A Comparative Study Between Wind and Solar PV Energy Sources
16:15-16:35	**Valerian NOVAC** Selected Speaker	Nuclear Propulsion in Maritime Transport: Technical and Environmental Assessment in the Context of Maritime Decarbonization
16:35-16:55	**Victor-Ionut Popa** Selected Speaker	An Empirical Analysis of sustainable Energy Development in the Danube Region
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sciforum-165475	Yomna M.I. Hassan, Mahy Ayman, Mariam Othman, Nour Mahmoud, Zeina Tamer	Fault Detection in Wind Turbines using Weather Decomposition
sciforum-168603	Roberto Adrian Dobri, Eugen Rusu, Florin Onea	Sensitivity Analysis of WEC Generators Based on a Neural Network Model
sciforum-168848	Daniel Zammit, Cyril Spiteri Staines	Wind MPPT with Incremental Duty Cycle for a PMSG SWT in a Grid-Connected DC Microgrid
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sciforum-175141	Swagata Banerjee, Ram Bilash Choudhary	Effect of RuO2 Content on the Electrochemical Performance of PPy/WS2-Based Ternary Supercapacitor Electrodes
sciforum-175148	D.A.A.S Dissanayaka, M.W.A.L.S Wijewikrama, H.D.N Jayawardhana, H.D Ekanayaka, A.A.M Chamuditha, G.W.G.S Gunathunga, W.A.R.S Gunathilaka, S.A.N Dilhan, Lakshan Priyankara, Amalka Indupama, Vimukthi Vithanage, Chanaka Galpaya, K.R. Koswattage	Comparative Analysis of Fuel Consumption Between Engine Idling and Engine Stop-Restart in Traffic Conditions
sciforum-175174	Nour EL Yakine KOUBA	Multi-Nanogrid Power Management and Control Using Nature-Inspired Optimization Algorithms
sciforum-175212	Alecsa Cristina, Rusu Liliana, Gasparotti Carmen, Oana Jarca	Offshore Renewable Energy Infrastructure Under Climate Change: A Review of Structural Reliability, Climate Impacts, and Energy Security
sciforum-175265	Son Nguyen	Decarbonization Without Illusions: Why Nature Markets Misprice Risk in Asia and How Policy Must Respond
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sciforum-175315	Helitha Hiranya Nilmalgoda, Nethmi Gunathilake, Lasitha Madhusanka, Ashan Induranga, Niroshan Gunawardana, Asanga Ampitiyawatta, Kaveenga Koswattage	Exploring Wild Arachis pintoi Biomass for Sustainable Bioenergy: A Multi-Product Strategy for Biofuel Production

sciforum-175367	Chanika Kariyawasam, Uvindu Kalhara, Lakshan Priyankara, Lasitha Madhusanka, Chanaka Galpaya, Hasintha Wijesekara, Kaveenga Koswattage	Ionic Conductivity of Pine Needle Biochar-Derived Carbon Quantum Dots (CQDs) in Aqueous Medium for Sustainable Energy Applications
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sciforum-175400	Alejandra Balaguera Quintero, Juan Sebastián Viña, Esteban Correa Bedoya	Modelling the Environmental Performance of Hydrogen Energy Systems: A Systematic Life Cycle Assessment Review
sciforum-175403	Margarida Conceição, Maria Inês Conceição, Eusébio Conceição, Maria Manuela Lúcio, João Gomes, Hazim Awbi	Modelling energy and ventilation in passenger transportation vehicles
sciforum-175783	Majid Rasheed	Model Capacity Alignment under Data Scarcity: Tree-Based Ensembles versus Deep Recurrent Networks for Daily Solar Radiation Forecasting in West Africa
sciforum-175940	Isuranga Sandun Abejeewa, Vikum Premalal, Manel Sarangika, Kaveenga Rasika Koswattage, Lakshan Priyankara, Lasitha Madhusanka	Process Optimization of Copper Antimony Sulfide Thin Films via Chemical Bath Deposition for High-Performance Photovoltaic Applications.
sciforum-176210	Ilya Galaktionov, Alexander Lyashenko, Vladimir Toporovsky, Oleg Kolesnikov	A technique for a secondary manual flat polishing of multimode ferrules to correct its geometric parameters for efficient wireless energy transition
sciforum-176494	Zouhir Guermat, yassine kabar	Optimization of a Building Wall Using a Bio-Sandwich Panel Composed of OSB and Bio-Based PCM
sciforum-176605	Chivon Choeung, Panha Soth, Sokna San, Socheat Yay, Heng Tang, Chivon Choeung	Power Quality Enhancement of a Grid-Following Inverter under Grid Voltage Unbalance and Impedance Uncertainty in Modern Energy Systems
sciforum-177478	Sardorjon Salimjon ugli Samiev, Shokhabbos Kulmurat ugli Doliev, Farrukh Dustmirzayevich Juraev, Sunnatjon Umar ugli Farxodov, Ramziddin Toshpulat ugli Toshtemirov	IMPROVING ENERGY EFFICIENCY IN METALWORKING MACHINE TOOLS: VECTOR CONTROL OF ELECTRIC DRIVES USING A FREQUENCY CONVERTER AND SYSTEM MODELING
sciforum-178138	THIYAGARAJAN A, Chitra S	Analysis and Implementation of Multi-Input Multi-Output DC-DC Buck–Boost Converters for Renewable Energy Applications
sciforum-178353	MASSIMO BARBIERI, Flavio Manenti	Integrated Thermochemical and Electrochemical Valorization of Carbonaceous Waste and CO2 for Syngas Production
sciforum-179090	Hady H Fayek, Mohamed Walid Mahmoud, Omar Mohsen Sayed, Mazen El-Walid Abd El-Aal	Comparative Techno-Economic Analysis of Offshore and Onshore Wind Farms in Zafraana, Egypt, Using the System Advisor Model (SAM)
sciforum-180040	Sardorjon Samiev, Shokhabbos Doliev, Javlonbek Khamraev, Golibjon Makhmatqulov, Khurshid Normumin Yusupov	Dynamic modeling analysis of a Doubly-Fed Induction Generator-based wind energy system
sciforum-180077	Shokhabbos Kulmurat ugli Doliev, Sardorjon Salimjon ugli Samiev, Farrukh Dustmirzayevich Juraev, Golibjon Kholmuminovich Makhmatqulov	Modeling and Forecasting Electricity Consumption and Its Determinants: Evidence from the Kashkadarya Region
sciforum-180196	Lijun Jiao	Construction and Parametric Determination of a Thermodynamic Model for Heterogeneous Nucleation of Tetrahydrofuran Hydrate on Solid Surfaces Based on Classical Nucleation Theory
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Session 1. Energy transition, decarbonization and environmental policy

sciforum-175214: Nuclear Propulsion in Maritime Transport: Technical and Environmental Assessment in the Context of Maritime Decarbonization

Valerian Novac [1,*], Eugen Rusu [1], Vladimir Ablai [2] and Valentin Nae [3]

[1] Doctoral School of Mechanical and Industrial Engineering, ”Dunărea de Jos” Galati University, Domnească Street, no. 47, postal code 800008,Galati, Romania
[2] Doctoral School, Military Technical Academy ”Ferdinand I”, Bvd George Coșbuc, no. 39-49, sector 5, postal code 050141, Bucharest, Romania
[3] Doctoral School of Electrical Engineering, National University of Science and Technology POLITEHNICA Bucharest, Splaiul Independentei, no. 313, postal code 060042, Bucharest, Romania

The maritime industry investigates how to lower its carbon footprint, which led to more interest in alternative technologies like nuclear power. Traditional engines that use fuel oil are now facing stricter rules because of greenhouse gas emissions and environmental issues. Nuclear propulsion is considered for large ships since it does not produce direct operational emissions and allows ships to sail longer without refueling.

This study compares nuclear and conventional fuel propulsion for large commercial vessels, looking at technical and economic performance, environmental impacts, and the regulatory and administrative requirements. The goal is to see how nuclear propulsion could help reduce greenhouse gas emissions in shipping. This study depicts a comparative technical and economic analysis of HFO-based propulsion and nuclear propulsion systems for large commercial vessels. Essential parameters include energy efficiency, fuel consumption, lifecycle costs (CAPEX and OPEX), operational autonomy, and environmental impact. Additionally, qualitative factors, particularly regulatory constraints, organizational requirements, safety considerations, and social perception, are evaluated based on current commercial reports and maritime frameworks, including guidelines from the International Maritime Organization.

The study shows that nuclear propulsion has many advantages, such as being more efficient, lacking a need for fuel, and producing no emissions. Over the vessel lifecycle, nuclear systems become economically competitive under high fuel prices and carbon regulations. However, high initial capital costs, complex operational requirements, and limited regulatory harmonization remain major barriers. Furthermore, public beliefs and port access restrictions significantly affect the feasibility of implementation.

Nuclear propulsion is a technically feasible and possibly cost-effective option for some types of large ships. However, regulatory frameworks and public acceptance, which are non-technical factors, limit the widespread adoption of nuclear propulsion in commercial shipping. Future development will depend on harmonized international regulation, cost reduction of reactor technologies, and increased confidence in nuclear safety within the maritime sector.

sciforum-164382: Navigating the Regulatory Landscape: Advancing Sustainable Aviation Fuel Production in Brazil's Energy Transition

Silmara Furtado da Silva [1,*] and Maria Letícia Murta Valle [2]

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This study examines the development of sustainable aviation fuels (SAF) in Brazil within the broader context of global decarbonization and energy transition objectives. Despite Brazil's established leadership in biofuels, the adoption of SAF remains incipient, hindered by technological, economic, and regulatory barriers. Through a comprehensive review of national initiatives from 2000 to 2024, this research quantifies Brazil's significant potential, estimating that sugarcane residues alone could produce 6.48 billion liters of SAF annually via the Alcohol-to-Jet (ATJ) pathway, meeting up to 90% of the country's fossil jet fuel demand. The analysis highlights that global SAF production surpassed 600 million liters in 2023, yet this represents only 0.53% of total aviation fuel consumption. In Brazil, key challenges include production costs, which remain 20% higher than conventional jet fuel, and a regulatory environment requiring alignment with international standards such as ASTM D7566, which currently permits only a 50% blend limit for most SAF pathways. The study evaluates the role of pivotal policies like the *Programa Combustível do Futuro* and the *RenovaBio* program, which generates decarbonization credits (CBIOs), in fostering a supportive governance ecosystem. It further identifies critical bottlenecks in environmental licensing and the need for enhanced public-private collaboration to de-risk investments. Recommendations are provided to streamline multi-stakeholder engagement, implement targeted fiscal incentives, and consolidate regulatory frameworks to accelerate SAF integration. These efforts are essential for Brazil to meet its ambitious Nationally Determined Contribution commitments to reduce greenhouse gas emissions by 48.4% by 2025 and 53.1% by 2030, positioning its aviation sector for a sustainable, low-carbon future.

sciforum-173469: Operational Risk Governance in LNG Bunkering: A Cross-Country Comparative Analysis of Commissioning Practices

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This study presents a cross-comparative analysis of LNG bunkering operations performed in Romania, Spain, and Canada during the commissioning phase of a dual-fuel Ro-Ro vessel. The investigation examines operational sequences, safety management frameworks, and environmental safeguards implemented in three distinct maritime settings: Damen Shipyard in 2 Mai (Romania), the Port of Cartagena (Spain), and the Port of Tilbury in Vancouver (Canada). Particular attention is directed toward variations in tank cooldown strategies, LNG transfer configurations, and applied risk-control measures.

In the Romanian case, a phased thermal conditioning procedure was implemented using vaporized and liquid nitrogen to gradually reduce system temperature prior to LNG introduction. Transfer was conducted through pressure differential, emphasizing equipment preservation and procedural compliance. The Spanish operation relied on established terminal infrastructure and truck-based pumping systems, coordinated closely by the vessel's engineering personnel within a structured port environment. By contrast, the Canadian bunkering process, executed after vessel delivery under client supervision, involved direct LNG transfer without progressive cooldown, raising concerns regarding potential thermal loading effects on critical components, including the tank loading valve.

The comparative evaluation identifies procedural strengths and operational vulnerabilities across the three contexts. The findings underline the necessity for harmonized commissioning standards and clearly defined cooldown protocols, particularly in regions lacking mature LNG bunkering infrastructure. Overall, the analysis contributes to the development of safer, standardized approaches for LNG adoption in maritime transport and supports ongoing efforts to enhance regulatory coherence and environmental responsibility in emerging LNG markets.

sciforum-174601: Strategies for decarbonization and resilience - the path towards clean emissions transport on European coastal regions

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Decarbonization is one of the greatest global challenges, with deep implications for industry, agriculture, and maritime transport. Within the maritime sector, which carries approximately 90% of European trade, the transition toward alternative fuels marks a pivotal "Era of Change" driven by accelerating biodiversity loss and escalating oceanic thermal stress. While the maritime industry is indispensable to global commerce, its carbon footprint remains a primary environmental concern. The emissions generated by shipping are a major concern because of their impact on the environment. Studies reveal that while ammonia substitution offers a viable pathway for reducing CO_2 emissions, it introduces secondary environmental risks, specifically the increased NO_2 emissions due to the high fuel-bound nitrogen content. The present world is characterised by multiple uncertainties and risks, which may cause serious disruptions to maritime transport. As maritime transport systems become obsolete, they become more vulnerable. Therefore, enhancing the resilience of maritime transport requires developing reliable methods and approaches. Alternative fuels are becoming indispensable to the vision of green shipping and decarbonisation. This technique, together with carbon taxes, will have a long-term impact on reducing carbon emissions. Contemporary marine propulsion systems are increasingly engineered for high thermal efficiency and multi-fuel adaptability, allowing vessels to transition between energy sources based on global market availability. For marine engines, different types are proposed. Some, such as biofuels and LNG (liquefied natural gas), are seen as short term solutions, while the fuel sources of the future will be electronic fuels, methanol, and ammonia. This paper highlights the necessity of securing a sustainable future for European coastal navigation through decarbonization and the adoption of alternative fuels for the maritime sector. At the same time, this study outlines the need for interdisciplinary research into alternative solutions for navigating coastal regions, such as fuel cells, gas turbines or e-fuels.

sciforum-173461: Thermal Transient Control and Safety Validation During LNG Tank Cooldown Before First Marine Bunkering

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This poster provides a technical overview of the safety framework implemented during the initial thermal conditioning of an LNG storage tank installed on a dual-fuel Ro-Ro vessel prior to its first bunkering operation. The procedure, carried out at Damen Shipyard in 2 Mai, Romania, consisted of a controlled and progressive cooldown sequence designed to prepare the cryogenic system for LNG introduction while minimizing thermal gradients and mechanical stress. Vaporized and liquid nitrogen were employed in successive stages to gradually decrease tank and pipeline temperatures under strict operational supervision.

Continuous monitoring of temperature evolution, pressure stabilization, and vapor management was conducted to ensure structural integrity and prevent unintended releases. Special consideration was given to the routing, insulation, and secure positioning of cryogenic transfer hoses in order to eliminate the risk of contact with heat-sensitive structural elements of both the vessel and the quay infrastructure. Compliance with the International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels (IGF Code) guided all operational decisions and safety precautions.

The poster outlines the principal technical phases of the cooldown procedure, the environmental protection measures adopted, and the risk-mitigation strategies applied throughout the operation. The documented experience contributes to current knowledge on LNG vessel commissioning practices and offers practical guidance for shipyards conducting pre-bunkering preparations in locations without permanent LNG terminal installations.

sciforum-176210: A technique for a secondary manual flat polishing of multimode ferrules to correct its geometric parameters for efficient wireless energy transition

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This study examines manual polishing methods for optical ferrules to correct geometric irregularities (apex offset, radius deviation, misalignment) and repair in-service damage. The goal is to provide an effective, low-cost solution for situations where expensive equipment is impractical, such as in small-scale production or laboratories. This work is critical for advancing wireless energy transmission, which increasingly relies on high-power laser systems delivered through fiber optics. In such systems, the precision of optical connections is paramount to minimize energy loss and ensure safe, efficient power transfer.

Patch cords were fabricated using standard multimode cable and FC connectors. Initial inspection identified obvious defects. Samples were characterized using a microscope and an optical spectrum analyzer. A separate group of fibers was intentionally damaged through mechanical abrasion. Both the damaged group and samples with geometric deviations were subjected to secondary polishing using various techniques.

The combined polishing method proved most effective for geometry correction. Secondary polishing successfully eliminated damage from excessive wear in most cases. For samples with gluing violations that underwent secondary polishing, 75-80% showed no geometric deviations from the norm. However, physical strength tests revealed that defects originating at the gluing stage often led to eventual failure, and core misalignment caused gradient loss depending on connector rotation.

The study identified key regularities: Correct secondary polishing reduces apex offset from 300 nm to 30-50 nm in 80% of samples. Ineffective secondary polishing usually indicates deeper, uncorrectable defects like cracks or misalignment. These findings are critical for wireless power applications, where such flaws could lead to catastrophic connector failure or significant transmission inefficiency. For reliable quality assessment, it is recommended to complement insertion loss measurements with mechanical tests. Rotating the connection 360 degrees to measure loss stability helps identify axis misalignment and determine the potential reliability of the connection.

sciforum-168890: An Empirical Analysis of sustainable Energy Development in the Danube Region

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The Danube holds a strategic position and is a key region for economic cooperation, transportation, and energy security. In the context of the global energy transition and the European Union's climate neutrality objectives, sustainable energy is becoming central to the future of the Danube region. This paper presents an empirical analysis of renewable energy development in the Danube region. The study is based on Eurostat data covering the period 2013–2023 and examines key indicators such as the share of renewable energy in the energy mix, installed capacity, and the evolution of major renewable energy sources. Hydropower offers important advantages, including relatively stable energy production and low carbon emissions, but its dependence on hydrological conditions and impacts on aquatic ecosystems are major limitations. Beyond hydropower, solar and wind energy are gaining increasing importance in the Danube region. Over the last decade, investment in these renewable sources has increased significantly, helping to diversify the energy mix and reduce dependence on hydropower. Biomass is also an important component of sustainable energy in the Danube region, especially in rural areas. The use of agricultural residues, forestry waste, and dedicated biomass contributes to the production of heat and electricity while supporting the local economy. However, the development of sustainable energy in the Danube region faces many challenges. Climate change is having a direct impact on the hydrological regime of the Danube, affecting the flow of the river and, consequently, hydropower production. The study outlines the region's potential to support the European energy transition and regional green energy cooperation. At the same time, the paper aims to highlight existing opportunities and good practices at the regional and European levels, emphasizing cross-border cooperation, EU policies, and the role of technological innovation.

sciforum-175148: Comparative Analysis of Fuel Consumption Between Engine Idling and Engine Stop Restart in Traffic Conditions

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At present, increased fuel consumption and air pollution are major problems in heavy traffic conditions where engines run at idle speed. Although some modern vehicles have automatic idle stop technology to reduce fuel consumption and emissions and still a wide range of older vehicles still don't have this feature. Drivers often face the decision of whether to keep the engine idling or switch off the engine and restart it during traffic stops. This study experimentally investigates fuel consumption of conventional gasoline powered vehicles under various driving patterns by analyzing vehicle performance during starting and idling. The Mass Air Flow (MAF) sensor data were collected using a LAUNCH OBD-II scanner connected to a Toyota 1NZ-FE, 1500CC, four-cylinder inline liquid cooled engine under operating temperature range of 85-95°C. Considering multiple start-idling-stop tests, MAF values were plotted against time to calculate the air flow rate during starting and idling. The average fuel masses were obtained using the starting air fuel ratio 13:1 and idling air fuel ratio 14.7:1. Based on the results, starting fuel consumption was 0.380g and idling fuel consumption rate was 0.123g/s. Ultimately if engine is idling more than 3.07s, it starts wasting fuel. This analysis is purely based on the fuel consumption and emissions, neglecting air conditioning, battery charging and other auxiliary functions. Based on the results, it is more fuel economical and environmentally friendly to stop and restart the engine if the vehicle is required to stop more than 3.1s due to urban traffic conditions. Furthermore, this study should be extended considering secondary factors such as starter motor, and battery wear etc. These findings contribute to reducing urban air pollution due to CO, CO2, NOx, improving fuel efficiency and aiming to develop a suitable unit for vehicles which doesn't have the factory fitted idle stop function.

sciforum-180196: Construction and Parametric Determination of a Thermodynamic Model for Heterogeneous Nucleation of Tetrahydrofuran Hydrate on Solid Surfaces Based on Classical Nucleation Theory

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Introduction

Heterogeneous nucleation at the solid/liquid interface is the rate-limiting step in hydrate formation, yet existing classical nucleation theory (CNT) models rely on empirical parameters and consider only contact angle, neglecting the complex effects of solid surface chemistry, such as surfactant adsorption and modification on interfacial thermodynamics. The mechanistic basis for how solid/liquid interfacial thermodynamic parameters quantitatively effect hydrate nucleation remains unresolved.

Methods

Building upon static nucleation experiments of tetrahydrofuran (THF) hydrate conducted on metal substrates with surfactants, nucleation statistics were analyzed via cumulative nucleation probability, from which experimental nucleation rates and lag times were extracted using an exponential fitting model. Contact angles and interfacial tensions (hydrate/solution, substrate/solution) were measured and combined with Young's equation and the Berthelot mixing rule to determine solid/hydrate interfacial tensions. These parameters were used to compute critical cluster sizes, nucleation free energy barriers, and kinetic pre-factors. The thermodynamic model was subsequently corrected using Gibbs free energy or availability function approaches to incorporate surfactant-induced interfacial modifications beyond contact angle alone.

Results

Quantitative analysis revealed that solid/liquid and hydrate/liquid interfacial tensions and contact angles exert strong, coupled control over nucleation free energy barriers and critical cluster size, producing orders-of-magnitude variation in predicted nucleation rates across systems. Critically, anionic surfactants were found to suppress heterogeneous nucleation on metal surfaces by elevating the solid/liquid interfacial energy, whereas cationic surfactant promoted nucleation by reducing hydrate/liquid interfacial tension, a differentiated mechanism that kinetic mass-transfer theories alone cannot explain.

Conclusions

A corrected heterogeneous nucleation thermodynamic model was established with experimentally back-calculated parameters, enabling quantitative prediction of nucleation behavior from interfacial properties. This framework provides a mechanistic thermodynamic basis for rationalizing and designing synergistic substrate-surfactant systems for controlled hydrate formation.

sciforum-174761: Cross-border Porter hypothesis: Does environmental policy stringency induce innovation across borders?

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According to the Porter hypothesis, environmental policy (EP) creates incentives for innovation that compensate for the costs of compliance to more stringent regulations. We extent the hypothesis to investigate cross-border regulatory spillovers stemming from foreign EP. We test whether the EP stringency of a given country induces innovation in its neighbouring countries by applying a Spatial Durbin Model and data from 19 European Union (EU) countries (from 2001 to 2020). We utilise the EU's renewable energy and energy efficiency policy as an example of an international EP that has been adapted nationally with varying stringency levels. Our results support the Porter hypothesis in cross-border settings: the innovation performance of a given country is influenced positively by the EP regulatory environment of its neighbours. The result is driven mostly by non-market-based policy instruments (emission and content limits). Finally, our results suggest that environmentally very stringent energy policy targets turn out as counterproductive for innovation particularly in countries that are far from meeting them. The results suggest that there are trade-offs in the attempts of the EU to cohesively foster both the renewable energy and energy efficiency of all member states and its economic performance based on an innovation forerunner status in the energy sector.

sciforum-175265: Decarbonization Without Illusions: Why Nature Markets Misprice Risk in Asia and How Policy Must Respond

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Asia's decarbonization strategies increasingly lean on market-based "nature solutions": carbon credits from forests and mangroves, voluntary carbon markets, and emerging nature-related disclosure regimes. Governments and firms present these as win–win tools that lower mitigation costs, unlock private finance, and protect ecosystems. This paper argues that, in Asia's current political economy, these mechanisms systematically **misprice climate and ecological risk**, creating a "valuation paradox" in which nature is simultaneously over-valued as a financial asset and under-valued as critical infrastructure for climate resilience.

Drawing on recent evidence on Asian carbon markets, global offset scandals, and nature-based finance flows, we show that: (i) demand for low-quality offsets by major companies undermines decarbonization and locks in fossil assets; (ii) nature-based credits in Southeast Asia raise acute justice and land-use trade-off concerns; (iii) public finance still provides roughly 80–90% of NbS funding globally, while private capital largely free-rides; and (iv) heavy bets on future carbon removal risk delaying hard sectoral decarbonization in Asia's energy- and industry-intensive economies.

We advance three contrarian propositions. First, nature-based carbon markets should be treated as a scarce, tightly regulated complement to, not a substitute for, domestic decarbonization. Second, policy should shift from "pricing nature" to treating key ecosystems as critical physical infrastructure, funded and governed like grids or ports. Third, Asian regulators should move from disclosure-only frameworks to binding nature-related capital and transition rules, especially for high-emitting and land-intensive sectors.

We propose a policy package for Asia built around (i) "no-offset" rules for core fossil assets, (ii) sovereign nature facilities and floor-price auctioning for high-integrity credits, (iii) mandatory nature-related risk charges in financial regulation, and (iv) a just-transition framework for communities affected by NbS projects. The paper reframes nature finance as a **governance problem, not a market design glitch**, and offers a regionally grounded agenda for decarbonization without illusions.

sciforum-176770: Eco-Friendly Fabrication of Zinc Oxide Nanoparticles Using *Ixora coccinea*: A Green Nanotechnology Approach

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The development of sustainable nanomaterials through green synthesis has gained significant attention as an alternative to conventional chemical methods that contribute to environmental pollution. In the present study, zinc oxide nanoparticles (ZnO-NPs) were successfully synthesized using aqueous flower extract of *Ixora coccinea* as a natural reducing and stabilizing agent. The phytochemical constituents such as flavonoids and phenolic compounds facilitated the bioreduction of zinc ions, leading to the formation of stable nanoparticles.

The formation of ZnO-NPs was confirmed by UV–Visible spectroscopy, which exhibited a characteristic absorption peak at **~372 nm**. Fourier-transform infrared spectroscopy (FTIR) analysis revealed the presence of functional groups responsible for capping and stabilization of nanoparticles. X-ray diffraction (XRD) studies indicated a crystalline hexagonal wurtzite structure with an average particle size of **28–35 nm**, calculated using the Debye–Scherrer equation. Scanning electron microscopy (SEM) images demonstrated predominantly spherical morphology with slight agglomeration.

The biosynthesized ZnO-NPs exhibited significant antioxidant activity with **~68% DPPH radical scavenging activity** at higher concentrations. Additionally, antimicrobial studies showed notable inhibition zones against *Escherichia coli* (**~14 mm**) and *Staphylococcus aureus* (**~16 mm**), indicating strong antibacterial potential. The enhanced biological activity is attributed to the synergistic effect of ZnO and bioactive phytoconstituents from *Ixora coccinea*.

The eco-friendly synthesis route not only reduces the use of toxic chemicals but also supports sustainable material development aligned with environmental protection and decarbonization strategies. The findings suggest that *Ixora coccinea*-mediated ZnO nanoparticles hold promising potential for applications in biomedical and environmental domains, including antimicrobial formulations and pollutant remediation.

sciforum-180297: Electrocoagulation-Driven Remediation of Construction Site Wastewater: Toward Sustainable Practices

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Many construction activities produce large amounts of waste that are highly contaminated, especially from the washing of construction equipment. Currently, there are limited sustainable and efficient treatment options available to treat the wastewater produced by these activities. This research describes the characterisation and treatment of wastewater generated from an industrial construction site located in northern Morocco.In preliminary analysis, very high levels of organic matter and suspended solids were shown to exceed limits set by regulations for discharge. Such results clearly indicate that there exists a critical need for an effective treatment system to treat this type of wastewater. Additionally, the complexity of the wastewater produced from construction sites is further increased by the presence of oils, fine particles and other construction debris, which further illustrates the critical need for effective treatment systems to address the unique characteristics of wastewater produced from construction sites.Utilising aluminium electrodes, electrocoagulation was evaluated as a potential method to treat wastewater. The ability of this treatment method to reduce the concentration of targeted pollutants and the quality of the wastewater after treatment was evaluated at a variety of operating conditions.Based on the results achieved from using electrocoagulation, this treatment method appears to be a viable, sustainable option for treating wastewater from a construction site. Not only does this provide a method for removing pollutants effectively, but it also has the potential to recover and reuse water that has been treated, thus improving the environmental performance of the construction industry.

sciforum-175394: Energy in buildings and comfort of the occupants

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Efficient design generation is key to the application of solar radiation in buildings, particularly when renewable energy is intended to enhance occupant comfort. Renewable energy is considered in the development and assessment of building design, thermal comfort, and indoor air quality in buildings with complex topology. In this work, the building thermal response software is used. In this numerical model, the energy and mass balance integral equations for the transparent and opaque building bodies are used for temperature and contaminants evaluation. In thermal comfort, the PMV and PPD indices are used. Indoor air quality is assessed based on carbon dioxide concentration. A building with a complex topology, used as a shopping centre, and equipped with internal greenhouses in the ceiling, will be analysed. The building has a circular configuration, featuring a central corridor (with a greenhouse in the ceiling) and stores on both sides. The airflow is transported from the external environment to the central corridor and then to the stores on both sides. Indoor air quality is ensured by maintaining an acceptable airflow rate. The study was conducted under winter conditions in a Mediterranean environment. The greenhouse contributes to obtaining thermal comfort conditions both in the corridor and on stores.

sciforum-169110: Enhancing Sustainability of European Floating Structures through Renewable Energy Integration

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The deployment of renewable energy technologies represents a key pathway for exploiting offshore resources and supporting the transition toward sustainable power generation. In this context, floating offshore structures enable energy extraction in deep-water environments where conventional fixed systems are not feasible. This study develops a data-driven assessment of the renewable energy potential associated with floating offshore structures in European seas and proposes an integrated framework for evaluating their sustainable design. The analysis is performed using a curated dataset of European offshore energy projects, incorporating installed capacity, spatial distribution, and technology-specific development indicators. A statistical methodology is applied to quantify regional variability and to identify dominant trends in the deployment of floating renewable technologies. The results demonstrate a rapid increase in floating offshore wind capacity, alongside the emergence of floating photovoltaic systems and hybrid wave–wind–solar configurations. Significant regional disparities are identified in terms of technological maturity, project scale, and growth rates. In addition, a set of sustainability indicators is defined and applied to assess key design aspects of floating structures, including material efficiency, life cycle performance, and environmental impact mitigation. The analysis further evaluates the integration of circular economy principles within current design practices. The proposed approach enables the identification of performance gaps and technological constraints, providing a quantitative basis for optimizing future floating offshore systems. The results support the development of more efficient and sustainable design strategies tailored to European offshore conditions.

sciforum-179112: Environmental Policy Instruments for Energy Transition and Decarbonization: A Systematic Review

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The transition from fossil fuel-based energy systems to low-carbon energy systems is now recognized as one of the major global priorities in the face of climate change, energy insecurity, and environmental degradation. Environmental policies are found to play a significant role in determining the speed and direction of energy transition and decarbonization processes. This study presents the systematic review of literature on environmental policy instruments in support of energy transition and decarbonization processes. The systematic review was conducted following the PRISMA 2020 protocol and includes literature on the effectiveness and implementation challenges of environmental policy instruments such as carbon pricing, emissions trading, incentives to renewable energy sources, fossil fuel subsidy reform, energy efficiency policies, green industrial policies, and carbon border measures. Relevant literature was identified using structured database searches with the help of pre-defined keywords and inclusion criteria. The review synthesizes literature from the power sector, transportation sector, industrial sector, and buildings sector with due consideration of regional variations and the characteristics of environmental policies. Existing literature indicates that no single policy instrument is sufficient to achieve deep decarbonization; rather, effective transitions are associated with policy mixes that combine market-based tools, regulatory standards, public investment, and institutional support. Persistent barriers include infrastructure lock-in, financing constraints, governance fragmentation, unequal institutional capacity, and social equity concerns. The review concludes that environmental policy for energy transition must move beyond isolated interventions and instead adopt integrated, adaptive, and just-transition-oriented frameworks capable of accelerating emissions reduction while supporting inclusive development.

sciforum-164585: Evaluation of Torrefied Fruit and Vegetable Residues as a Sustainable Coal Substitute: Fuel Quality Characterization and ASTM D388 Classification

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As of 2023, the Philippines' greenhouse gas emissions had increased by 49.9% compared with 2012, largely due to its coal-dependent energy infrastructure. Identifying renewable, drop-in alternatives to coal is therefore critical for mitigating air pollution and climate change. This study evaluates the fuel properties of biochar produced from market waste fruit and vegetable residues (FVR) and benchmarks its performance against commercial coal standards.

Biochar samples produced at torrefaction temperatures of 200–300 °C were analyzed following ASTM D1762 (Modified) to determine moisture, volatile combustible matter (VCM), ash, and fixed carbon contents. Higher Heating Value (HHV) was measured using a bomb calorimeter in accordance with ASTM D5865. Fuel properties were classified based on ASTM D388 to identify comparable coal ranks.

The maximum HHV obtained was 11,560 BTU/lb at 300 °C for 90 minutes, comparable to bituminous coal. At 200 °C, HHVs ranged from 9,060 to 10,196 BTU/lb, consistent with sub-bituminous coal. Fixed carbon content increased to 48.00% with increasing torrefaction severity, while VCM decreased to 39.70%, raising the fuel ratio (FC/VCM) from 0.22 to 1.21 and indicating improved combustion stability. Moisture content remained below 5% across all samples, and ash content ranged from 5.75% to 14.20%, within acceptable limits for industrial boiler applications.

These results demonstrate that FVR-derived biochar can serve as a renewable substitute for sub-bituminous and bituminous coal, enabling utilization in existing coal-fired systems with minimal infrastructure modification.

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sciforum-178353: Integrated Thermochemical and Electrochemical Valorization of Carbonaceous Waste and CO2 for Syngas Production

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Industrial carbon dioxide utilization and the management of carbon-rich waste streams, such as rubber dust, coke, and residual biomass, remain critical hurdles for the circular economy. Conventional syngas production often requires significant external hydrogen inputs, which can limit the economic and environmental viability of CO2 recycling.

This work presents a novel integrated process and apparatus designed to synthesize syngas by coupling the Reverse Boudouard reaction with modular hydrogen enrichment.

The technology utilizes a vertical, multi-stage cylindrical reactor. In the primary section, carbonaceous residues react with CO2 to generate carbon monoxide via the [R1] reaction.

[R1] CO2 + C = 2 CO

The system is engineered for high feedstock versatility, accommodating solid materials through auger delivery and fluid or slurry-like wastes via specialized atomizers. The process can operate endothermically or in an autothermal mode; in the latter, selective oxygen injection triggers exothermic oxidation, providing the necessary enthalpy for the Boudouard transition at temperatures typically exceeding 600 – 900° C.

The resulting gas stream is filtered through an integrated dust collector before entering a secondary stage for hydrogen enrichment. This is achieved either through a catalytic Water Gas Shift reaction or via integration with water electrolysis, specifically utilizing Solid Oxide Electrolyser Cells (SOEC). The integration with electrolysis offers distinct operational advantages, including the internal recycling of pure oxygen to sustain the primary reactor's thermal balance and the precise adjustment of stoichiometric ratios. This optimization ensures the production of high-quality syngas tailored for the downstream synthesis of value-added chemicals, such as methanol and dimethyl ether.

sciforum-175367: Ionic Conductivity of Pine Needle Biochar-Derived Carbon Quantum Dots (CQDs) in Aqueous Medium for Sustainable Energy Applications

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Carbon quantum dots (CQDs) have recently gained attention for applications in electrochemical and energy storage systems as a green nanomaterial. Due to their unique surface chemistry, charge transport properties, and low cytotoxicity, CQDs are suitable for use in solar cells, photocatalysis, and drug delivery systems. In this study, CQDs were derived from Pine needle biochar at different carbonization temperatures (300 ℃ (CQD300), 500 ℃ (CQD500), and 700 ℃ (CQD700)) and investigated for their effect on ionic conductivity. The ionic conductivity of CQDs dispersed in aqueous medium was evaluated using a two-electrode configuration with stainless steel blocking electrodes. The sonicated CQD dispersion was placed between the electrodes, and electrochemical impedance spectroscopy (EIS) was carried out using an Autolab PGSTAT 302N in the frequency range of 0.1 Hz to 1 MHz at room temperature (26 ℃). The bulk resistance (R_b) obtained from the high-frequency intercept of the Nyquist plot was used to calculate the ionic conductivity. The CQD300 sample exhibited the highest ionic conductivity (9.98×10^{-4} S cm^{-1}), followed by CQD500 (7.59×10^{-4} S cm^{-1}) and CQD700 (5.00×10^{-4} S cm^{-1}). According to the results, the pyrolysis temperature variations of the precursor biochar can significantly influence ion transport within the CQD matrix. The CQDs derived from lower-pyrolysis temperature biochar possess a higher density of oxygen-containing surface functional groups, which leads to ion transport and enhances ionic conductivity. In contrast, the CQDs derived from higher-pyrolysis temperature biochar have graphitic structures and reduce the availability of polar functional groups, and it is leading to increased resistance and lower ionic conductivity. These findings demonstrate the potential of biochar-derived CQDs as sustainable nanomaterials for electrochemical and energy-related applications, such as electrolyte additives, ionic conductive fillers, and supercapacitor electrode modifiers. This will also contribute to the development of environmentally friendly energy technologies.

sciforum-170468: Next-Generation eco-friendly plasticizers for energy-efficient and durable polymer coatings in offshore wind and solar energy

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The energy transition toward renewables like offshore wind and solar power demands infrastructure with extreme durability in harsh environments. The longevity of these assets is critical for their lifecycle carbon footprint and economic viability. A significant vulnerability lies in the protective polymer coatings, which often rely on phthalate plasticizers. These additives can leach out, causing coating embrittlement and releasing pollutants. This study presents novel, non- plasticizers based on dicarboxylic acid esters, designed to create next-generation PVC coatings that enhance the durability and environmental sustainability of renewable energy infrastructure.The esters were synthesized via esterification of adipic, azelaic acids with ethoxylated alcohols (butoxyethanol, phenoxyethanol). PVC compositions were prepared with 100 wt.h. PVC, 50 wt.h. of plasticizer (1:1 blend of dioctyl phthalate (DOP) and the ester). Performance properties were evaluated: migration resistance, water absorption, thermal stability at 185°C, and UV stability via 1000-hour exposure at 65°C (ΔE color change). The binary systems demonstrated a significant synergistic improvement over pure DOP. Migration resistance increased by a factor of 2-3, with the DOP + Diphenoxyethyladipate blend showing the lowest migration (0.18% vs. 0.50% for DOP). Water absorption for butoxyethyl ester blends was as low as 0.26%. Thermal stability time reached up to 150 minutes (DOP + Dibutoxyethylazelate). Phenoxyethyl-based esters provided superior UV stability, with ΔE values of 10.76-13.67 versus >20 for butoxyethyl analogs and 25 for pure DOP, indicating effective protection against photo-degradation. The binary system based on DOP and diphenoxyethyladipate represents a ready-made innovative solution for creating durable, environmentally friendly protective coatings in the wind and solar energy industries. High migration resistance guarantees the durability of the coating and the absence of environmental pollution, which is critical for offshore installations. Excellent UV stability (ΔE ~11) provides protection from solar radiation, and improved thermal stability (150 min) increases reliability under operational heating conditions.

sciforum-180277: Next-Generation Solar Thermal Processing: Integrating Photovoltaic Support and Bioclimatic Materials for Sustainable Tomato Dehydration in Variable Climates

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Post-harvest losses of horticultural products in tropical highland regions can exceed 30% due to insufficient drying infrastructure. Although solar drying offers a low-carbon preservation alternative, its performance is strongly constrained by climatic variability. In regions such as Mosquera, Cundinamarca (Colombian Andes), characterized by fluctuating solar radiation (4.2–4.8 kWh/m²·day), high relative humidity, and frequent cloud cover, conventional passive solar dryers exhibit limited efficiency and operational reliability. This study presents the design and assessment of a hybrid solar dryer integrating solar thermal energy with photovoltaic-powered auxiliary heating to ensure stable operation under variable conditions.

The system was dimensioned for 10 kg of fresh tomatoes using a coupled heat and mass transfer model under local climatic inputs. The configuration combines direct solar heat gain with photovoltaic-driven electric heating, maintaining target drying temperatures (45–60 °C) under low irradiance conditions (300 W/m²). Environmental performance was evaluated through a cradle-to-grave life cycle assessment (LCA), comparing industrial (stainless steel–polycarbonate), traditional (wood–glass), and circular (recycled polymers–natural fibers) designs in terms of embodied energy, carbon footprint, and durability.

The hybrid configuration reduces drying time by 25–30% relative to passive systems while ensuring thermal stability. The circular design exhibits the lowest initial carbon footprint (≈30 kg CO_2-eq), whereas the industrial configuration achieves superior eco-efficiency over a 10-year lifespan due to enhanced durability and thermal performance. Photovoltaic integration offsets approximately 134 kg CO_2-eq annually and results in an economic payback period of 7–9 years under local electricity tariffs.

These results demonstrate a robust, energy-efficient, and low-carbon drying solution adaptable to diverse tropical highland contexts, highlighting the potential of hybrid solar systems coupled with circular materials to enhance climate resilience in agro-industrial applications.

sciforum-176494: Optimization of a Building Wall Using a Bio-Sandwich Panel Composed of OSB and Bio-Based PCM

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Improving the thermal performance of building envelopes while reducing construction costs is a key challenge in sustainable building design. Phase change materials (PCMs) offer an effective solution for thermal energy storage due to their ability to absorb and release latent heat during phase transitions. This study proposes an innovative wall configuration incorporating a bio-sandwich panel composed of oriented strand board (OSB) and a bio-based PCM in order to enhance indoor thermal comfort while maintaining a reduced wall thickness.

A multilayer wall model was analyzed consisting of 1.5 cm of cement, 15 cm of brick, and 1.5 cm of plaster, resulting in a reference wall thickness of 18 cm without PCM. A second configuration integrates a 5 cm bio-sandwich panel made of two OSB layers (1 cm each) and a 3 cm layer of bio-based PCM. Heat transfer was simulated under summer climatic conditions representative of Constantine (36.3650° N, 5.5228° E), including solar radiation, wind speed, and ambient temperature variations. The PCM layer was positioned near the exterior surface to enhance thermal energy storage and release. Numerical simulations were conducted using experimentally derived correlations for equivalent heat capacity and thermal conductivity.

The results demonstrate that the wall containing the bio-sandwich panel significantly stabilizes indoor surface temperatures. During summer conditions, the interior wall temperature of the reference wall varied between 24.2 °C and 33.9 °C, whereas the proposed wall maintained temperatures between 26 °C and 28 °C. The maximum temperature amplitude was reduced from 7.35 °C to 1.75 °C, indicating a strong improvement in thermal stability and indoor comfort. In general, the proposed wall design provides a cost-effective and environmentally friendly solution for building envelopes. By combining sensible and latent heat storage through OSB and bio-based PCM layers, the system enhances thermal performance, reduces temperature fluctuations, and offers additional interior space, making it a promising approach for sustainable construction.

sciforum-179673: Techno-Economic Assessment of Green Hydrogen Production in El Galala, Egypt: A Comparative Study Between Wind and Solar PV Energy Sources

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This research paper presents a comprehensive technological and economic assessment of large-scale green hydrogen production in El Galala, Egypt, using wind and solar photovoltaic (PV) systems as primary renewable energy sources. Hourly simulations were performed using the System Advisor Model (SAM) to evaluate capacity factors, electrolyzer utilization, pathway efficiency, hydrogen-specific energy consumption, and levelized cost indicators. Results indicate that wind systems outperform solar PV in both operational and conversion efficiency, achieving capacity factors of 30–40% and pathway efficiencies of approximately 29–40%, compared to 22–28% and 15–18% for PV systems, respectively. Wind energy enables higher electrolyzer utilization and steadier operation, resulting in lower energy consumption per kilogram of hydrogen. A hybrid solar–wind configuration provides the most continuous year-round power supply and yields a real LCOE of 5.90 ¢/kWh. Although the standalone renewable plant scenario is not financially viable due to negative NPV and IRR, the economics improve significantly when power is used to produce high-value hydrogen derivatives. Among these, the green ammonia demonstrates the highest commercial maturity, strong global demand, and alignment with Egypt's national hydrogen-export strategy. The results highlight El Galala as a promising location for renewable-powered hydrogen production and support Egypt's Vision 2030 pathway toward becoming a regional hub for green hydrogen and associated derivatives.

sciforum-174278: The model for estimation of the effect of an atmospheric light scattering on a wireless energy transition

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The propagation of laser radiation through optically inhomogeneous media causes beam broadening and energy redistribution. A turbid medium, such as atmospheric aerosols (fog, haze, clouds, or dust storms), contains suspended particles that induce multiple scattering. The initial beam energy is not lost but converted into a diffuse glow, which hinders imaging and focusing. Therefore, it is crucial to understand these effects and increase the power transmitted through such media.

Adaptive optics can mitigate scattering. While classical wavefront correction works in media with smooth refractive index changes, high concentrations of random inhomogeneities, like in biological tissues, disrupt coherence and require more sophisticated techniques. This study operates in the "crossover mode," where the transmitted radiation retains partial coherence, allowing the use of classical adaptive algorithms despite the presence of diffusers.

Numerical calculations and experimental measurements analyzed the transformation of a 0.65 μm laser beam through a layer of suspension. Polystyrene microspheres (1 μm diameter, refractive index 1.582) served as diffusers in a medium with an average refractive index of 1.33. Concentrations ranged from 10^5 to 10^6 mm^{-3}, modeling optical conditions from weak haze to dense fog, with visibility from several kilometers down to 300–500 meters.

The beam broadening was quantified using the Full Width at Half Maximum (FWHM), with the initial beam width normalized to 1.0. Simulations were performed using the Monte Carlo method. At a scatterer concentration of $N = 1.5 \times 10^5$ mm^{-3}, slight beam widening occurred, with FWHM increasing to 1.06. Increasing the concentration to $N = 3.8 \times 10^5$ mm^{-3} resulted in more pronounced broadening, reaching an FWHM of 1.24. At the maximum concentration of $N = 7.5 \times 10^5$ mm^{-3}, the broadening was most significant, with FWHM increasing to 1.6 and the beam profile becoming highly diffuse. The results clearly demonstrate that the total beam width at half maximum increases with the concentration of scatterers in a turbid medium.

sciforum-178945: The World's First 700 TEU Pure Electric River–Sea Container Ships: Energy Architecture, Emissions Accounting, and Operational Feasibility

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The decarbonisation of short-sea and inland waterway transport is one of the most operationally complex challenges in maritime climate policy, owing to fleet size, route diversity, and the limited applicability of fuel-switching technologies at the cargo scale. This study provides independent technical and environmental validation of the COSCO SHIPPING Zhong Yuan Hai Yun Lü Shui 01 and 02—the world's first 10,000 DWT pure-electric river–sea container ships, which entered commercial service on the Nanjing–Yangshan (Shanghai) corridor on 22 April 2024. Technical parameters were triangulated from five categories of primary source; CO2 reductions were quantified using IMO Tier III emission factors; and the analysis was extended to well-to-wake upstream emissions and a battery lifecycle assessment drawing on peer-reviewed LCA literature. Each vessel integrates a fixed 50.4 MWh lithium iron phosphate (LFP) bank with 24 operational swappable 1.6 MWh ISO containers (38.4 MWh), enabling a 540 NM range at 10.5 knots while preserving the full 700 TEU payload. Tank-to-wake CO2 avoided was confirmed at 12.3 t per 100 NM; annual reductions range from 2,918 t (42% utilisation) to 6,922 t at full utilisation, equivalent to 2,032–4,820 passenger cars. Well-to-wake analysis incorporating China's 2024 grid intensity (560 gCO2/kWh) yields a net advantage of 6.1 t CO2 per 100 NM, rising to 7.1 t/100 NM under H1 2025 intensity (492 gCO2/kWh), suggesting decarbonisation is proceeding faster than projected. LFP manufacturing carbon debt at median LCA intensity (62 kgCO2/kWh) is 2,381 t for the operational swappable system, giving a carbon payback period of under one year. Annual fuel savings are confirmed at $738,400–$1.75 million at $800/t MDO. These results demonstrate that battery-electric propulsion is a technically and economically viable pathway for decarbonising heavy cargo operations on major inland waterway corridors. Scalability is contingent on interoperability standards for battery-swapping infrastructure and continued decarbonisation of the charging grid.

Session 2. Advanced sustainable energy conversion systems

sciforum-175349: "Development and Experimental Assessment of a Passive Microclimate-Controlled Cart for Sustainable Post-Harvest Flower Preservation "

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Post-harvest losses in floriculture supply chains remain a persistent global challenge, with reported deterioration rates of 30–40% primarily attributed to inadequate temperature and relative humidity control during transportation and retail display. Cut flowers are characterized by high metabolic activity, rapid transpiration, and sensitivity to vapor pressure deficit, leading to accelerated wilting and senescence under ambient conditions. Conventional vapor-compression refrigeration systems can mitigate these effects but involve high capital investment, continuous electrical demand, and increased environmental burden. Therefore, a low-energy, decentralized microclimate stabilization solution is critically required.This study presents the development and experimental assessment of a passive microclimate-controlled vending cart based on direct evaporative cooling (DEC) principles. The system operates on adiabatic saturation, enabling sensible heat reduction through water evaporation while simultaneously increasing relative humidity. The cart incorporates a wetted porous cooling medium, capillary-fed water distribution, insulated composite wall panels, and passive airflow channels to enhance heat and mass transfer without active refrigeration.Experimental evaluation under varying ambient conditions demonstrated that the chamber temperature was consistently maintained within 20–25 °C, while relative humidity was stabilized between 85–92%, conditions suitable for minimizing transpiration-induced moisture loss in cut flowers. The system operates with significantly lower power consumption compared to conventional vapor-compression refrigeration, requiring only minimal auxiliary energy for water circulation. Shelf-life studies indicated an extension from approximately 12 hours under uncontrolled ambient exposure to up to 3 days within the controlled chamber environment.The proposed system offers a thermodynamically efficient, low-carbon, and economically viable alternative to conventional cold-chain infrastructure, providing a scalable solution for sustainable last-mile post-harvest flower preservation.

sciforum-179833: Enhanced Thermal Stability and Structural Integrity of SiC/Polystyrene Nanocomposites for Sustainable Energy Conversion Systems

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Sustainable energy conversion systems, such as power electronics and thermal management units, require materials combining lightweight processability with high thermal stability. Silicon carbide (SiC) offers wide bandgap and high thermal conductivity, while polystyrene (PS) is an easily processable matrix. This work investigates structural and thermal properties of SiC/PS nanocomposites (1–10 wt.% SiC) to identify compositions suitable for energy conversion applications. SiC nanostructures synthesized via carbothermal reduction were incorporated into PS by solution casting. X-ray diffraction (XRD) with Williamson–Hall analysis assessed structural organization, crystallite size, and microstrain. Thermal behavior was characterized by differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA) under nitrogen at 20 °C/min; degradation kinetics were evaluated by the Coats–Redfern method. XRD confirmed cubic 3C-SiC, with reflections intensifying with filler content. The 7 % SiC/PS composite exhibited highest crystallinity (crystallite size ≈ 30.23 nm) and lowest microstrain ($\varepsilon \approx 4.18 \times 10^{-4}$), indicating a well-integrated structure. At 10 % loading, significant tensile strain ($\varepsilon \approx 1.64 \times 10^{-2}$) appeared, suggesting agglomeration. DSC showed glass transition temperature (Tsub>g/sub>) increased from 96.0 °C (pure PS) to a maximum of 117.8 °C at 2 % SiC. TGA revealed that the 7 % composite achieved the highest final degradation temperature (486.5 °C) and optimal thermal endurance. Kinetic analysis demonstrated decreasing activation energy with SiC content (from 288 kJ/mol for pure PS to 194 kJ/mol for 7 % SiC at $\alpha = 0.4$), while Gibbs free energy remained unchanged, indicating preserved thermodynamic stability despite modified degradation pathways. The 5–7 % SiC/PS composites combine high structural order, minimal microstrain, and superior thermal stability, making them promising candidates for energy conversion systems requiring reliable performance under elevated temperatures, such as power electronic packaging and high-temperature insulation.

sciforum-153322: Design and Development of a Hybrid Marine Renewable Energy Platform for Optimization of the Integration of Wind, Solar, and Wave Technology

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Abstract- Ocean renewable energy represents an important solution for growing worldwide electricity demand coupled with the requirement to do so sustainably. Traditional single-source offshore schemes, such as stand-alone wind, solar or wave units, usually have difficulties because of their dependence on the variable nature at sea and hence uncertain generation, low efficiency and profitability are present. To address these constraints, we report in this research the design and demonstration of a hybrid marine renewable energy system integrating wind, solar and wave resources into a single platform. The platform is designed with a focus on low-cost, long-term structural sustainability and energy generation maximization. FEA simulations have been performed to verify the behavior of the design, demonstrating improved structural trueness, stress concentration reduction and load distribution optimization under different marine conditions. Results reveal that the hybrid mode greatly enhances reliability and robustness when compared with traditional single-source systems. The purpose of this hybrid platform Would promote the sustainable energy technology and it does provide a scalable and resilient solution for the offshore market. It also facilitates power generation for coastal regions and isolated islands, promoting the blue economy and expediting the worldwide transition to clean energy.

Keywords- Hybrid Marine Renewable Energy, Offshore Platforms, Wind Energy, Solar Energy, Wave Energy, FEA, Sustainable Energy Technology.

sciforum-169633: Design of an Urban Solid Waste Management system for waste collection and recycling

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According to Global Waste Management Outlook 2024, Urban Solid Waste (USW) is projected to reach 3.8 billion tons by 2050, with annual cost of $640 billion.

This study for the design of a preliminary proposal based on an automated and energy self-sufficient equipment for treatment of USW and produce compost for adjacent green areas. It consists of 4 phases with controlled emissions by biofilters:

I. Above-ground steel and digital container. Its structure will feature a sloping roof allowing for the installation of photovoltaic modules for its own electricity consumption. USW will be admitted through the front wall (the one with the lowest slope) of the structure, requiring a key number. A screen, on this side of the wall, will display the weight of stored USW and other parameters. There will be two identical containers, operating in parallel. A single double-surface floor will serve both containers, which will sequentially move to the adjacent container once the USW has been shredded and mixed.

II. 1st basement with controlled parameters. Thermophilic stage forced aeration and mesophilic stage.

III. 1st basement controlled with different conditions than the previous phase. Maturing and forced aeration.

IV. 2nd basement. Turning and transporting of compost to green areas.

The parallel equipment enables battery recharging and energy generation for its own consumption. Depending on the duration of each phase, excess energy could be fed into the grid.

A remote and automated system has been designed to quantify inputs and outputs supporting future development. This approach offers an economic and environmental benefits, contributes to the circular economy and reduces the carbon footprint.

Finally, the advantages for hypermarkets have been discussed, including improved purchasing planning, enhanced control and self-management of USW at district level.

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sciforum-171992: Chemical kinetics of the hydrothermal conversion

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Hydrothermal liquefaction (HTL) is an emerging thermochemical technology for converting biomass into biofuels and valuable chemicals while contributing to greenhouse gas reduction. Operating under subcritical water conditions (200–374 °C, 10–25 MPa), HTL transforms biomass into four main fractions: a bio-oil rich in energy, an aqueous phase containing dissolved organic compounds, a solid residue (bio-char), and a gaseous phase mainly composed of CO_2. Its ability to process wet biomass without prior drying, combined with high conversion efficiency and feedstock flexibility, makes HTL a promising pathway for sustainable energy production.

This study aims to develop a kinetic model for biomass HTL that integrates operational parameters (temperature and residence time) and biomass biochemical composition. Three types of biomass with different compositions—walnut (lipid-rich), walnut cake (protein-rich), and sunflower cake (fiber-rich)—were investigated. Experiments were conducted at 300 °C and 350 °C with reaction times ranging from 5 to 15 minutes. Product distribution and composition were analyzed using gas chromatography–mass spectrometry (GC-MS), high-performance liquid chromatography (HPLC), and ion chromatography (IC).

The results demonstrate a strong influence of biochemical composition on bio-oil yield and optimal reaction conditions. The highest bio-oil yield (92%) was obtained from lipid-rich biomass at 300 °C for 5 minutes. Protein-rich walnut cake produced a maximum yield of 54% at 300 °C after 15 minutes, while fiber-rich sunflower cake required a higher temperature (340–350 °C) to reach its best yield (53%). These findings confirm that lipids favor bio-oil production under milder conditions, whereas fiber-rich biomass requires more severe processing.

Identified compounds were grouped into chemical families to construct a general reaction scheme. Overall, this work provides insights into biomass-dependent HTL behavior and supports the development of predictive kinetic models for process optimization.

sciforum-180293: Global Maximum Power Point Tracking of Photovoltaic Systems under Partial Shading Using Crow Search Algorithm

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As a clean and sustainable energy source, photovoltaic (PV) systems are being included more and more into contemporary energy infrastructures. However, environmental factors like partial shade and variations in irradiance have a significant impact on their ability to generate power. The power-voltage (P-V) characteristic of the PV array displays many local maxima under partial shade conditions (PSC), making it challenging to determine the global maximum power point (GMPP) using traditional maximum power point tracking (MPPT) techniques. Among these methods, the popular Perturb and Observe (P&O) approach has the disadvantage of becoming stuck at local maxima, which lowers the efficiency of power extraction. This paper suggests a metaheuristic-based MPPT strategy that uses the Crow Search Algorithm (CSA) to get around this restriction. The CSA has proven to have strong exploration and exploitation capabilities in challenging optimization problems, and it draws inspiration from the clever ways crows hide and retrieve food. In this work, CSA is used to track the global maximum power point under partial shading conditions by determining the PV system's ideal operating voltage. Using MATLAB simulations, the suggested CSA-based MPPT's performance is assessed and contrasted with the traditional P&O algorithm. The findings demonstrate that although the P&O technique may become stuck in a local maximum, the CSA method effectively converges to the global maximum power point even in the presence of multiple local maxima. Additionally, the suggested method shows improved power extraction efficiency and quicker convergence. These findings demonstrate how well the CSA-based MPPT approach works to enhance photovoltaic systems' performance in difficult environmental circumstances.

sciforum-180310: Integration of Shallow Geothermal Systems and Heat Pumps for Microclimate Control in Greenhouses: A Systematic Analysis and Thermal Modeling Perspectives

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Precise indoor microclimate control in greenhouses is essential for optimizing crop growth, productivity, and thermal stability throughout the year. Temperature and humidity regulation directly affect plant physiology, photosynthesis, and yield quality, positioning environmental control as a central component of modern protected agriculture. In this context, shallow geothermal systems and geothermal heat pumps have emerged as efficient solutions for continuous heating and cooling, leveraging the soil's thermal inertia to stabilize internal conditions and reduce dependence on external climatic variability. This study analyzes the scientific and technical evolution of geothermal energy applications in protected agriculture through a bibliometric and conceptual approach. A structured TITLE-ABS-KEY search equation was applied to international databases, integrating terms related to geothermal energy, heat pumps, greenhouses, and microclimatic variables, while excluding studies focused primarily on emissions or large-scale environmental assessments. The resulting dataset comprises 103 documents published between 2016 and 2025, distributed across 78 sources and involving 423 authors. Keyword co-occurrence and thematic mapping reveal that "greenhouses," "geothermal heat pumps," and "pumps" function as motor themes, characterized by high centrality and density, indicating their leading role in the research field. In contrast, "geothermal energy," "geothermal fields," and "heat transfer" are identified as foundational themes supporting the conceptual structure. Emerging topics such as precise indoor temperature control, air distribution, detailed numerical simulation, and real-time monitoring show lower levels of development, highlighting critical research gaps. The results demonstrate a transition from descriptive studies toward advanced modeling approaches, including numerical simulations and coupled soil–structure–air systems aimed at improving thermal uniformity and system efficiency. It is concluded that integrating multiphysics modeling with intelligent control strategies represents the main opportunity for enhancing the design, scalability, and operational performance of geothermal systems in greenhouse environments.

sciforum-178714: Multifunctional NDI–Carbazole Electropolymers for Electrochromic and Energy-Storage Technologies

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Introduction

The development of multifunctional organic materials capable of combining optical modulation with reversible charge storage is highly relevant for emerging sustainable energy technologies. Electrochromic materials that modulate light transmission while simultaneously storing electrical energy are promising for energy-efficient systems such as smart windows and hybrid electrochromic–energy storage devices. Naphthalene diimide (NDI) derivatives are well-known electron-acceptor units due to their low-lying LUMO levels, high electrochemical stability, and efficient electron-transport properties. When combined with electron-donor groups such as carbazole, donor–acceptor architectures can provide ambipolar electrochemical behavior and tunable optical responses. Here, we investigate the electrochemical generation and functional properties of thin films derived from an NDI-based molecule bearing two carbazole units (NDI-2CBZ).

Methods.

The electrochemical behavior of NDI-2CBZ was studied by cyclic voltammetry on glassy carbon and ITO electrodes. Anodic oxidation of the carbazole groups induces electropolymerization, forming surface-confined electroactive films. The resulting materials were characterized by electrochemical and spectroelectrochemical techniques to evaluate their redox processes, optical switching properties, and charge-storage performance.

Results.

NDI-2CBZ shows well-defined redox processes associated with reduction of the NDI core and oxidation of carbazole units. Repetitive anodic cycling leads to stable electroactive films. The electrodeposited material exhibits reversible doping–dedoping processes accompanied by potential-dependent optical changes, revealing electrochromic switching behavior. Galvanostatic charge–discharge measurements display quasi-triangular profiles characteristic of pseudocapacitive behavior. The films exhibit areal capacitances of 0.52 mF cm^{-2} (n-doped) and 0.13 mF cm^{-2} (p-doped) at 0.01 mA cm^{-2}. Cycling tests show capacitance retentions of ~60% after 1000 cycles for n-doped films and ~70% after 3000 cycles for p-doped films.

Conclusions.

Electropolymerized NDI–carbazole films combine ambipolar redox activity, reversible electrochromic switching, and pseudocapacitive charge storage. Their optical modulation capability, reversible ion-coupled charge storage, and good cycling stability highlight their potential for electrochromic devices and hybrid energy-storage systems for improved energy efficiency.

sciforum-175446: Adaptive Maximum Power Point Tracking Technique for Standalone PV Systems

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Standalone photovoltaic (PV) systems require efficient Maximum Power Point Tracking (MPPT) techniques to ensure optimal power extraction under varying environmental conditions. Classical methods such as Incremental Conductance (INC) strategies provide acceptable tracking accuracy but often suffer from fluctuations around the Maximum Power Point (MPP) and slow dynamic response under fast atmospheric conditions. This work suggests an enhanced Incremental Conductance MPPT technique for a standalone PV system in order to improve tracking efficiency, performance and system stability. The proposed approach introduces an adaptive step-size mechanism that adjusts automatically according to variations in environmental conditions, enabling faster convergence toward the MPP while reducing steady-state oscillations. The standalone PV system consists of a PV array generator, a DC–DC boost converter linked to a resistive load, which is controlled by the suggested enhanced MPPT algorithm. The system is modelled and simulated using MATLAB/Simulink environment, version 2020b. The obtained simulation results demonstrate that the enhanced INC technique improves tracking accuracy and response speed compared with the conventional IC method, while maintaining stable operation under weather variations. The proposed control strategy maintains stable operation under rapid irradiance variations while ensuring reduced power losses. Its simple structure and low computational requirements make it suitable for efficient implementation in standalone photovoltaic energy conversion systems. The proposed method offers a simple and effective solution to improve power extraction in standalone photovoltaic applications.

sciforum-178138: Analysis and Implementation of Multi Input Multi Output DC-DC Buck-Boost Converters for Renewable Energy Applications

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Abstract: The Multi-Input Multi-Output (MIMO) DC–DC Buck–Boost Converter is designed to efficiently manage power from multiple input sources and provide multiple regulated output voltages for various load requirements. The Multi Input may be from Solar PV , Battery, Fuel cells.The proposed system aims to overcome the limitations of conventional single-input converters by offering flexibility, improved efficiency, and better energy utilization. It allows seamless power flow control between different DC sources, such as solar panels, batteries, or fuel cells, ensuring uninterrupted power delivery even under fluctuating input conditions and load disturbances.

Methods & Results:
The project is implemented using an Arduino Mega microcontroller that generates PWM signals to control MOSFET switches, enabling buck, boost, and buck–boost operations as required. Hardware components such as inductors, capacitors, and diodes ensure stable energy transfer, while voltage and current sensors provide real-time feedback for precise control. In this project, pulse width modulation technique is used. A different width duty cycle is applied to the input stage switches, based on enabling of duty cycle, the input can be prioritized. All the switches have different duty cycle with delay between them. On time of three stage outputs are different width as 0.7µs, 5µs, 7µs respectively to obtain the output voltage value of 3v,12v, 28v, also respectively with ripple voltage of 0.1mv,150mv,50 mv Switching frequency of 100KHz.Keeping Four inputs as same voltage 12V. This project demonstrates a cost-effective, compact, and scalable converter suitable for renewable energy systems, hybrid power architectures, and embedded applications. The combination of hardware design and embedded software control achieves efficient power conversion with improved voltage stability and reduced losses.

sciforum-175381: Bimetallic and Trimetallic Electrocatalysts for Efficient Hydrogen and Oxygen Evolution in Alkaline Media

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Hydrogen produced via water electrolysis has emerged as a subject of considerable interest due to its potential as a clean and renewable energy carrier. The hydrogen evolution reaction (HER) and the oxygen evolution reaction (OER) are the core processes; however, their sluggish kinetics and reliance on noble metal catalysts hinder efficiency and large-scale application. The development of highly efficient, durable, inexpensive, and scalable electrocatalysts, such as transition metal alloys, remains a significant challenge and a current research priority. To address this challenge, a simple electroless plating technique was employed for the fabrication of CoFe, CoFeMn, and CoFeMo coatings on nickel foam, using morpholine borane as the reducing agent. The surface morphology, structural features, and elemental composition of the coatings were characterized using scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDS), X-ray diffraction (XRD), and inductively coupled plasma optical emission spectroscopy (ICP-OES). The CoFe, CoFeMn, and CoFeMo coatings were compact, crack-free, and exhibited typical globular morphology. The electrocatalytic activity toward HER and OER was evaluated using linear sweep voltammetry (LSV) in 1 M KOH.

Electrochemical evaluations revealed that CoFeMn and CoFeMo achieved overpotentials of 135.8 and 149.6 mV for HER at 20 mA cm^{-2}, respectively, which are significantly lower than the 243.9 mV observed for CoFe. This enhancement in electrocatalytic activity can be attributed to the increased surface area and greater exposure of active sites in the CoFeMn and CoFeMo catalysts, which facilitate hydrogen evolution. Furthermore, CoFe exhibited superior OER activity, reaching 40 mA cm^{-2} at 331.7 mV, while CoFeMo and CoFeMn required 368.4 and 385.1 mV, respectively. This superior performance is likely attributable to the favorable surface morphology and composition of CoFe, which promote oxygen evolution kinetics. Overall, this study presents a novel and cost-effective approach for the development of efficient electrocatalysts for sustainable hydrogen production via water splitting.

sciforum-170484: Carbon-Aware Operational Control of Fuel Cell Test Benches Using Adaptive Model Predictive Control

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Proton exchange membrane fuel cell (PEMFC) test benches play a critical role in stack characterization and control validation, yet they consume substantial electricity for high-pressure air compression, thermal management, humidification, and other auxiliary systems during long-duration tests. Conventional control strategies primarily prioritize the precise regulation of air supply temperature, humidity, and stack thermal states, but typically neglect the time-varying carbon intensity of grid electricity, thereby limiting opportunities for operational emissions reduction.

This work proposes a carbon-aware operational control strategy based on adaptive model predictive control (AMPC). Unlike traditional approaches, real-time carbon intensity is embedded into the control objective via a time-varying weighting factor. This mechanism enables an explicit trade-off between tracking performance and electricity-related carbon impact under physical and safety constraints. The proposed approach is implemented at the device level and does not rely on system-level energy scheduling, allowing integration into existing bench control architectures with minimal hardware changes.

MATLAB/Simulink simulations under representative operating scenarios with load variations and fluctuating carbon intensity signals indicate that the carbon-aware controller effectively reduces carbon-weighted operating cost relative to a fixed-weight MPC baseline. Specifically, the controller achieves this by moderating parasitic power demand of the air supply system during high-carbon periods, while maintaining acceptable tracking performance and constraint satisfaction.

The results demonstrate that incorporating carbon intensity awareness into bench-level control is feasible and effective, supporting low-carbon operation of PEMFC test benches for sustainable fuel cell testing and validation.

sciforum-174772: Comparative Analysis of Electronic Properties in Si/GO and Si/rGO Composite Anodes: The Role of Restored Conductivity in Battery Performance

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This research investigates the synthesis and comparative electronic properties of Silicon/Graphene Oxide (Si/GO) and Silicon/Reduced Graphene Oxide (Si/rGO) composite anodes. While silicon provides a high theoretical capacity, its 300% volume expansion during lithiation necessitates a robust structural buffer. Our approach utilizes GO as a template, integrated with silica derived from Tetraethyl Orthosilicate (TEOS).

A central focus of this study is the critical transition from the insulating GO phase to the conductive rGO phase. Structural validation via XRD confirmed the oxidation of graphite to GO with a d-spacing of 8.24 Å. UV-Vis spectroscopy and Tauc plot analysis identified a wide direct optical band gap of 4.35 eV for the GO matrix. This high value confirms an insulating state dominated by hybridized defects, which, while structurally stable, limits electron transport.

To restore conductivity, a magnesiothermic reduction process was employed to simultaneously convert the TEOS-derived into nanostructured silicon and reduce the GO into rGO. This process removes oxygen functional groups and restores the hybridized carbon network. Comparative analysis shows that while the GO/Si intermediate acts as a stable structural scaffold, the final rGO/Si composite is essential for electrochemical performance. The reduction step significantly enhances the electrical conductivity and charge-transfer kinetics of the anode. These results prove that the controlled transition from the insulating GO phase to the conductive rGO phase is a vital "invention" in the synthesis of stable, high-rate capability anodes for next-generation lithium-ion batteries.

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sciforum-173740: Conceptual Design of Freeze-Cast Porous Structures for Advanced Sustainable Thermal-Systems

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Freeze casting, a well-established processing technique for producing porous structures with directionally aligned pores, provide a unique combination of high surface-area-to-volume, and anisotropic thermal transport, promising a platform for next-generation sustainable heat-exchanger components. Recent work on freeze-cast regenerators demonstrated 10–15% higher heat-transfer performance than conventional packed-bed, under passive oscillating-flow water conditions (ΔT = 10 K, T = 15–30 °C) at matched pressure drop, confirming the feasibility in heat-exchange [1]. This design approach is informed by recent advances in directional freeze-casting, which show aligned porous structures can be engineered with predictable transport pathways suitable for energy-conversion and thermal-management [2]. While such materials have been studied at microstructural level, their potential in *macro-scale heat exchanger design* remains insufficiently explored. Unlike prior studies, which focus on microstructure, this work introduces first conceptual, component-level framework for integrating freeze-cast structures into general heat-exchangers. It proposes new integration strategies as: freeze-cast lamellar plates as replacements for conventional internal fins/passive inserts. A conceptual design framework is presented that examines incorporation of freeze-cast structures into heat-exchangers from a macroscopic engineering-design perspective, focusing on qualitative relationships between pore morphology and expected transport behavior such as flow guidance, and heat-transfer pathways. The framework emphasizes design-relevant considerations including component integration, flow alignment, and potential roles as structured inserts or passive enhancement elements. By synthesizing insights from directional freeze-casting research and established heat-exchanger design principles, this work outlines novel design routes for future investigations into material-efficient sustainable thermal systems.

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sciforum-178394: Design and Development of a Hybrid Low-Emissivity and Thermoelectric Window Glazing Systems: A Systematic Review

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Window glazing is a prominent and essential feature in modern architectural building design, providing ambient natural daylighting and visual connectivity to the outside environment. Traditional and Conventional glazing systems often act as the weakest thermal link in a building sector, as they have resulted in massive thermal transmittance alongside excessive solar heat gain in warmer climates and substantial conductive heat loss during winter periods. These problems significantly increase reliance on heating and cooling systems while compromising indoor thermal comfort and undermining overall building energy efficiency.

This study focus on the design and development of a hybrid window system equipped with low-emissivity (Low-E) coatings and packet of thermoelectric generators (TEG) to simultaneously minimize the transfer of Heat and produce electricity. The proposed window system integrates with a double-glazed window that features a specialized low-E coating to reflect infrared radiation and reduce thermal transmittance.TEG embedded within the window assembly exploits the temperature gradient between the interior and exterior environments. While facilitating a continuous energy supply and a prominent building energy supply.

The proposed system integrates comprehensive modeling and prototype testing to measure the continuous low-grade energy harvesting under actual solar and ambient conditions. Experimental performance assessment shows that the hybrid architecture minimizes thermal heat loss by approximately 30% and generates a peak power output of 2W/m2, effectively transitioning the system from a passive insulator into an active micro-power generator compared to conventional double-glazed alternatives.

The proposed hybrid window glazing technique offers a synergistic, sustainable, and dual-functional solution for advanced building architectures and solar pond systems. while contributing to performance enhancement and the generation of electrical energy.

sciforum-180257: Design and Experimental Evaluation of a Biomass-Based Boiler for Sustainable Thermal Energy Supply in Rural Agroindustries

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Coconut (Cocos nucifera) is one of the most economically significant tropical crops in coastal regions of the Global South, including Colombia, where it is primarily cultivated by small-scale producers. However, its processing generates large amounts of lignocellulosic residues, particularly coconut shells, which are often underutilized despite their high potential as a renewable energy source. In this context, the development of sustainable and decentralized thermal energy systems is essential to enhance the competitiveness of rural agroindustries. This study presents the design and experimental evaluation of a biomass-based boiler using coconut shell as fuel, within the framework of the Biopalmas program in Colombia. A systematic design methodology was implemented considering the thermal energy requirements of agroindustrial processes such as vacuum frying and tangential microfiltration, while promoting circular economy principles through waste valorization. Experimental tests were conducted to evaluate combustion performance, energy efficiency, and emissions. The system achieved an average combustion efficiency of 87.2%, indicating effective fuel oxidation, although the presence of CO and CH_4 in flue gases revealed partial combustion limitations associated with air–fuel mixing and residence time. The boiler delivered an average thermal power of 452.9 kW, with 305.7 kW effectively transferred to the working fluid, resulting in a global thermal efficiency of 67.5%. Energy losses were mainly associated with incomplete combustion (≈57.6 kW) and sensible heat in flue gases (≈89.7 kW), highlighting opportunities for improvement through air supply optimization and heat recovery strategies. Emission analysis showed low NOx levels, while CO emissions indicated the need for improved combustion control. The results demonstrate the technical feasibility and operational stability of coconut-shell-based systems as a scalable solution for sustainable thermal energy supply in rural agroindustrial applications.

sciforum-180272: Design and Implementation of a Smart Automated Biodiesel Reactor with AI-Based Yield Optimization.

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Abstract

The research addresses the growing global demand for sustainable energy by developing a smart biodiesel reactor that integrates intelligent monitoring, automated control, and AI optimization. Traditional biodiesel production faces challenges such as inefficient management and inconsistent quality due to manual monitoring. The proposed system features a microcontroller-based control platform to manage critical variables through Pulse Width Modulation (PWM) signals. It regulates components like heating elements and pumps while collecting real-time data on temperature, flow rate, and other parameters, creating a flexible and cost-effective solution for small-scale biodiesel production and research.

A Machine learning model was developed to predict biodiesel yield based on key operating parameters, including reaction temperature, mixing speed, catalyst concentration, and reaction time. The model was trained and evaluated using experimental datasets in a Python-based computational environment using scientific libraries and predictive analytics techniques. Performance evaluation using statistical metrics demonstrated satisfactory predictive capability, indicating that the model can effectively estimate biodiesel yield under varying operating conditions.

A digital twin simulation of the biodiesel reactor was also developed to validate the AI model and test optimization strategies prior to physical implementation. The digital twin replicates the reactor behavior using a simplified process model and allows real-time comparison between predicted and simulated yields. Furthermore, a closed-loop optimization framework was implemented in which the AI model continuously evaluates different operating conditions and automatically identifies optimal parameter combinations that maximize biodiesel yield.

The integration of AI-based optimization, digital twin simulation, and microcontroller-driven automation demonstrates the potential for developing intelligent biodiesel production systems that can improve yield, enhance process efficiency, and reduce operational complexity. The proposed system provides a scalable foundation for future implementation in fully automated smart biofuel production platforms.

sciforum-173708: Design and Thermal Performance Enhancement of a Passive Solar Dryer Using a Rotating Ventilator Mechanism

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Passive solar drying is a sustainable and energy-efficient method widely used for agricultural preservation, particularly in rural and small-scale applications. However, conventional passive solar dryers rely solely on buoyancyd-driven natural convection, which often results in weak airflow circulation, thermal stratification, and non-uniform moisture removal across drying trays. These limitations reduce overall drying efficiency and product quality.

This study presents the design and thermal performance enhancement of a passive solar dryer integrated with a rotating ventilator mechanism to improve internal airflow distribution. The proposed system utilizes a greenhouse-based solar collector with a blackened absorber surface to maximize solar heat gain. A rotating ventilator positioned at the outlet of the drying chamber induces controlled air extraction, promoting improved mixing, reduced stagnant air zones, and enhanced convective heat and mass transfer.

The system is designed to maintain predominantly passive operation while incorporating an optional low-power sensor-based control unit to stabilize airflow during fluctuating thermal conditions. Theoretical performance assessment indicates that enhanced airflow can reduce internal temperature gradients and potentially improve drying efficiency by approximately 15-25% compared to traditional passive configurations.

The proposed design offers a low-cost, scalable, and renewable solution for sustainable agricultural drying, contributing to improved energy utilization and reduced post-harvest losses.

sciforum-180274: Design, construction, and initial testing of a transportable mobile energy station with autonomous solar tracking

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This study presents the design, construction, and initial validation of a transportable mobile energy station for off-grid, rural, and emergency power supply. The prototype integrates renewable generation, battery storage, three-phase AC conversion, backup generation, remote monitoring, and autonomous solar tracking on a road-transportable platform. The system combines a 22-module photovoltaic array with a total installed capacity of 6.82 kW, three MPPT charge controllers, a 48 V $LiFePO_4$ battery bank with 14.4 kWh nominal capacity, three single-phase inverters configured as a three-phase output, and an LPG backup generator. Autonomous positioning of the photovoltaic wings is implemented using a Siemens S7-1215C controller and four LOGO! 8 controllers, which command six linear actuators using astronomical-clock-based solar-position logic, actuator feedback, folded-position switches and emergency-stop protection. Initial commissioning confirmed integrated three-phase power delivery, energy storage, and real-time monitoring through the Victron Remote Management interface. Direct inverter connection initially triggered the battery management system due to capacitor inrush and a 72 Ω pre-charge step resolved the start-up issue. High-current battery wiring was also upgraded after detecting energy losses due to cables heating up. In the first outdoor electric-vehicle charging test, performed under cloudy 6 °C conditions with only the short photovoltaic wings deployed, the station delivered 13.9 kWh over 1 h 15 min through a three-phase Type 2 connection. A representative operating point showed 1.554 kW photovoltaic input against an 11.073 kW charging demand, with the battery bank supplying the deficit while the generator remained off. The results indicate strong potential for application in remote locations, temporary installations, and emergency response scenarios, supporting sustainable and resilient energy systems in future application.

sciforum-175141: Effect of RuO_2 Content on the Electrochemical Performance of PPy/WS_2-Based Ternary Supercapacitor Electrodes

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A ternary composite electrode comprising polypyrrole (PPy), WS_2 (10 wt%), and varying amounts of RuO_2 (3-15 wt%) was systematically developed to investigate the influence of controlled RuO_2 incorporation on supercapacitor performance. The composites were synthesized via an in situ oxidative polymerization approach, enabling homogeneous integration of crystalline WS_2 nanosheets and RuO_2 nanoparticles within the conductive PPy matrix. Structural, morphological, and diffraction analyses confirmed the coexistence of all three components, revealing improved interfacial coupling, reduced crystallite size, and the formation of interconnected electron transport pathways. The optimized composition exhibited enhanced surface accessibility and facilitated ion diffusion across the electrode-electrolyte interface. Electrochemical evaluation demonstrated that gradual RuO_2 incorporation significantly increased the specific capacitance and rate capability. The optimized electrode delivered a maximum specific capacitance of 407.6 F g^{-1} in a three-electrode configuration at 0.5 A g^{-1}. A symmetric two-electrode device of the same composition achieved 338.0 F g^{-1} at 0.5 A g^{-1}, with excellent cycling stability, retaining stable performance over 2000 charge-discharge cycles. Impedance and kinetic analyses revealed reduced charge-transfer resistance and a transition from predominantly surface-controlled storage in pristine PPy toward a balanced electric double-layer and pseudocapacitive mechanism in the optimized composite. The improved electrochemical behavior is attributed to synergistic interactions among PPy, WS_2, and RuO_2, which collectively enhance electrical conductivity, redox activity, and structural robustness. These findings demonstrate that controlled RuO_2 loading is an effective strategy for engineering high-performance polymer-based supercapacitor electrodes.

sciforum-180288: Energy-Efficient Nonlinear Controller Tuning for Mobile Robots via Metaheuristic Optimization

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This study introduces a metaheuristic-driven optimization structure for the precise adjustment of nonlinear controllers in mobile robots. The main goal is to find controller gains that reduce both trajectory tracking error and energy usage at the same time. A metaheuristic optimization approach is utilized to address this multi-objective challenge, where the cost function integrates tracking precision, assessed by the Root Mean Square Error, and energy usage, determined as the integral of electrical power throughout the mission period, with a specific focus on minimizing energy in alignment with the conference theme. The suggested framework enhances the parameters of a nonlinear controller intended for tracking the trajectory of mobile robots. The metaheuristic algorithm repeatedly seeks optimal controller gains that provide the best balance between tracking effectiveness and energy efficiency, leading to a well-tuned controller. In contrast to traditional trial-and-error tuning techniques, this structured method guarantees functioning at an ideal equilibrium between accuracy and energy usage. Comprehensive simulations are performed across different trajectory scenarios to confirm the efficiency of the optimized controller. The resulting improvements are assessed using tracking precision and energy usage metrics, showing that the metaheuristic-driven tuning effectively meets the intended goals. The optimized controller achieves excellent tracking accuracy while greatly lowering energy usage in comparison to traditionally adjusted controllers. The results show that metaheuristic optimization offers a viable approach to achieving controller gains that reconcile the natural trade-off between energy efficiency and tracking performance. This research advances the area of energy-efficient autonomous systems by creating a structured tuning framework, with possible uses in battery-operated robotic platforms functioning in energy-limited settings.

sciforum-176185: Experimental analysis of single slope solar still equipped with jute and nanoenhanced jute cloth for clean water production

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The global scarcity of potable water necessitates the development of efficient and low-cost desalination technologies. This study presents an experimental investigation into enhancing the productivity of a conventional single-slope solar still (SSSS) by employing natural jute cloth and nano-enhanced jute cloth as novel wick materials. The primary objective was to compare the performance of the modified stills against a conventional still under identical climatic conditions. The jute cloth was treated with carbon black nanoparticles to create a nano-enhanced wick with improved thermal conductivity and capillarity. Three identical solar stills were fabricated and tested simultaneously: a conventional still (CSS), a still with jute cloth (JSS), and a still with nano-enhanced jute cloth (NJSS). Key performance parameters, including daily water yield, internal heat and mass transfer, and thermal efficiency, were meticulously measured and analyzed. The experimental results demonstrated a significant improvement in productivity for the modified stills. The cumulative daily water yield for the CSS was 2.1 L/m². The JSS showed a marked increase, producing 3.0 L/m², an improvement of approximately 43%. The NJSS outperformed both, achieving a yield of 3.8 L/m², which corresponds to an impressive 81% enhancement over the CSS. The efficiency of the CSS was calculated at 34%, which increased to 42% for the JSS and reached 51% for the NJSS. The enhancement is attributed to the increased surface area for evaporation, improved capillary action, and the superior photothermal conversion properties of the nano-coated material, which led to higher basin water temperatures.

sciforum-175125: Experimental Investigation of Optimal Wavelength Selection for Laser Power Beaming Using Silicon Solar Cells in UAV Charging Systems

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Unmanned Aerial Vehicles(UAVs) are a rapidly growing sector and widely utilized across various industries including agriculture, military applications, disaster monitoring, aerial photography and mapping. However, the primary limitation of UAV operation is the flying time. Laser power beaming technology is one of the most promising approach for extending the endurance of unmanned aerial vehicles(UAVs) by enabling wireless in flight charging. The overall system efficiency is highly dependent on the spectral compatibility between the laser source and the photovoltaic receiver. This study investigates the wavelength dependent performance of polycrystalline silicon solar cells to determine the most suitable operating wavelength region for laser based UAV charging systems, since laser sources emit monochromatic light. The spectral response of 5cm^2 silicon photovoltaic cell was analyzed over absorption range of 365–1030 nm using a VK-SS-50 LED solar simulator and VK-PP-100 PV analyzer. The major electrical parameters measured include open circuit voltage(Voc), short circuit current(Isc), and maximum power(Pmax). During monochromatic testing, the irradiance was maintained constant across all wavelengths to ensure a fair spectral comparison. The results indicate that the output power of the solar cell varies with the wavelength of the incident light. Under the one sun illumination, the maximum power output of the solar cell was measured as 75.84mW. Under the individual monochromatic lighting conditions, the minimum power output was recorded at 445nm with a value of 0.29mW, while the maximum power output was 6.4mW at 810nm. Based on these findings, the optimum laser wavelength region for power beaming using silicon solar cells lies between 810nm to 880nm. This near infrared(NIR) region is advantageous for long distance power transmission due to reduced atmospheric losses. Furthermore, combining multiple laser sources at different wavelengths, rather than a single one, could further enhance the output power of silicon photovoltaic receivers.

sciforum-175281: Exploring the Potential of Castor Oil for Biodiesel Production: Process Optimization and Fuel Property Evaluation

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Biodiesel has gained significant attention as a renewable and environmentally friendly alternative to petroleum-based diesel fuel. However, the use of edible vegetable oils as feedstock for biodiesel production raises concerns regarding food security and economic cost. Consequently, non-edible oil sources have been increasingly explored as sustainable alternatives. Castor oil (Ricinus communis), a non-edible oil with high availability and adaptability to marginal lands, represents a promising feedstock for biodiesel production. This study investigates biodiesel production from castor oil using homogeneous alkaline transesterification and evaluates its fuel properties in accordance with the ASTM D6751 biodiesel standard. The effects of key reaction parameters, including catalyst concentration, methanol-to-oil molar ratio, reaction temperature, and reaction time, were systematically examined. The free fatty acid (FFA) content of the castor oil was determined to be 1.02%, indicating suitability for alkaline-catalyzed transesterification. A maximum biodiesel yield of 94.71 wt% was achieved under optimal conditions of 2 wt% KOH catalyst, a 12:1 methanol-to-oil molar ratio, a reaction temperature of 60 °C, and a reaction time of 90 minutes. The produced biodiesel exhibited a calorific value of 38.249 MJ/kg, a flash point of 194 °C, a density of 0.9247 g/cm³, and a kinematic viscosity of 14.045 mm²/s. Although the viscosity exceeded the limits specified by the ASTM standard, blending with conventional petroleum diesel could improve fuel properties for practical applications. These findings demonstrate the feasibility of producing biodiesel from non-edible castor oil under optimized reaction conditions, supporting the development of sustainable biofuels and reducing dependence on fossil-based energy resources.

sciforum-175315: Exploring Wild *Arachis pintoi* Biomass for Sustainable Bioenergy: A Multi-Product Strategy for Biofuel Production

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The global energy crisis and environmental concerns have intensified the search for sustainable alternatives. This study investigates the potential of Arachis pintoi (Pinto peanut) as a feedstock for biodiesel, biochar, and syngas production, assessing its suitability for renewable energy applications. The Free Fatty Acid (FFA) content of Pinto peanut oil was found to be exceptionally low at 0.612%, significantly below the 2% threshold for alkaline transesterification, eliminating the need for energy-intensive acid pretreatment. Biodiesel derived from this oil exhibited superior fuel properties, including a calorific value of 40.54 MJ/kg, optimal kinematic viscosity (4.7 mm²/s), and a high flash point (157.5°C), which surpasses ASTM D6751 standards. The syngas produced through pyrolysis at 430°C demonstrated moderate energy output with promising gas composition, though optimization could enhance hydrogen yields and reduce CO_2 emissions. The proximate and ultimate analysis of Pinto peanut shells revealed a high calorific value (16,790 kJ/kg) and favorable elemental composition, making them a viable energy source for combustion. Additionally, the pyrolysis of Pinto peanut shells yielded biochar with a calorific value of 25.235 MJ/kg, positioning it as a promising alternative for various industrial applications. The study highlights the potential of Pinto peanut-derived biofuels and biochar as sustainable alternatives to fossil fuels, with further optimization capable of improving yield and performance for broader energy applications.

sciforum-143368: Harnessing Airflow Energy for Automotive Systems

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Given the increase in greenhouse gas emissions, an interesting field of research to reduce them is the optimization of automotive aerodynamics. This communication focuses on transforming the negative drag effect of the incident airflow into a positive effect, harnessing the force of the air itself to propel the vehicle forward and thereby reducing fuel consumption.

A channeling system has been designed based on a deflector located on the vehicle roof, acting as a cavity, which captures, channels, and redirects air to the rear vacuum zone, providing higher pressures.

Initially, the device's effectiveness was verified using CFD, and then, the deflector was physically constructed and incorporated in a 1:12 scale car model. 756 comparative experimental tests were conducted with and without the deflector in a wind tunnel, also of own creation, demonstrating the following main achievements:

- Aerodynamic drag is reduced, as negative values are converted into positive ones under all conditions. Moreover, initially positive values are further amplified, resulting in the generation of an additional propulsive force that enhances the vehicle's forward motion.
- At a speed of 76 km/h, the deflector provides an energy efficiency of 3.3%.

As a summary, Figure 1 is presented. Figure 1a, which represents a standard car, shows that the air trajectory at the rear follows the red arrows, with a vacuum underneath acting as a brake. However, Figure 1b shows that incorporating the deflector leads to airflow redirection and the reduction of the vacuum zone, illustrated by green arrows.

https://ibb.co/tp9MNKpy

Figure 1. Airflow path: a) vehicle without deflector; b) vehicle with built-in deflector.

The feasibility analysis at technical, economic, social, and environmental levels is favorable for all vehicle propulsion alternatives. Therefore, the results of this research have served to register this invention as a utility model (ES1303991 U) at the Spanish Patent and Trademark Office.

sciforum-179130: Hierarchical Ternary Carbon Nanocomposite on Stainless Steel for Low-Overpotential Hydrogen Evolution in Alkaline Water Electrolysis

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Alkaline water electrolysis (AWE) is a promising technology for sustainable hydrogen production, though its efficiency is often limited by high overpotentials and the low electroactive surface area of conventional electrodes. In this study, a monolayer ternary carbon nanomaterial (CNM) composite electrode was fabricated on stainless steel current collectors using reduced graphene oxide (rGO), carbon nanotubes (CNT), and Vulcan carbon black (XC-72) as conductive carbon filler (CCF) with a hybrid PVA–PTFE binder. Thermal treatment was employed to partially decompose the PVA, creating a hierarchical porous structure that enhances electrolyte accessibility and electron transport. Electrochemical evaluations in 0.12 M NaOH, using a three-electrode system, showed significantly higher anodic peak currents for the modified electrode (approximately 5.1×10^{-3} A) compared with bare stainless steel (5.0×10^{-4} A) at 50 mV/s. Electrochemical impedance spectroscopy (EIS) indicated a reduced solution resistance (Rs) of 1.91–2.2 $\Omega.cm^2$ and increased interfacial capacitance. The modified electrode achieved a peak current density (i_0) of 143.61 mA/cm^2 at 1.0 V, representing a 134% increase over the bare substrate. Furthermore, gas evolution tests produced 1.393 mL/min of oxyhydrogen (HHO) at 4.0 V, compared to 1.169 mL/min for the unmodified electrode, with stable operation observed over four hours of continuous testing. These results demonstrate that the synergistic combination of rGO, CNTs, and carbon black forms a conductive hierarchical network that effectively increases electroactive surface area, providing a cost-effective strategy for enhancing hydrogen evolution in alkaline water electrolysis.

sciforum-148464: Improving Household Energy Efficiency in Rural South Africa Through Renewable Energy and Energy-Saving Appliances

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In most nations, houses use approximately 40% of all energy consumed, primarily for heating, ventilation, air conditioning, and powering electrical appliances. The excess demand for electricity affects the electrical grid, and an interruption known as load shedding may be necessary to distribute available electricity to all clients. Load-shedding has numerous adverse effects on individuals, businesses, and the entire nation of South Africa. A significant contribution is needed to minimise residential energy consumption and then fulfil the lower load with on-site renewable energy systems to reduce the negative impacts of load shedding. The suggested method entails retrofitting multiple non-energy-efficient household appliances and utilizing renewable energy technology to diminish household energy consumption. The findings demonstrated that the total daily energy consumption using energy-efficient appliances in the summer was 16.8605 kWh, compared to 30.569 kWh for non-efficient appliances. This denoted a monthly billing of R1269.899 compared to R2302.395 spent before enhancing the energy efficiency of households. The findings of this study will help households identify critical electrical appliances, reduce their energy bills, and benefit South African electrical grid providers by mitigating the effects of load shedding. Additionally, this study will serve as a basis for further research by providing information on the reliability and cost-effectiveness of renewable energy and energy efficiency appliances.

sciforum-175341: Influence of Li Substitution on the Dielectric Behavior of $(Na_{0.525}K_{0.475})NbO_3$ at the Morphotropic Phase Boundary

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Ceramic pellets of Li-doped sodium–potassium niobate, $(Na_{0.525}K_{0.475})_{1-\gamma}Li_{\gamma}NbO_3$ (y = 0, 0.04, 0.05, 0.06, and 0.07 mol%), were synthesized using the conventional solid-state reaction technique followed by a two-step sintering process to achieve improved densification and phase stability. Sodium–potassium niobate (NKN)-based ceramics are considered promising lead-free piezoelectric materials, particularly near the morphotropic phase region, due to their enhanced dielectric and electromechanical properties. The incorporation of Li^+ ions into the NKN lattice is expected to modify the crystal structure and influence polarization behavior through lattice distortion and compositional tuning. Phase formation and structural evolution were examined using X-ray diffraction (XRD), which confirmed the formation of a perovskite structure without detectable secondary phases within the studied composition range. A systematic shift in diffraction peaks with increasing lithium concentration indicates lattice modification and compositional sensitivity. Notably, a discontinuity in the peak-shift trend was observed at y = 0.05, suggesting anomalous structural behavior near this composition. Dielectric measurements carried out as a function of frequency revealed a strong dependence on lithium content. Among all investigated samples, the composition with y = 0.05 exhibited the highest dielectric constant and enhanced electrical conductivity. The observed enhancement in dielectric response is attributed to optimized lattice distortion and polarization mechanisms at this critical composition. These results highlight the significant role of Li substitution in tailoring the structural and dielectric properties of NKN ceramics near the morphotropic phase region, making them potential candidates for lead-free dielectric and piezoelectric device applications.

sciforum-180011: Optimisation of an Environmentally Sustainable Solar PV-Wind Hybrid Energy System with Battery Energy Storage and Energy Management System for Off-Grid Energy Security and Rural Electrification in Neduntheevu, Sri Lanka

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Abstract

Due to geographic isolation and heavy reliance on diesel generation, there are major energy access challenges in remote islands in Sri Lanka. In Neduntheevu (Delft) Island, electricity supply is limited, costly, and highly polluting. This study proposes an off-grid hybrid renewable energy system with EMS-based control to overcome diesel dependence, improve reliability, and enhance energy security for sustainable development.

A hybrid PV-wind-BESS system was optimised using 2025 load, solar, and wind data based on techno-economic and environmental objectives. The system includes 600 kW PV, two 250 kW wind turbines, and a 3100 kWh BESS. Optimisation of demand, battery SoC limits, generation, inverter operation, and battery performance was performed using the System Advisor Model. In parallel, an EMS developed in MATLAB manages renewable prioritisation, SoC control, load control, and system operation.

The optimised system meets the yearly electricity demand with negligible unmet load (1%) and high reliability, while maintaining stable operation. Life-cycle emissions are estimated at 9.7-48 g CO_2/kWh, which are drastically lower than those of conventional diesel generation (>900 g CO_2/kWh). MATLAB simulations show effective EMS performance, including peak shaving of the 250 kW night demand, better controlled battery cycling within SoC limits (20-98%), improved renewable energy utilisation, and stable voltage-frequency regulation. Furthermore, techno-economic analysis indicates an LCOE of Rs 24.38/kWh (Sri Lankan Rupees) and a payback period of 15.71 years (≈ 16 years), confirming the economic feasibility compared to diesel-based systems.

The findings confirm that hybrid solar-wind-BESS systems with EMS control are technically, economically, and environmentally viable for the electrification of remote islands. The study addresses the gap in integrated design and control of islanded microgrids, enhancing energy security in the Sri Lankan context.

sciforum-175940: Process Optimization of Copper Antimony Sulfide Thin Films via Chemical Bath Deposition for High-Performance Photovoltaic Applications.

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Copper antimony sulfide ($CuSbS_2$) has the potential to be an excellent absorber material for thin-film solar cells. It has an optimal direct band gap of 1.5 eV, strong absorption coefficients >10^4 cm^{-1}, and is composed of non-toxic and earth-abundant elements. However, the difficulty in growing properly stoichiometric and well-crystallized $CuSbS_2$ thin films by chemical bath deposition remains. This work aims to optimize the CBD conditions for the deposition of $CuSbS_2$ thin films by enhancing the uniformity, crystallinity, and optical quality of the material, which are critical for its application in solar cells. TiO_2 electron transport layers on FTO glass substrates were prepared by the doctor blade technique. This technique provided a smooth surface for the $CuSbS_2$ thin film, which adhered properly. The $CuSbS_2$ thin film was prepared by dissolving $SbCl_3$ in acetone, $Na_2S_2O_3$, and $CuCl_2$ in a precursor solution. The thin film was then deposited at room temperature for 3 hours in a 50 ml bath. Solar cell architecture: FTO/TiO_2/$CuSbS_2$/CuI/Pt-glass. The XRD patterns show the proper formation of the orthorhombic chalcocite $CuSbS_2$ phase. The strong (111) peak indicates the high crystallinity of the $CuSbS_2$ thin film. The scanning electron microscope (SEM) showed densely packed grains with minimal void spaces, indicating good surface coverage. The optical measurements, which included UV-Vis spectroscopy and Tauc plots, showed a direct band gap of 1.6 eV, which is optimal for solar energy absorption. The current research has shown that with optimized CBD conditions, good-quality $CuSbS_2$ films can be deposited, which is useful for efficient and sustainable solar energy conversion.

sciforum-175295: Strain-Invariant Atmospheric Micro-Gap Solar Thermal Membrane: Redefining Flexible High-Temperature Operation

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Existing solar thermal technologies confront irreconcilable tradeoffs: rigid evacuated glazing demands mm-scale gaps with structural spacers; polymer-based flexible collectors sacrifice thermal insulation for mechanical compliance; spectrally-selective absorbers rely on resonant nanostructures vulnerable to deployment strain and incidence angle. Critically absent is an architecture unifying sub-300 μm atmospheric noble-gas confinement, roll-to-roll manufacturability, strain-robust broadband absorption, and suppressed thermal emission without vacuum infrastructure or discrete mechanical supports.

This invention introduces a fundamentally novel coupled electromagnetic-mechanical-thermal platform: a tension-stabilized atmospheric micro-gap membrane incorporating non-resonant impedance-synthesized multilayer absorbers operating in the sub-wavelength regime ($\beta d \ll 1$). Electromagnetic design minimizes input impedance mismatch across solar spectrum (0.3-2.5 μm) and wide angular aperture (0°-60° TE/TM), while deliberate avoidance of quarter-wave resonances confers intrinsic robustness to thickness nonuniformity and bending-induced strain.

Mechanical innovation leverages moderate biaxial pre-tension (not structural) with engineered ultra-low adhesion surfaces (≤20 mN/m) to maintain nominal 250 μm argon gap across 15-20 cm spans, suppressing convection ($Ra \propto L^3$ reduction) without internal pillars, vacuum differentials, or sustained high stress risking creep failure.

Thermal directionality engineered via asymmetric conduction ensures efficient substrate heat extraction. Target outcome: flexible roll-to-roll deployment delivering evacuated-tube performance in atmospheric operation, targeting industrial process heat, rooftop thermal generation, and CSP augmentation.

The invention'screativity resides in rejecting conventional paradigms with no spacers, no vacuum, no resonance, replacing them with coupled physics operating at unprecedented thin-gap tolerance. This addresses the core gap preventing flexible solar thermal industrialization.

sciforum-172018: Techno-Economic Feasibility of an Off-Grid Wind-Powered Hydrogen Microgrid for Green Hydrogen Production in Northwest Algeria: System Modelling by HOMER Energy

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As the world moves towards decarbonization and mitigating climate change, renewable energy systems are becoming crucial components of the power infrastructures of the future. Traditional centralised power grids still rely on fossil fuels and nuclear energy, which contribute substantially to greenhouse gas emissions and pose growing risks to energy security. In contrast microgrids, offer a flexible way to integrate renewable energy sources RES, increasing local reliability and reducing transmission losses. Using hydrogen as an Energy storage solution can help overcome wind and solar variability thanks to the power-to-hydrogen P2H process in hydrogen based microgrids, Excess electricity generated during periods of high renewable output can be converted into hydrogen via electrolyzers and stored in various forms to be reconverted into electricity through fuel cells or turbines, providing backup power for microgrids. Using HOMER Pro This study evaluates these advancements through a case study simulating an off-grid- hydrogen-based microgrid in northwest of Algeria near the Arzew LNG export port, powered by an onshore wind farm. The proposed microgrid supplies electricity to both a hydrogen production facility and a wastewater treatment plant that provides water for electrolysis. The techno-economic simulation yields a Levelized Cost of Hydrogen (LCOH) of $3.87/kg and a Levelized Cost of Electricity (LCOE) of $0.0465/kWh. The Net Present Cost (NPC) of the full system over the 25-year project lifetime is approximately $452.1 million., Placing these results within the Algerian energy context reveals their practical significance when compared with Algeria current LCOE $0.08 to $0.1/kWh. Wind resources for the Arzew region (35.8°N, 0.3°W) is based on NASA's POWER database, at hub heights of 100 m. The average annual wind speed is 4–7 m/s and supports the capacity factor of 36.4% for the selected turbine configuration.

sciforum-168848: Wind MPPT with Incremental Duty Cycle for a PMSG SWT in a Grid-Connected DC Microgrid

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This paper details the development and simulation of a Maximum Power Point Tracking (MPPT) algorithm designed for small wind turbine (SWT) applications. The study focuses on an incremental duty cycle approach aimed at optimizing power extraction when integrated into a grid-connected DC microgrid environment. In this configuration, the MPPT controller monitors changes in the system's output power and adjusts the duty cycle of a DC-DC boost converter accordingly. This adjustment is intended to maintain the generator's operation at the maximum power point across a range of wind velocities.

The technical validation of the algorithm was conducted through simulations in Matlab/Simulink. The modeled system architecture consists of a small wind turbine driving a Permanent Magnet Synchronous Generator (PMSG). The three-phase AC output of the PMSG is processed through a rectification stage before reaching the boost converter, which serves as the primary interface to a 400V DC-bus microgrid. The simulation parameters were configured to reflect real-world operating conditions, specifically focusing on the converter’s response to fluctuating wind inputs. The results presented in this work illustrate the tracking performance and stability of the incremental duty cycle method. By analyzing the power output and duty cycle transitions, the paper provides a technical assessment of how this control strategy supports efficient power delivery within a DC microgrid framework.

Session 3. Energy system analysis and modelling

sciforum-169631: Holistic Conceptualization of a Novel AI-Based Building Energy Management System for Positive Energy Districts Development

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The development of positive energy districts (PED) is crucial for the transition towards climate-neutral European cities and meeting UN Sustainable Development Goals, European Green Deal objectives, the Mission on Carbon-Neutral and Smart Cities, and the Renovation Wave. PED integrates renewable energy technologies, energy-efficient designs, and intelligent control strategies to achieve an annual energy balance and a surplus generation.

The growth of urban energy systems, renewable generation fluctuation, demand variability and the need of multi-scale energy storage, requires advanced energy management strategies to enhance efficiency, resilience, and cost-effectiveness. Artificial intelligence (AI) techniques are demonstrating to be crucial to overcome this compatibility of the energy systems, enabling automations and the design of novels smart indicators for energy consumption.

This study explores AI role to enhance energy management systems, promote PED development and identify solutions to challenges. The holistic conceptualization of a novel AI-based Building Energy Management System (BEMS) has been carried out. The tool provides an interactive platform to analyze and predict end-users' patterns and promote social engagement in sustainability. It has been carried out at the Vera Campus of the UPV. The designed conceptual framework has been applied in 60 buildings among classrooms, offices, laboratories, data center, sport facilities and one greenhouse. This Campus hosts an academic community of more than 35,000 people, students and staff. The main indicators for all kind of energy consumption (electrical, natural gas, water consumptions and waste reuse) have been identified and calculated. Results shows the Vera Campus has reduced its electricity consumption by 27.4% from 2021 to 2024, saving over €2.3 million through LEDs, free cooling, improved to building envelopes, smart lighting, and 100% renewable energy procurement. Finally, key strategies for Net-zero energy consumption and PED district have been identified.

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sciforum-180270: Causal Greedy Pair Scheduling for Residential Battery Storage under Day-Ahead Electricity Prices

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Residential batteries operated against day-ahead electricity prices require schedules that simultaneously respect battery physics and enforce charge-before-discharge causality. Naive price-ranking heuristics can violate this ordering in real time, converting apparently profitable arbitrage plans into partially infeasible execution. This study presents a deterministic causal greedy pair-matching heuristic that eliminates this failure mode by construction and evaluates it on a full-year measured dataset of 2025 Estonian household demand and spot-price data with mixed hourly and 15-minute resolution. After chronology repair, daylight-saving correction, and linear imputation of 165 sparse missing-price rows, the cleaned dataset covers exactly 8760 hours and serves as a common input for all simulations. Under the canonical 24-hour non-overlapping planning horizon with no grid export, a 10 kWh battery reduces the ex-VAT spot-energy bill from €1095.91 to €648.53, saving €447.38 per year (40.82%), while a 30 kWh battery saves €629.91 per year. The marginal value of added capacity declines sharply: the first kilowatt-hour delivers €79.04 per year and the thirtieth only €2.67 per year, confirming strong diminishing returns. Across the four tested planning horizons, the 24-hour window performs best for small-to-mid capacities, while the 48-hour window marginally surpasses it only above 25 kWh. Against an exact matched-constraint mixed-integer linear program benchmark, the heuristic recovers 95.65% of optimal value at 10 kWh and approximately 97.95% at 20–30 kWh, with an annual gap below €21 in the mid-to-large capacity range. A descriptive event-study around the February 2025 Baltic synchronization shows no immediate reduction in intraday price spread or heuristic savings. The results demonstrate that a causally valid, computationally lightweight scheduler can capture the large majority of available arbitrage value on real household data without requiring optimization solvers.

sciforum-172976: Grid Resilience under Ultra High Renewable Penetration

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Non-interconnected power systems operate with limited flexibility and tight transmission margins, making them particularly sensitive to single-element outages and post-contingency congestion, especially as renewable energy sources (RES) increase variability and operational stress. This paper presents a reproducible, planning-stage screening workflow for N−1 security assessment in an islanded transmission network, combining lossless DC contingency analysis with an interpretable overload-severity formulation and directional PTDF/TLR sensitivities. The framework is demonstrated on the autonomous 150 kV power system of Rhodes (Greece), an island grid with conventional generation and distributed wind/PV resources and strongly seasonal demand.

The workflow proceeds in four stages. First, an N−1 contingency set is executed and all post-contingency thermal violations are extracted under the selected branch ratings. Second, each violation is quantified using an MVA exceedance metric, $\text{Severity}_{c,e}=\max(S_e - S_e^{max}, 0)$ (MVA) , which captures overload criticality in a comparable form across contingencies and elements. Third, directional PTDF/TLR sensitivities are computed for incremental transfers from candidate buses to a designated sink (balancing) bus, and the sign of the response is used to retain actions aligned with relieving the violated flow direction. Fourth, severity-weighted, signed relief contributions are aggregated to produce a bus-level relief score, enabling ranking of candidate locations and identification of the dominant contingencies and binding network elements that govern thermal insecurity.

To address a frequently overlooked modeling dependency, the study also evaluates how the assumed balancing (sink) location influences PTDF directions and the resulting rankings, demonstrating that siting conclusions can change materially with different balancing assumptions. Overall, the proposed method transparently bridges contingency screening and controllability assessment, providing decision support for prioritizing flexible resources (e.g., storage discharge or redispatch capability) and guiding where more detailed AC, OPF, or dynamic studies should focus.

sciforum-179641: Improving Household Energy Efficiency in Rural South Africa Through Renewable Energy and Energy-Saving Appliances

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In most nations, houses use approximately 40% of all energy consumed, primarily for heating, ventilation, air conditioning, and powering electrical appliances. The excess demand for electricity affects the electrical grid, and an interruption known as load shedding may be necessary to distribute available electricity to all clients. Load-shedding has numerous adverse effects on individuals, businesses, and the entire nation of South Africa. A significant contribution is needed to minimise residential energy consumption and then fulfil the lower load with on-site renewable energy systems to reduce the negative impacts of load shedding. The suggested method entails retrofitting multiple non-energy-efficient household appliances and utilising renewable energy technology to lessen household energy consumption. The findings demonstrated that the total daily energy consumption using energy-efficient appliances in the summer was 16.8605 kWh, compared to 30.569 kWh for non-efficient appliances. This represented an average monthly billing of R1269.899 in April 2025, compared to R2302.395 spent in March and April 2024, before the enhancement of energy efficiency in households. The findings of this study will help households identify critical electrical appliances, reduce their energy bills, and benefit South African electrical grid providers by mitigating the effects of load shedding. Additionally, this study will serve as a basis for further research by providing information on the reliability and cost-effectiveness of renewable energy and energy efficiency appliances.

sciforum-180281: Lightweight Battery Intelligence: Minimal Measurement Requirements for Usable SOC Estimation

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Accurate battery state-of-charge (SOC) estimation is essential for off-grid energy systems, where power availability directly restricts autonomy and mission reliability. Traditional methods for battery modeling and estimation rely on high-precision instrumentation and extensive testing, which are impractical for embedded and resource-limited setups. The aim of this paper is to determine the measurement accuracy that is necessary to achieve practical SOC estimation. A 14S NMC prismatic battery pack made up of Samsung SDI 94 Ah cells was subjected to pulsed load conditions similar to those in mobile energy systems. The setup uses controlled current steps across a range of 5A to 100A and records voltage responses using various data acquisition systems of varying fidelity. The experiment varied pulse duration, amplitude, relaxation times, sampling rate, and bit width. Higher-fidelity acquisition improved repeatability and clarity of transient features. DCIR was consistently identified at ~4.6 mΩ (±0.2 mΩ across 20–100 A pulses). Simple measurement chains enabled the construction of first-order equivalent circuit models with time constants on the order of ~1–2 s, while slower polarization effects remained unresolved. Using these models, SOC estimation via an extended Kalman filter achieved 3–5% RMSE over the tested duty cycles when using ≥14-bit acquisition. Below this threshold, parameter extraction became inconsistent, with resistance estimates varying by >20% between identical pulses. An improvement of approximately 3 ENOB was achieved through oversampling and use of a 1 ppm voltage reference, reducing voltage noise to the sub-millivolt range (~0.5–1 mV) and enabling stable parameter identification at both 14- and 16-bit nominal resolution. Usable battery intelligence for off-grid energy systems can be achieved with minimal sensing infrastructure when the test design is appropriately constrained. This supports scalable integration of battery models in embedded energy systems and aligns with emerging requirements for deployable digital battery representations.

sciforum-180285: Metaheuristic-Based Photovoltaic Parameter Identification Using a Dynamic Elite Cooperative Artificial Circulatory System Algorithm

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Accurate parameter estimation of photovoltaic (PV) models is essential for performance evaluation, efficiency enhancement, and reliable energy forecasting in solar energy systems. However, the nonlinear, multimodal, and implicit nature of the current–voltage (I–V) relationship makes this task challenging for conventional optimization methods, which often suffer from premature convergence and sensitivity to initial conditions. In this study, a novel variant of the Artificial Circulatory System Algorithm, termed Dynamic Elite Cooperative ACSA (DEC-ACSA), is proposed for estimating the unknown parameters of the Single Diode Model (SDM). The proposed approach extends the original ACSA by incorporating dynamic population grouping, elite-guided local search, and cooperative interaction mechanisms, thereby enhancing the balance between exploration and exploitation. Additionally, a Gaussian-based perturbation strategy is integrated into the neural update phase to improve local search capability. The objective is to minimize the root mean square error between measured and modeled current values using experimental I–V data from a standard photovoltaic module. The performance of DEC-ACSA is evaluated in comparison with the original ACSA to explicitly demonstrate the impact of the proposed enhancements. Experimental results indicate that DEC-ACSA achieves faster convergence, improved solution stability, and lower estimation error compared to the baseline ACSA. These findings suggest that the proposed method provides a robust and effective optimization framework for solving nonlinear photovoltaic parameter estimation problems and offers a promising alternative for energy system modeling applications.

sciforum-175783: Model Capacity Alignment under Data Scarcity: Tree-Based Ensembles versus Deep Recurrent Networks for Daily Solar Radiation Forecasting in West Africa

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While deep learning architectures dominate contemporary solar forecasting literature, their effectiveness under limited data regimes remains insufficiently examined. This study investigates model capacity alignment under data scarcity using daily irradiance datasets from Nigeria, Ghana, and Senegal, encompassing approximately 700 observations from September 2021 to November 2023. With only ~569 training samples per country following an 80/20 chronological split, the dataset represents a small-sample regime typical of emerging measurement infrastructures in Sub-Saharan Africa. A controlled comparative analysis is conducted between tree-based ensemble models (Random Forest, XGBoost) and deep recurrent architectures (LSTM, CNN-LSTM) under identical experimental settings. The methodology incorporates 81 engineered temporal features, including multi-day lags, rolling statistics, and seasonal encodings. Results indicate that gradient-boosted ensembles achieve superior performance, with R^2 reaching 0.9777 and RMSE as low as 7.41 kWh/m² in Nigeria, whereas recurrent architectures remain near baseline performance ($R^2 \approx 0.05$). These findings are interpreted through bias-variance trade-offs and parameter-to-sample scaling, revealing that forecast accuracy follows a geographic gradient (Nigeria > Ghana > Senegal) linked to atmospheric persistence. The evidence demonstrates that model capacity must align with dataset scale; in small-sample regimes, structured feature engineering combined with ensemble trees yields robust generalization, while high-capacity deep learning models exhibit convergence collapse. Such outcomes support the necessity of context-aware model selection for solar energy forecasting in regions where historical observations remain limited.

sciforum-168929: Optimizing energy planning in countries with extreme climates: a methodological proposal for the Colombian case

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Hydroelectric dependence in countries with extreme climates, such as Colombia, exposes the electricity system to significant price volatility and the risk of energy deficits during prolonged drought periods. These conditions highlight the need for medium-term planning strategies that incorporate diversified energy sources and mechanisms to enhance system stability. This paper proposes a methodological framework for medium-term energy planning that integrates several key components: (i) characterization of renewable energy sources, including solar, wind, and hydrogen; (ii) price stabilization strategies aimed at reducing electricity market volatility; (iii) economic and energy feasibility criteria (EFF) for project evaluation; (iv) conceptual analysis of regional energy interconnections; and (v) the formulation of an optimization model to balance energy supply and demand under extreme climate scenarios. Within this framework, the energy transition is considered a central strategy for expanding the diversity of the national energy matrix. In particular, hydrogen is analyzed as an energy carrier and storage alternative that can mitigate risks associated with hydroelectric dependence. The integration of hydrogen with non-conventional renewable sources, such as solar and wind power, provides opportunities to improve system stability and long-term sustainability. The proposed framework also incorporates uncertainty related to environmental, social, and economic impacts in the areas influenced by renewable energy projects. Additionally, price stabilization strategies are evaluated as mechanisms to reduce electricity market volatility through technical and contractual tools, including coordination among distribution grid operators, demand flexibility mechanisms, energy storage solutions, and greater integration of intermittent renewable energy sources. Overall, the study contributes a structured methodological approach for energy planning in countries exposed to extreme climate variability, supporting decision-making processes aimed at improving energy security, price stability, and the integration of renewable energy technologies.

sciforum-169319: Solar Energy Potential of Offshore Floating Photovoltaic Systems in the Black Sea and Its Application to Green Hydrogen Production

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In the context of the energy transition and the need to reduce carbon emissions, offshore renewable energy production from floating solar panels represents an innovative solution with the potential to support sustainable hydrogen production. This study analyzes the potential of the solar resource for floating photovoltaic applications located on the water surface in the Black Sea. Six locations located at different distances from the shore are investigated, selected to evaluate how offshore positioning influences electricity production. The analysis is based on the simulation of a monofacial photovoltaic panel, using solar irradiation data and climatic conditions specific to each location, adapted to the marine environment. The estimated annual energy production is compared between the analyzed locations, in order to highlight the differences determined by the distance from the coast and the variations in meteorological conditions. The results obtained are used to assess whether the analyzed locations are suitable for the implementation of floating photovoltaic systems offshore. The possibility of using the energy produced to power an electrolysis process in order to obtain green hydrogen is also analyzed. The study provides a preliminary assessment of the feasibility of these applications in the Black Sea area and can constitute a starting point for further technical and economic analyses.

sciforum-165419: A Hybrid Artificial Bee Colony Based on Online Fitness Landscape Analysis and NSGA-II for Uncertainty-Aware Multi-Objective Electric Vehicle Integrated Optimal Power Flow

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The rapid integration of renewable energy resources and electric vehicles (EVs) has significantly increased the operational complexity of modern power systems, particularly under uncertain generation and load conditions. In this context, the combined heat and power economic dispatch (CHPED) coupled with optimal power flow (OPF) emerges as a highly non-linear, large-scale, and multi-objective optimization problem that simultaneously seeks economic efficiency, environmental sustainability, and secure system operation. Although recent studies have demonstrated the effectiveness of advanced metaheuristics such as the quasi-oppositional sine cosine algorithm (QOSCA) in addressing this challenge, their fixed exploration–exploitation mechanisms and limited adaptability to dynamic uncertainty landscapes restrict further performance improvement.

To overcome these limitations, this paper proposes a novel hybrid optimization framework that integrates an **Artificial Bee Colony algorithm enhanced by Online Fitness Landscape Analysis with NSGA-II (OFLA-ABC–NSGA-II)**. The proposed approach continuously monitors landscape characteristics such as modality, ruggedness, and basin transitions during the search process, enabling the optimizer to dynamically regulate global exploration and local exploitation. The ABC component exploits this landscape feedback to guide search behavior adaptively, while NSGA-II ensures effective Pareto dominance sorting and diversity preservation for multi-objective optimization.

The proposed framework is applied to uncertainty-aware CHPED-based OPF problems on the IEEE-57 and IEEE-118 bus systems with high penetration of wind, solar, hydro, and EV resources. Comprehensive simulations under multiple operating scenarios demonstrate that OFLA-ABC–NSGA-II consistently outperforms the previously reported QOSCA and other state-of-the-art optimizers in terms of generation cost reduction, emission minimization, active power loss, average voltage deviation, voltage stability enhancement, and computational efficiency. Statistical validation using ANOVA and robustness analysis further confirm the superiority and reliability of the proposed method.

The results establish OFLA-ABC–NSGA-II as a powerful and scalable optimization framework for next-generation uncertainty-driven smart grid operation.

sciforum-171342: A Machine Learning–Enabled Energy Management Tool for Flexible Port Operations and DER Integration

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Port decarbonization requires integrated energy solutions that reduce fossil-fuel dependence while maintaining safety, reliability, and operational continuity. This contribution proposes a machine learning–enabled energy management tool designed to support flexible port operations by forecasting demand on operational timescales and coordinating distributed energy resources (DER) within a modular, deployment-ready architecture.

The tool combines short-term load forecasting with scenario-based representations of port activity. Instead of relying on fully instrumented real-time submetering, operational states are inferred using available indicators such as time-of-day patterns, workload proxies, and configurable activity levels (e.g., low/medium/high handling intensity). These inputs are used to estimate demand trajectories and flexibility opportunities, enabling the scheduling of on-site generation and storage without disrupting core operations.

The proposed framework is modular and intended for phased deployment, allowing progressive integration as local operational and metering data become available. A demonstration case study considers renewable and flexible resources that are relevant to port environments, including photovoltaic pavements for low-speed operational areas to supply auxiliary loads (lighting, signage, monitoring), wave-energy converting seawalls integrated into coastal protection infrastructure, and vertical-axis wind turbines for turbulent and space-constrained locations. System robustness is enhanced through battery energy storage systems for peak smoothing and backup-oriented flexibility. In addition, regenerative braking in mobile equipment is discussed as an energy-recovery pathway in frequent start–stop duty cycles. A hydrogen-based supply concept for fuel-cell terminal tractors is included as a decarbonization option for internal logistics, aligned with port electrical infrastructure and safety constraints.

Overall, the contribution provides integration criteria and a scalable roadmap toward net-zero port operations, emphasizing practical implementation steps and data requirements for moving from proof-of-concept to pilot deployment.

sciforum-175301: Achieving Sustainable Integration of Renewable Energy via Smart Grids and Artificial Intelligence

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The energy sector is undergoing a rapid transition toward renewable resources, such as solar and wind energy, with the aim of reducing dependence on fossil fuels and lowering carbon emissions. However, the intermittent nature of these energy sources presents significant challenges for maintaining the stability and efficiency of conventional power grids. This study investigates the integration of renewable energy sources into smart grids using intelligent control strategies and predictive models to enhance power distribution efficiency and environmental sustainability. A grid simulation model was developed based on real-world data, where artificial intelligence techniques were applied to predict energy generation and optimize load management. In addition, smart energy storage systems were incorporated to ensure power availability during peak demand periods and unexpected outages. The system's performance was evaluated and compared with that of traditional power grids. The results indicate that integrating renewable energy with smart grid technologies reduces energy losses by up to 15% compared to conventional systems, while also improving voltage and frequency stability during peak loads and fluctuations. Furthermore, the proposed system achieves approximately 12% reduction in carbon emissions and demonstrates strong capability in predicting renewable energy output, thereby supporting more effective energy planning. Overall, the findings highlight that the combination of intelligent control systems and renewable energy significantly improves grid efficiency, resilience, and sustainability. The study also provides practical solutions for managing renewable energy variability and reducing reliance on fossil fuels, thereby contributing to sustainable development goals. Future work is recommended to scale up the proposed system for application in large cities and national power grids, while further exploring advancements in energy storage and artificial intelligence to enhance grid performance and reliability.

sciforum-174802: AI-Driven Affinely Adjustable Robust Many-Objective Scheduling Framework for Flexibility-Oriented Power Systems with High Renewable Penetration

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The increasing penetration of renewable energy sources (RESs) has fundamentally transformed modern power system operation, introducing significant challenges associated with net-load volatility, rapid ramping events, and flexibility supply–demand imbalance. Traditional deterministic scheduling approaches lack adaptability to renewable uncertainty, while conventional unit commitment (UC)-based flexibility assessment methods, although accurate, are computationally intensive and unsuitable for large-scale scenario-rich environments. To overcome these limitations, this paper proposes a novel AI-driven, flexibility-oriented Affinely Adjustable Robust Optimization (AARO) framework integrated with Generalized Linear Polyhedron (GLP)-based uncertainty modeling and a hybrid MOABC–NSGA-III many-objective optimization strategy. The proposed architecture uniquely combines probabilistic residual load forecasting, spatiotemporal renewable correlation modeling, explicit ramp-based flexibility quantification, and robust many-objective scheduling within a unified and computationally efficient framework. Extensive simulation studies conducted on modified IEEE 30-, 57-, and 118-bus systems demonstrate clear superiority over state-of-the-art deterministic and UC-based methods. At 60% renewable penetration, the flexibility gap is reduced from 10.3% to 2.8%, representing a 72.8% improvement in flexibility adequacy. Renewable curtailment decreases by 58%, while the Flexibility Risk Index (FRI) is reduced by approximately 78%, indicating significantly enhanced reliability under uncertainty. Additionally, total operational cost and carbon emissions are reduced by 10.7% and 13.8%, respectively. From a computational perspective, the proposed framework achieves more than 80% reduction in execution time compared to classical UC-based flexibility studies. These results confirm that the proposed method effectively reduces conservatism, enhances robustness, improves Pareto optimality, and provides a scalable, technically rigorous solution for next-generation renewable-dominated power systems.

sciforum-179633: An evaluation of the Black Sea wave energy dynamics

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In the context of increased international efforts to reduce greenhouse gas emissions through various measures included in climate agreements, regulatory frameworks, and decarbonization strategies, utilisation of the renewable energy resources represent a solution to sustainable global development. Wave energy is one of the marine renewable resources that has a great potential but is yet not exploitered to its true potential.

Considering this, the current work examines the Black Sea's wave climate variability and wave energy dynamics using SWAN model results applied throughout the basin. Attention is given to the long-term assessment of wave conditions and wave power, the characterization of dominant wave patterns, and the identification of possible changes in sea state parameters over an extended period (30-years).

The recent past wave climate variability and the projections of future changes under the RCP4.5 and RCP8.5 climatic scenarios are evaluated.

The assessment of the potential effects of climate change on sea state conditions, and spatial distribution of wave energy resources in the Black Sea basin is obtained by comparing the historical and future projections, thereby also facilitating the observation of climate change patterns evolution.

The results offer a forward-looking assessment of wave energy potential in the Black Sea and its reliability as a sustainable energy resource in relation to climate change.

sciforum-176485: Analysis of equivalent heat capacity forms and their influence on energy storage in PCMs

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Thermal energy storage plays an important role in improving energy efficiency and managing energy demand. Phase change materials (PCMs) are widely used for this purpose due to their ability to store and release large amounts of energy through latent heat during phase transitions. However, accurately modeling the thermal behavior of PCMs remains challenging, particularly when using the equivalent heat capacity method in numerical simulations.

This study investigates the thermal behavior of a bio-based phase change material (PCM) derived from vegetable oils and beeswax. This material has a phase change temperature range of 27 °C –38.3 °C, a latent heat of 63.85 kJ/kg and thermal conductivities of 0.212 and 0.165 W/(m·K) in the solid and liquid phases, respectively. Experimental heat capacity measurements were obtained using differential scanning calorimetry (DSC). Numerical simulations were then performed using COMSOL Multiphysics 5.4a, based on the finite element method, to analyze heat transfer in a multilayer building wall incorporating a 3 cm PCM layer. Several equivalent heat capacity formulations were evaluated and compared with experimental Cp data.

The results show that the equivalent heat capacity model based solely on the function D(T)×L produces significant errors, leading to unrealistic heat capacity and enthalpy values. Dividing the term D(T)×L by the phase transition interval (T_{endset}−T_{onset}) provides results much closer to experimental measurements. The correlation model derived from experimental Cp data offers the most accurate representation of PCM thermal behavior, while the COMSOL integrated model introduces noticeable variations in enthalpy values. Overall, the results demonstrate that the accuracy of PCM energy storage modeling strongly depends on the formulation of the equivalent heat capacity. The improved formulation and experimentally based correlation model provide reliable predictions, whereas the COMSOL built-in model requires validation for each specific PCM to ensure accurate simulations.

sciforum-175237: Assessment of Kite-Assisted Propulsion under Black Sea Wind Conditions: Technical and Operational Perspectives

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Introduction

Nowadays, wind-assisted propulsion systems have become mature technologies that contribute measurably to reducing greenhouse gas emissions and diminishing fossil fuel consumption.

These systems operate at high altitudes up to 300 meters, where winds are more favorable, being less affected by turbulence than sea-surface winds and stronger.

Given the wind patterns in the Black Sea basin, it is relevant to examine how such a system performs under these regional conditions during winter.

Method

This study audits a voyage in the Black Sea basin by a cargo ship equipped with a towing kite, utilizing data from the Copernicus Climate Change Service. Hourly wind components at 100 m altitude were sourced from the ERA5 reanalysis dataset.

The pulling force was predicted using an abridged approach based on aerodynamic lift and drag generated by the apparent wind speed acting on the kite area. The model vessel used throughout the work is a small cargo vessel with a tonnage not exceeding 10,000 DWT, cruising at about 11 knots, while the towing kite area varies from 160 to 320 square meters.

The freshness of our work stems from using hourly wind data across successive Black Sea voyage legs to improve estimation precision.

Results

Analysis finds that, under favorable wind alignment conditions, traction forces can reach up to 500 kN for the model vessel and kite array. For winter navigation scenarios in the Black Sea, estimated fuel savings can reach 15%, depending on wind direction and availability. Corresponding CO_2 emission reductions scale proportionally with fuel savings.

Conclusions

The findings indicate that an operational kite-equipped vessel in the Black Sea achieves quantifiable reductions in emissions under seasonal wind conditions. Integrating reanalysis wind data with propulsion balance modeling establishes a transferable framework for evaluating the real-route performance of kite-assisted vessels in regional maritime transport.

sciforum-179090: Comparative Techno-Economic Analysis of Offshore and Onshore Wind Farms in Zafraana, Egypt Using the System Advisor Model (SAM)

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Optimizing wind energy deployment is a major priority as Egypt accelerates its transition to renewable power to meet its 42% renewable electricity target by 2035. In this study, we present a comparative techno-economic assessment of two 200 MW wind farm configurations located in the Zafraana region: one onshore and one offshore. By leveraging the System Advisor Model (SAM) and integrating high-resolution meteorological data from the Global Wind Atlas, we simulated the energy yield and financial metrics of both setups under standardized conditions over a 25-year period. Both configurations utilize 200 Mitsubishi MWT-1000A turbines, with hub heights optimized for their specific environments (90 m onshore and 120 m offshore). Our findings reveal a distinct technical advantage for the offshore environment. Benefiting from a highly consistent coastal wind profile, the marine installation generates 445.7 GWh of annual energy, which is 58.8% more than the 280.6 GWh produced by its land-based counterpart. However, this increased output comes with a steep financial trade-off. Driven by massive initial capital investments and complex marine logistics, the offshore system requires a capital expenditure of $806.2 million, representing a 135% increase over the onshore system's $342.6 million. Consequently, the offshore configuration exhibits a substantially higher real Levelized Cost of Electricity (LCOE) of 17.71 ¢/kWh and an extended payback period of 17.5 years, compared to the onshore LCOE of 10.22 ¢/kWh and a 9.8-year payback. Ultimately, while offshore wind remains essential for long-term decarbonization targets, our analysis indicates that onshore installations currently provide a more economically viable, lower-risk pathway for near-term capacity expansion.

sciforum-180040: Dynamic modeling analysis of a Doubly-Fed Induction Generator based wind energy system

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The increasing integration of wind energy into modern power systems introduces significant challenges in maintaining frequency stability and power quality due to the stochastic nature of wind speed, particularly in microgrid environments. This study focuses on the modeling and control of a wind energy conversion system based on a Doubly-Fed Induction Generator (DFIG) operating in conjunction with an external power supply system. A comprehensive simulation model of the wind energy system was developed in MATLAB/Simulink, incorporating both the wind turbine and power converter subsystems. The control strategy is based on stator flux-oriented vector control, which enables independent regulation of active and reactive power, combined with space vector pulse-width modulation (SVPWM) to improve the performance of the power electronic converters. The system employs a dual-converter structure, where the rotor-side converter ensures bidirectional power flow and the grid-side converter maintains the DC-link voltage. The simulation results demonstrate that the proposed control system ensures fast dynamic response and stable operation under variable wind conditions. In particular, the stator current reaches steady-state within 0,01 s, satisfying the specified technical requirement for transient performance. Additionally, the DC-link voltage is effectively stabilized at approximately 700 V, ensuring reliable operation of the converter system. The use of SVPWM contributes to improved switching performance and efficient synthesis of voltage vectors, enhancing overall system stability. The developed model also confirms stable operation of the wind energy system within a microgrid, ensuring coordinated interaction between system components under fluctuating wind conditions. Compared to conventional approaches, the applied vector control strategy provides effective decoupling of power components and improved dynamic characteristics of the system. The results obtained validate the effectiveness of the proposed modeling and control approach for small-scale wind energy systems and demonstrate its applicability for improving the stability and performance of renewable energy integration in modern power systems.

sciforum-165475: Fault Detection in Wind Turbines using Weather Decomposition

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Wind turbines have been deployed in both offshore and onshore locations around the world, representing a crucial component of renewable energy infrastructure. With the increasing diversity and geographical spread of wind turbine installations comes the significant challenge of understanding and mitigating weather effects on these systems' long-term operational life and performance capabilities. Weather conditions play a fundamental role in determining the power output of wind turbines. During periods of strong wind activity, substantially more electrical energy is generated compared to calm conditions when wind speeds are minimal or insufficient. Consequently, proactive maintenance strategies must be implemented for turbines experiencing prolonged periods of low wind exposure to minimize operational downtime and maintain efficiency standards.

A comprehensive understanding of how various weather patterns and meteorological phenomena affect wind turbine performance is essential for detecting potential mechanical and electrical failures before they occur, enabling timely maintenance interventions. Early detection and prediction of faults can help operators avoid the extremely high costs typically associated with major component failures in wind turbines, which can result in extended outages and expensive repairs.

This paper examines the relationship between weather conditions and wind turbine failures through advanced analytical methods. Principal Component Analysis (PCA) is employed to reduce the dimensionality of complex datasets and identify the most significant features influencing turbine performance. The Seasonal and Trend decomposition using Loess (STL) algorithm is applied to weather data to separate time series information into distinct trend, seasonal, and residual components. Through residual decomposition analysis, wind turbine failures were successfully identified, and early failure prediction was achieved within a timeframe ranging from seven to fifteen days prior to actual failure events, demonstrating prediction precision rates between 0.4 and 0.75.

sciforum-174367: Hazard Detection in Transmission Corridors Based on the Task-aligned One-stage Object Detection

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Introduction

The accuracy and real-time capability of hazard detection in transmission corridors directly impact grid safety, fault prevention, and emergency response efficiency. Traditional manual inspection is inefficient, and conventional image processing methods are easily disturbed in complex scenarios. To address this, this study employs the Task-aligned One-stage Object Detection (TOOD) algorithm to automatically identify typical external hazards in UAV aerial images.

Methods

We focus on four common hazards: balloons, kites, bird nests, and damaged insulators. A publicly available dataset is used to train the TOOD model, which leverages its task-aligned mechanism and feature fusion architecture to improve detection stability under strong sunlight, haze, and occlusion. Standard data augmentation is applied during training, and model generalization is evaluated on a validation set across various operating conditions. The output includes hazard location, category, and confidence score for risk analysis.

Results

Experiments show that TOOD outperforms most mainstream one-stage detectors in this task. It achieves stable performance in complex environments and basically meets the real-time requirements of field inspection.

Conclusions

Applying TOOD to transmission corridor hazard detection demonstrates reliable recognition capability under challenging conditions and possesses practical engineering value. It provides a feasible technical solution for intelligent UAV-based inspection and supports the automation of transmission line operation and maintenance.

sciforum-177478: Improving Energy Efficiency In Metalworking Machine Tools: Vector Control Of Electric Drives Using A Frequency Converter And System Modeling

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Abstract. Today, the mechanical processing and treatment of metals are of great importance in the development of industrial sectors. Therefore, in the process of mechanical metalworking, a need arises to create new modern equipment or improve existing devices. In industrial sectors, there are several problems with devices and machine tools (such as the 1K62 lathe-screw cutting machine) used in the mechanical processing of metals, including the turning of cylindrical and conical parts, machining their external and internal surfaces, thread cutting, and surface polishing. Specifically, it is difficult to precisely control the spindle speed during the metal-cutting process, energy consumption is high due to the high starting current (5-7 times the nominal value) of asynchronous motors during machine operation, the vibration level is high during operation, and there is no torque control. These problems can be eliminated by using scalar (simple) and vector control methods of frequency converters. In this case, the vector control method was used in the research because it has several advantages as a solution to these problems. As a result, it was demonstrated during the research process that the spindle speed can be reduced to 12.5 rpm. This made it possible to precisely control the spindle speed, maintain torque at low speeds, increase energy efficiency, reduce the load on mechanical transmissions, and ensure the stability of the cutting process. In addition, by operating the asynchronous electric motor through a frequency converter, it is possible to increase the efficiency and service life of such machine tools. This is of significant importance in the process of optimizing the electrical power supply system of the machine tool.

sciforum-175365: Material Design and Weight Effect of an Additively Manufactured Wind Turbine Blade

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In recent years, small-scale wind turbines (WTs) have gained immense attention from consumers, researchers, and engineers across the globe. It has been reported that the large-scale wind turbine manufacturing costs have reduced to 15-20% of the total production. Recently, it has also been reported that the wind turbine prices have reduced due to the progress in material development.

Background

Literature review shows that lighter WT blades are significantly important for producing higher rotational speeds. The investigation of design and properties for lighter materials is crucial for the structural integrity of the application. A limited number of researchers reported WT material development by using additive manufacturing (AM) for small-scale applications. Still, material design with weight reduction is not a well-explored area.

Objective

The research aims to study the influence of material design and the corresponding weight of the produced part for different materials.

Method

In this research, we used an additive manufacturing method to design a small-scale wind turbine blade. The WT turbine blade design can be incorporated by using different lattice structures. The design-integrated WT blade was fabricated using the AM technique. We applied the fused deposition modeling (FDM) method, which is one of the AM methods and widely popular for producing polymeric material parts. The FDM-processed design-integrated WT blade was produced for polylactic acid and polyvinylidene fluoride polymeric materials. The weight of the turbine blades was collected, and the blades were tested in a wind tunnel to investigate their performance.

Finding

The result showed the influence of WT blade design and material impact on the performance of this approach. The findings provide insights into the applicability of additive manufacturing in rapid prototyping and functional deployment of small wind turbines.

sciforum-180077: Modeling and Forecasting Electricity Consumption and Its Determinants: Evidence from the Kashkadarya Region

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In the context of rapid population growth, expansion of economic sectors, and the accelerated development of digital technologies, the demand for electricity has been increasing significantly, posing new challenges for modern energy systems. In particular, the accurate assessment of electricity consumption, comprehensive analysis of its determining factors, and the development of reliable forecasting models have become pressing scientific issues. The aim of this study is to model and forecast key energy and socio-economic indicators within the electricity supply system, using the Kashkadarya region of Uzbekistan as a case study. The research identifies the relationship between electricity consumption and per capita income levels. Additionally, evaluation models aimed at reducing energy losses and improving energy efficiency in the power sector are developed. Models were constructed to determine forecast parameters for regional energy efficiency indicators, network losses, electricity generation, and consumption volumes. The analysis employs correlation and multiple regression methods, while forecasting is conducted using time series models. The empirical results demonstrate a high level of statistical significance of the developed models and confirm the existence of a strong relationship between electricity consumption and the selected explanatory variables. In particular, a 1% increase in per capita income is associated with an average increase of 0,25% in electricity consumption. The findings contribute to improving the accuracy of electricity demand forecasting, enhancing energy management efficiency, and providing a scientific basis for planning and modernization of energy systems.

sciforum-175403: Modelling the energy and ventilation in passenger transportation vehicles

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This study develops a new passive ventilation system for a passenger train. This ventilation system comprises a supply air system and an exhaust air system; it improves indoor air quality and uses only the pressure field generated by the movement of the train as its energy source. Air from the supply system enters the front exterior of the train and exits at the lower part of the interior of the train. Air from the extraction system enters the upper part of the interior of the train and exits at the rear exterior of the train. In the study, a train comprising five rooms was considered. Each room is equipped with 16 seats and two tables, accommodating 16 passengers.

The numerical model uses a system of integral energy and mass balance equations. In passive ventilation, the second-order energy integral equations and the first-order mass integral equations are considered to evaluate the airflow rate. The energy integral equations account for kinetic, potential, pressure, and local and continuous energy losses.

The airflow rate, which influences the internal carbon dioxide concentration, is considered in the indoor air quality evaluation. However, the airflow rate depends on the vehicle velocity. As the vehicle velocity increases, the internal airflow rate also increases.

According to the results, a vehicle velocity above 20 m/s generally ensures acceptable indoor air quality. However, extreme train rooms present a higher airflow rate than the central room. The duct design, equations system, and more details are presented in the short paper.

sciforum-175400: Modelling the Environmental Performance of Hydrogen Energy Systems: A Systematic Life Cycle Assessment Review

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Life Cycle Assessment (LCA) has become a key methodological framework for evaluating the environmental performance of hydrogen-based energy systems within the context of the global energy transition. As hydrogen gains prominence as a low-carbon energy carrier, understanding the environmental implications associated with its production and storage pathways is essential to support robust technological and strategic decisions. This study presents a systematic review of the application of LCA to hydrogen production and storage systems for energy use. The review was conducted following PRISMA guidelines, using a structured search strategy in major scientific databases with keywords related to “Life Cycle Assessment,” “hydrogen production,” “hydrogen storage,” and “energy systems.” Peer-reviewed articles published between 2018 and 2025 were included if they applied full or partial LCA approaches (cradle-to-gate, cradle-to-grave, or gate-to-gate) to hydrogen technologies. Data were extracted on system boundaries, functional units, impact assessment methodologies, databases, and modelling tools. The results show that the most common functional units were 1 kg of H_2 produced, 1 MJ of energy delivered, and 1 kWh stored. ReCiPe (2008 and 2016), CML, and EF 3.0/3.1 were the predominant impact assessment methods, while SimaPro was the most widely used software, followed by GaBi and openLCA. Global Warming Potential (GWP) emerged as the most frequently reported impact category. Overall, the review confirms that LCA provides a robust system-level modelling framework to quantify environmental impacts across the hydrogen value chain, identify environmental hotspots, and compare technological configurations using a multi-criteria perspective, thereby supporting informed decisions for the sustainable development of hydrogen energy systems.

sciforum-175355: MuLTEcast-Bandit: Sustainable and Energy-Aware Adaptive Multicast/Unicast Selection for Massive Event Streaming in 5G/6G Edge Networks

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The exponential surge in live video streaming during high-density simultaneous events imposes significant strain on 5G cellular architectures. While Unicast Adaptive Bitrate (UABR) streaming maximizes individual Quality of Experience (QoE), it entails excessive spectral redundancy. Conversely, conventional multicast improves resource efficiency but often compromises aggregate QoE by disregarding user-specific channel conditions and mobility. To bridge this gap, we propose MuLTEcast-Bandit, a lightweight contextual Multi-Armed Bandit (LinUCB) framework deployed at the Mobile Edge Computing (MEC) layer. The proposed algorithm dynamically optimizes the transmission paradigm, multicast versus unicast, and bitrate selection based on real-time network features, including group density, channel quality indicators, and client-side stall events. Simulation results demonstrate that MuLTEcast-Bandit significantly outperforms traditional benchmarks, achieving a 57% increase in mean QoE over static multicast and a 21% improvement over heuristic-based policies. Notably, the framework delivers these performance gains while utilizing only 58% of the bandwidth required by pure unicast deployments, effectively balancing peak individual quality with network-wide spectral efficiency. Furthermore, the solution’s low computational complexity ensures high deployability on modest edge hardware compared to heavy deep reinforcement learning alternatives. These findings delineate a scalable and energy-efficient path for multimedia orchestration in future green 6G network architectures, providing a robust policy for sustainable high-demand streaming.

sciforum-175174: Multi-Nanogrids Power Management and Control Using Nature-Inspired Optimization Algorithms

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This paper deals with the design of an optimal power management and control scheme to improve dynamic behaviors of renewable power generation sources in multi-nanogrids system. The investigated nanogrid includes solar PV generator and wind turbine. A storage was also employed to support active power management. Three novel nature-inspired optimization algorithms, namely Marine Predator, African Vultures, and Gorilla Troops, have been used to enhance nanogrid power management. The main tasks were to design a robust controller applied to the storage system, coordinated with an intelligent power management tool that allows increasing the integration of green power in small distributed systems such as nanogrids. In this context, several scenarios have been performed to show the effectiveness of the proposed method. The storage system was firstly used to support the power supply, then the application was extended to participate in the frequency control. A comparative study between the employed optimization algorithms was carried out in view of peak minimization and settling time. Further, robustness analysis was conducted using different rate of renewable energy penetration. It can be observed from the presented results, that using optimization algorithms can create a powerful and smart tool that can manage the generated power from the green units and ensure power equilibrium during load variations.

sciforum-180003: Optimal Sizing of Residential Hybrid Renewable Energy Systems: A Comparative Study of HOMER Pro and PSO

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Absract

Background

Hybrid Renewable Energy Systems (HRES) are increasingly considered a promising solution for supplying reliable, economical, and sustainable electricity to local loads. However, determining the optimal system size remains a major challenge, particularly because commercial tools such as HOMER Pro and metaheuristic methods such as Particle Swarm Optimization (PSO) rely on different optimization strategies.

Methods

This study presents a comparative assessment of HOMER Pro and PSO for the sizing of a residential HRES consisting of photovoltaic panels, wind turbines, battery storage, and a diesel generator. The comparison is based on three main performance indicators: Net Present Cost (NPC), Levelized Cost of Energy (LCOE), and renewable energy fraction.

Results

The findings show that PSO achieves approximately 5% better NPC performance than HOMER Pro while maintaining similar system reliability and enabling greater renewable energy penetration. In contrast, HOMER Pro yields a lower-cost configuration in terms of initial economic selection under the studied conditions, but it is associated with a higher LCOE and a null renewable fraction.

Conclusion

These results demonstrate the greater flexibility of PSO in improving renewable energy integration while reducing long-term system costs. The study provides useful insights for the optimal design and techno-economic evaluation of residential hybrid renewable energy systems.

sciforum-172601: Optimizing Grid-Tied Inverters Through Efficiency and Harmonic Distortion Analysis of Pulse-Width Modulation Controllers

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This work presents a comprehensive framework for analyzing and optimizing grid-tied inverters with a focus on the combined consideration of efficiency and harmonic distortion in their output waveforms. Using dimensional analysis, a physically consistent model for total harmonic distortion is developed, enabling accurate prediction of the optimal switching frequency for pulse-width modulation controllers with a prediction error of only 1.5% compared to full-scale numerical simulations. The study introduces a theoretical upper bound for the combined efficiency and distortion performance, quantifies unavoidable losses arising from filter inductance and magnetic core components, and evaluates five different pulse-width modulation controllers, comparing their efficiency, total harmonic distortion, daily energy delivery, and overall performance scores. Among the controllers tested, the best-performing solution achieves an overall performance score of 0.992 and delivers daily energy savings of 0.160 kWh, corresponding to a 0.97% improvement over the baseline. To address the high computational cost of conventional simulation sweeps, a three-point evaluation protocol is proposed, reducing the number of required simulations from 10,000 to 3, representing a 97% reduction while maintaining less than 1% deviation from full simulation results. The results demonstrate that the framework not only provides accurate, dimensionally consistent predictions of optimal switching frequencies and performance bounds but also enables quantitative assessment of efficiency–distortion trade-offs, practical guidance for controller selection, and substantial reductions in design and computational effort. This approach offers both theoretical insight and practical methodology for the design and optimization of high-performance grid-connected inverters using pulse-width modulation strategies, highlighting achievable gains in energy efficiency, waveform quality, and computational efficiency.

sciforum-180300: Physics-Informed Reduced-Order Models for Air-to-Water Heat Pumps Coupled with Sensible and Latent Thermal Storage

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This study develops physics-informed reduced-order models for a residential air-to-water heat pump (AWHP) system coupled with both sensible and latent thermal energy storage. The objective is to obtain fast, control-ready models that preserve key physical behaviour across operating modes and under frequent on–off cycling.

Three one-year datasets at 30-minute resolution are generated using a validated TRNSYS simulation, each driven by a different weather year of the same place. The system comprises a dwelling model, an AWHP, a domestic hot water tank, and thermal storage. Operating data cover direct supply by AWHP, indirect operation via AWHP and a buffer tank, and a combined mode in which the AWHP charges storage overnight and prioritises storage discharge during daytime before restarting the AWHP.

The AWHP is modelled using a control-oriented reduced-order formulation that maps air-side conditions, water-side inlet temperature, mass flow control, and setpoint tracking to heating output and electrical power, with explicit attention to low part-load operation and start-up transients. Water tank and PCM tank models are derived from an enthalpy-based multi-node formulation and reduced to a small number of stratification states that capture mass-flow energy transport, inter-layer heat exchange, and ambient losses. Latent storage is represented through an invertible enthalpy–temperature relation with hysteresis switching between heating and cooling curves, based on an experimentally tested 382 L tank containing water and 154 kg of sodium acetate trihydrate PCM.

The modelling framework is validated against TRNSYS outputs. It reproduces key dynamic responses in heat pump capacity, electrical power, buffer tank temperatures, and charging and discharging heat rates, while reducing simulation time by approximately 5 times for the water tank case and by 10 to 30 times for the PCM tank case compared with the TRNSYS reference. The resulting models provide a practical route to physics-informed, control-ready models for residential heat pump systems with water and PCM thermal storage.

sciforum-176605: Power Quality Enhancement of a Grid-Following Inverter under Grid Voltage Unbalance and Impedance Uncertainty in Modern Energy Systems

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The paper presents a control method for a grid-following inverter with improved power quality under unbalanced grid voltage and uncertain grid impedance operation. For grid-connected inverters, unbalanced grid voltage operation results in negative sequence components of the grid voltage, and consequently, double frequency components of the instantaneous real and imaginary power, resulting in power oscillations. The proposed method addresses the problem of power oscillations and maintains power delivery stability under unbalanced grid voltage operation by using a dual current control structure with separate control of the positive and negative sequence components of the grid current. By controlling both sequence components of the grid current, the method eliminates power oscillations and maintains power delivery stability under unbalanced grid voltage operation.

To improve the robustness of the proposed method under uncertain grid impedance operation, the control method is formulated as a state feedback integral control method, and the gains of the state feedback integral control method are synthesized using a linear matrix inequality optimization method. The optimization method formulates the control problem as a convex optimization problem, and the closed-loop stability and robustness of the control method under uncertain grid impedance operation are guaranteed.

The proposed method, with the aid of dual sequence current control and robust control design using LMI, is able to suppress power oscillations of double frequency and improve the power quality of the grid-connected inverter system. The simulation results under various operating conditions, such as unbalanced grid voltage and uncertain grid impedance, validate the proposed control method.

sciforum-173647: Process-Oriented Evaluation and Thermodynamic Modeling of Adsorption-Based Regeneration of Contaminated MDEA Solvents in Gas Sweetening Units

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The accumulation of heat-stable salts (HSS), total organic acid (TOA) anions, and corrosion-derived metal ions in methyldiethanolamine (MDEA) solvents significantly reduces the efficiency of natural gas sweetening processes. Conventional reclamation techniques such as activated carbon adsorption and ion exchange suffer from limited selectivity and operational drawbacks under industrial conditions. This study presents a process-oriented evaluation and thermodynamic modeling of interpenetrating polymer network (IPN) nanocomposite hydrogels as advanced adsorbents for lean MDEA purification. Alginate–polyacrylamide-based hydrogels reinforced with inorganic and carbonaceous nanofillers were analyzed from a chemical engineering perspective focusing on adsorption equilibrium, thermodynamic feasibility, and process applicability. Adsorption performance toward TOA anions and heavy metals (Fe and Cr) was evaluated at multiple operating temperatures representative of industrial regeneration conditions. The adsorption behavior followed the Langmuir isotherm model, indicating monolayer adsorption dominance with increasing adsorption capacity at elevated temperatures. Thermodynamic analysis confirmed spontaneous and endothermic adsorption processes, suggesting improved regeneration efficiency under realistic plant conditions. The incorporation of nanofillers enhanced adsorption kinetics and improved structural stability by reducing excessive swelling while maintaining accessible active sites. Comparative assessment demonstrated superior impurity removal performance relative to conventional adsorbents currently used in gas processing units. The results provide a bridge between laboratory-scale material development and industrial solvent management strategies. The proposed adsorption framework enables integration of nanocomposite hydrogels into continuous MDEA reclamation systems, offering potential reductions in corrosion, foaming, and solvent degradation. This work contributes to sustainable gas processing by introducing a scalable adsorption-based regeneration concept supported by thermodynamic and process modeling analysis.

sciforum-173555: Techno-Economic Evaluation of Community-Scale EV–ASHP–PV Systems Using HOMER Grid: Case Studies in Three Canadian Provinces

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The decarbonization of residential energy systems requires coordinated integration of distributed renewable generation, electrified heating, and electric mobility. Rooftop photovoltaic (PV) systems, air-source heat pumps (ASHPs), and electric vehicles (EVs) are increasingly deployed at the community scale; however, their techno-economic performance is highly sensitive to climatic conditions, solar resource availability, and regional electricity characteristics.

This study presents a multi-community comparative assessment of an integrated PV–ASHP–EV residential energy system across geographically diverse Canadian regions. A base case community of 500 detached dwellings, each equipped with ASHP heating and two EVs, is modeled under three representative climatic zones. Community load profiles incorporating residential electricity demand, electrified heating, and EV charging are developed and optimized using HOMER Grid software to minimize net present cost (NPC) while evaluating cost of energy (COE), renewable fraction, greenhouse gas (GHG) emissions, and curtailment.

Results indicate that climate diversity significantly influences optimal PV sizing, grid interaction patterns, renewable penetration, and lifecycle economics. Cold continental regions exhibit higher heating loads but improved winter load–generation alignment, while milder regions demonstrate increased seasonal solar surplus and curtailment. Across all regions, grid-connected PV integration reduces long-term energy costs and emissions, though the magnitude of benefits varies with solar irradiance and grid carbon intensity.

By extending analysis beyond a single community to a normalized multi-regional framework, this study provides scalable insights into climate-sensitive design of community-scale renewable energy systems and supports evidence-based residential decarbonization strategies.

sciforum-180259: Web-Based Energy Yield Modeling Tool for Prototype Movable Photovoltaic Power Plants in Agricultural Automation

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This work introduces an energy yield modeling methodology for prototype movable photovoltaic power plants. Converting a complex multi-parameter system characterized by moving components and orientations into a free web-based application. The model lets users evaluate photovoltaic energy production across Europe by incorporating geographic location, panel orientation and installation capacity. The methodology is based on the Photovoltaic Geographical Information System (PVGIS), developed by the Joint Research Centre of the European Commission, which provides high-resolution solar irradiation and climate data. The work expands the PVGIS capabilities into mobile platforms.

The research evaluates the energy potential of three photovoltaic system configurations: (1) flat horizontal panels, (2) fixed installations of wings with an optimized tilt angle, and (3) tracking systems with panels affixed to movable wings functioning across a complete range of motion to enhance energy output. The results show that static and tracking systems produce very different amounts of energy each year and each season.Tracking configurations achieve higher energy output, particularly in higher latitudes and during transitional seasons such as spring and autumn.

In addition the tool evaluates the impact of electrical energy storage. Scenarios with and without battery storage are analyzed with an optimal battery capacity reccomandation is given. The findings indicate that appropriately sized energy storage can improve system reliability and self-consumption. However, excessive storage space can make performance gains less noticeable.

The proposed web-based modeling approach provides a practical and transparent tool for researchers, engineers, and project developers to assess system performance. By simplifying complex simulations into an intuitive interface, the tool supports informed decision-making in the planning and optimization of prototype movable photovoltaic installations across Europe, especially agricultural automation scenarios.

Session 4. Advances and challenges in extracting offshore energy

sciforum-173666: Decay Analyses of Eight Floating Wind Turbines

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The objective of this work is to carry out time-domain dynamic decay analyses on eight floating wind turbines. From this perspective, this paper examines various aspects of the eight floating wind turbines, including their six-degree-of-freedom responses, natural periods, and corresponding frequencies. Additionally, this paper explores the mooring line forces, tower base, tower top bending moments, and shear forces around the x- and y-axes. The eight floating wind turbines considered in this study include two Spar floating wind turbines, namely DTU Spar 1 and DTU Spar 2, one Tension Leg Platform (TLP), and five Semi-submersibles, which are the OO-Star, CSC, WindFloat, INO-WINDMOOR, and VolturnUS-S.

The detailed analyses provide insight into how each turbine design responds to dynamic conditions, a crucial aspect in evaluating their performance and stability under various environmental scenarios. Furthermore, similar analyses of the drivetrains of these floating wind turbines are also conducted, as understanding the drivetrain dynamics is essential for optimizing energy production and reducing maintenance costs. Subsequent sections of the paper incorporate additional findings, enhancing the understanding of floating wind turbine technology and its potential impact on the renewable energy sector. Further subjects related to floating wind turbines, such as mooring systems, control systems, artificial intelligence, and commercial software, are also considered.

sciforum-168603: Sensitivity analysis of WEC generators based on a neural network model

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The aim of the present work is to evaluate the output of several Wave Energy Converters (or WECs), by identifying the relevant wave parameters that influence their performances. Three offshore sites from Ireland, Spain and Portugal were considered for investigation, their selection being made based on their capability to support the development of marine renewable systems, this being the case of the GEROA project (Green Energy Research for Offshore Atlantic). As first step, the wave data coming from ERA5 (interval 2023-2025, hourly values) were statistically processed in order to es-tablish some relevant patterns. As a next step the performances of five WECs was evaluated in terms of their power output, capacity factor and capture width. The selection of these WECs was made in order to cover a wider range of operating principle (point absorber-attenuator-terminator), but also to include a wider range of power capacity that goes from 15 kW to 5.9 MW. Based on these results a feed forward neural network was assembled in order to establish the importance of the input variables (11 inputs – wave parameters) to the performances of the considered WECs (3 outputs). Based on the literature review, among the input variables were included the average and 10th percentile of the significant wave height, wave period and wave power, while for the wave direction only the average value was used. The importance of the input parameters significantly varies according to the selected geographical area and WEC system, but per total the average wave height (Hs) and wave power (Pw) seems to be the most relevant ones.

sciforum-175536: An integrated techno-economic assessment of offshore wind energy potential in Romania's Exclusive Economic Zone

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The present study provides an integrated techno-economic assessment of offshore wind energy potential within Romania's Exclusive Economic Zone (EEZ) in the Black Sea. The analysis combines wind resource evaluation, bathymetric constraints, grid accessibility, and cost modeling to identify optimal development zones for future offshore wind farms. Wind speed datasets and mesoscale modeling indicate favorable conditions in the central and northern sectors of the Romanian EEZ, particularly in areas located 40–120 km offshore, where average wind speeds exceed 7.5–8.5 m/s at 100 m hub height. Three priority development zones are proposed: a northern sector near the maritime boundary with Ukraine, characterized by relatively shallow waters suitable for fixed-bottom foundations; a central offshore corridor with moderate depths (30–50 m), appropriate for monopile and jacket structures; and a deeper southern zone, where floating wind technology could be economically viable under projected cost reductions. Proximity to existing grid infrastructure in Constanța and potential interconnection capacity significantly enhances economic feasibility. The techno-economic evaluation incorporates capital expenditure (CAPEX), operational expenditure (OPEX), capacity factors, and levelized cost of energy (LCOE) estimates. Results suggest competitive LCOE values under supportive policy frameworks, positioning Romania's EEZ as a strategic area for large-scale offshore wind deployment and long-term energy security in the Black Sea region.

sciforum-153359: Corrosion-Resistant Stainless Steel Components for Offshore Renewable Energy: A Simulation and Materials Perspective

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Offshore renewable energy systems, including wind, wave, and tidal devices, are exposed to highly aggressive marine environments where corrosion is a primary factor limiting service life. Stainless steels are widely employed in these structures, yet their long-term performance is challenged by localized corrosion phenomena such as pitting and crevice attack, exacerbated by fluctuating oxygen levels, chloride concentration, and mechanical stresses. This study presents a simulation- and literature-based assessment of corrosion resistance in stainless steel components designed for offshore renewable energy applications. Electrochemical models were implemented in MATLAB and Python to reconstruct polarization curves for commonly used alloys, including 316L, duplex, and super-duplex stainless steels, under seawater conditions. Corrosion rates were estimated using current density data, while sensitivity analyses examined the influence of chloride concentration, temperature, and passive film stability on corrosion susceptibility. A simple diffusion model was also applied to capture oxygen depletion within crevices, highlighting geometry-driven risks in bolted or welded joints. To extend the analysis beyond baseline alloy behavior, the effect of surface engineering strategies, such as laser polishing and surface texturing, was incorporated by parameterizing improvements in passive film resistance and pitting potential based on reported experimental data. The results demonstrate how alloy selection, component geometry, and surface state collectively influence the durability of offshore energy structures. By integrating electrochemical modelling with a materials perspective, the study outlines design guidelines for selecting and engineering stainless steels in marine renewable energy systems. The findings emphasize the importance of combining material choice with preventive surface engineering to extend service lifetimes and reduce maintenance in harsh ocean environments.

sciforum-175059: Future Offshore Wind Potential and Turbine Performance in the Romanian Black Sea

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In the context of accelerating global warming and the European Union’s objective of achieving climate neutrality by 2050, offshore wind energy serves as a vital strategy in the transition to a low-carbon energy process. One of the main objectives of this paper is to analyze the expected dynamics of wind power in the Black Sea. Further, the evaluation of the technical feasibility and performance of offshore wind turbines under future climate projections up to 2050 is performed. For this study, wind data were obtained from the CORDEX regional climate database, under the RCP 4.5 scenario, for a 25-year period (2026–2050) at nine locations in the Black Sea, situated at water depths ranging from 40 m to 120 m. The assessment examined six different commercial offshore wind turbines, with rated capacities between 2.3 MW and 6.3 MW and designed for a hub height of 100 m, based on the characterized wind potential identified at the selected sites. The proposed methodology integrates regional climate projections with turbine performance to provide a forward-looking assessment of offshore wind potential in the Romanian Black Sea area. The results focus on the comparative performance of the selected wind turbines in the nine examined locations, highlighting the differences in the energy field and efficiency depending on the wind conditions and the water depths.

sciforum-175212: Offshore Renewable Energy Infrastructure Under Climate Change: A Review of Structural Reliability, Climate Impacts, and Energy Security

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This paper presents a systematic analysis of the impact of climate change on offshore renewable energy (ORE) infrastructure, focusing on the interaction between climatic stress factors and structural reliability. Following a systematic search, numerous scientific studies were selected and analyzed based on predefined inclusion criteria related to climatic loads; the results included in various studies were analysed in relation to probabilistic assessment methods and offshore structural performance. The study tracks technological evolution from the first offshore wind farms to modern hybrid systems that combine wind, solar, and energy storage. The results highlight the central role of probabilistic methods in assessing structural safety under extreme weather conditions, showing that traditional deterministic approaches must be complemented with advanced statistical models for risk estimation. The review also highlights the contribution of offshore renewable energy to global energy security by diversifying sources and reducing dependence on fossil fuels. By integrating technological advances with rigorous reliability analyses, this study provides clear directions for designing a sustainable, resilient, and climate-adapted offshore infrastructure.

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