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ABSTRACT BOOK

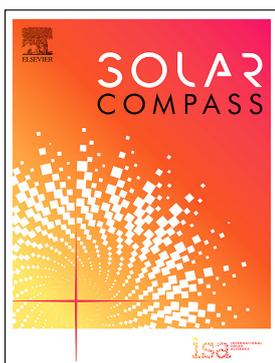2nd Edition

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Terence Collier, CEC Solutions, Richardson, TX

Terence Q. Collier CEC Solutions, LLC

Abstract:

Not a political statement. We are here to help reduce the dependence of the internal combustion engine. Never a goal to rid entirely, but where possible, provide alternative energy sources. And where needed, provide renewable fuels to use instead of fossil fuels. Green energy, in most forms, require catalytic materials. Be those materials coating a membrane for a fuel cell or biofuel reactor, catalyst facilitate those reactions. Catalyst are also in the silicon in solar cells. Remove the doping (catalyst) from silicon and its about as useful as the same it originated. Our team has transformed the method for applying catalyst. And we have improved those catalytic structures. In the next few pages, our overview will show that carbon capture can be profitable instead of depending on heavily supported government subsidies. In the best situation, carbon capture cost, including CapEx and OpEx, can create carbonate rocks for ~$120/ton. H2 generation is nowhere near the goal of $1/kg. And fuel cells are still inefficient. Each one of these items require a more reliable, robust and improved membrane. Each was presented with membranes possible of much higher than the 1000C proposed by the USDOE by 2030.

Keywords. Membranes, catalyst, fuel cells, carbon capture, hydrogen

Scenario-based Forecasting of the Global Energy Demand and Carbon Footprint of Artificial Intelligence

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[1]*Koc University, Türkiye*
[2]*Purdue University, USA*
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[4]*University of Denver, USA*

Abstract:

Artificial intelligence (AI) systems are expanding rapidly in both scale and application, raising concerns about their long-term environmental impact. This work quantifies AI's global energy demand and carbon emissions by employing a scenario-based forecasting model grounded in multi-regional input-output analysis and historical trends in energy efficiency and model complexity. We model six adoption and policy scenarios, incorporating algorithmic and hardware efficiency gains, and estimate that under the high-growth, low-efficiency case, AI workloads could consume 11.7% to 30.4% of projected global electricity and generate 4.6 to 8.4 gigatons of CO2-equivalent annually by 2050. These figures assume continued exponential growth in AI complexity and do not account for systemic constraints or regulatory intervention. Regional usage-emission asymmetries emerge, with training concentrated in high-income regions and usage growth driven by emerging markets. The analysis reveals trade-offs between centralized and decentralized AI deployment paths, with energy mix and model architecture choices critically affecting outcomes. These results indicate the importance of designing policies to moderate AI's environmental trajectory rather than assuming that efficiency gains alone will suffice.

Biography:

Metin Turkay is a Professor and Head of the Department of Industrial Engineering at Koc University, Istanbul, Turkey. He holds a PhD from Carnegie Mellon University (1996) and MS (1991) and BS degrees (1989) from Middle East Technical University. His research focuses on optimizations theory, mixed-integer programming, and development of novel solution algorithms for mixed-integer programming problems and machine learning. He is applying these theoretical developments on energy planning, sustainable energy, sustainable supply chain management and logistics, design of transportation system with special emphasis on sustainable supply chain and logistics and systems biology. Before joining Koc University in 2000 where he set up Systems Lab, he was principal consultant on optimization technologies at Mitsubishi Corporation Mizushima Research Center. His doctoral work and publications on generalized disjunctive programming was recognized with the 1997 Ted Peterson Student Paper Award by Computing and Systems Technology Division of AIChE. He is also the recipient of the Scientific and Technological Research Council of Turkey (TÜBİTAK) Career Award (2005), the TÜBİTAK Young Researcher Incentive Award (2006), Turkey's first IBM Shared University Research Award (2007), the IBM Faculty Award (2009) and the Open Collaborative Research Award by IBM Haifa Research (2012). He set up the Koc-IBM Supply Chain Research Center with funds from the IBM Shared University Research Award. In 2006, he was elected as the Chair of the EURO Working Group on Computational Biology, Bioinformatics and Medicine.

Metin Türkay published over 150 papers and is the recipient of 14 international patents.

Improving the Efficiency of Vertical Axis Wind Turbines

Xiuling Wang*, Khair Al Shamaileh, Julian Sink, Daniel Marroquin, Tyler Orloff and Shelby Hooley

Purdue University Northwest, Hammond, IN

Abstract:

In the field of renewable energy engineering, the Superformula has demonstrated promise for developing aerodynamically optimized wind turbine blades. Conventional aerodynamic modeling and Computational Fluid Dynamics (CFD) simulations are commonly used to design efficient blade shapes; however, these approaches can be computationally intensive and time-consuming. By employing the Superformula, blade profiles can be parametrically defined and optimized using a small set of mathematical parameters, thereby streamlining the design process. In this project, the potential of the Superformula equation to enhance the efficiency of Vertical Axis Wind Turbines (VAWTs) is investigated. The baseline design will follow the specifications of a standard Savonius turbine, while the optimized turbine geometries will be generated using mathematical analysis based on Gielis' Superformula. This research has two components: numerical and experimental. In Numerical Simulation part, simulations will be conducted using MATLAB, SolidWorks, and ANSYS Fluent to model and analyze turbine performance under various aerodynamic conditions; in Experimental Testing part: Two small-scale VAWT prototypes will be fabricated using 3D printing—one representing the standard Savonius configuration and the other incorporating the Superformula-derived design. Both models will then be tested in a wind tunnel to compare their aerodynamic efficiency and performance characteristics.

Biography:

Dr. Wang is a professor of ME at Purdue University Northwest with expertise in CFD, adaptive finite element method techniques, turbulent modeling, and wind energy. She has conducted extensive research in wind energy and has led many related federally sponsored projects. She has supervised 76+ (under)graduate students. She has engaged her students in research projects related to environmental and wind energy modeling and simulation.

Advanced deep learning techniques for time series: Application to diagnostics and forecasting for photovoltaic power plants

Oumayma Mabrouk*, Abdérafi Charki, Nizar Chatti, Xavier Sidambarompoulé

LARIS Laboratory, University of Angers, France

Abstract:

According to the IEA, solar PV will account for about 80% of renewable capacity additions by 2030("Solar," n.d.), underscoring the need for robust, industrial, data-driven monitoring. We present an AI-based predictive-maintenance framework for utility-scale PV plants that integrates real-time fault detection with short-horizon performance forecasting. Using multivariate operational time series—meteorology, power, voltage, current…—we conduct a comparative study of time-series models: Recurrent Neural Networks RNNs(Fatima et al., 2024), Long Short-Term Memory LSTMs(Lim et al., 2022; Yadav and Thakkar, 2024), and Gated Recurrent Unit GRUs(Khayat et al., 2025). Models are trained and fine-tuned with explicit environmental inputs to learn the plant's expected power response and dynamics. Physics-informed modeling of environmental drivers, combined with rigorous preprocessing (time alignment, outlier handling, imputation, normalization) and adaptive updating under evolving data regimes, improve robustness and enables real-time deployment. The models capture temporal dependencies, lags and regime shifts. Probabilistic outputs support calibrated early-warning alerts for incipient degradations (soiling, mismatch, partial shading, inverter faults). Using operational plant data, the framework prompts earlier interventions than corrective maintenance and is more cost-effective than preventive maintenance, reducing downtime and increasing energy yield.

Transmitter and Receiver Design for Space-Based Solar Power Systems

Jiafeng Zhou

University of Liverpool, UK

Abstract:

Space-Based Solar Power (SBSP) is an emerging technology that collects solar energy using satellites and transmits it to Earth through microwave power transfer. Recent studies commissioned by the UK government suggest that early SBSP prototypes could be deployed in the 2030s, with the potential to deliver up to 10 GW by 2050—supporting energy security and the UK's Net Zero targets.

A key challenge in SBSP is the efficient and safe design of the wireless power transmission system. The space segment requires high-efficiency power conditioning, phase-coherent microwave transmitters, and large-scale antenna arrays capable of precise beam shaping and steering. On the ground, rectenna arrays receive the microwave energy and convert it into DC electricity for grid integration.

This talk will discuss system-level design considerations for both the transmitter and receiver, including antenna architectures, conversion efficiency, and safety constraints. Preliminary results from ongoing research will be presented, together with an assessment of environmental and regulatory considerations related to microwave power beaming.

Biography:

Jiafeng Zhou is now with the Department of Electrical Engineering and Electronics, University of Liverpool, Liverpool, UK. His current research interests include wireless power transfer and energy harvesting, microwave power amplifiers, filters and metamaterials for wireless communications and space applications.

Simulation of power system contingencies using RGRID

Krzysztof Lowczowski[*], Stanislaw Mikulski

Poznan University of Technology, Poland

Abstract:

The RGRID simulator is presented as a tool for identifying critical components of the power grid and improving power system resilience. Key threats to modern power systems are discussed, including cascading failures, hybrid threats, and others. Selected approaches for mitigating the consequences of failures are outlined, along with methods for reducing vulnerability to failures and attacks. The focus is placed on the methodology of power system analysis and on selected parameters essential for conducting holistic assessments, e.g. including interdependencies with other sectors. Tools for load flow calculations incorporating modern solutions are also discussed, as well as rules for modeling the operation of protection systems and automation schemes that enable realistic reconstruction of failure scenarios.

Biography:

Assistant Professor at the Institute of Power Engineering, Poznan University of Technology. His research focuses on the integration of generation sources and loads into the power system, as well as control systems and protection and automation schemes, considering normal operating conditions, emergency states, and large-scale catastrophic failures. Member of CIGRE and Polish Association for National Security.

Harvesting Infrared Solar Radiation Beyond 1.1 μm Using Hot Carrier Effect through Thin Metal/Si Structure

Ching-Fuh Lin[1, 2, 3, 4*] and Wei-Cheng Hsu[1]

[1]*Graduate Institute of Photonics and Optoelectronics, The Department of Electrical Engineering, National Taiwan University, Taipei 10617, Taiwan*
[2]*Graduate school of Advanced rTechnology Program in Semiconductor Devices, Materials, and Hetero- integration, National Taiwan University, Taipei 10617, Taiwan*
[3]*Department of Electrical Engineering, National Taiwan University, Taipei 10617, Taiwan*
[4]*Graduate School of Advanced This design enables multiple reflections of incident light in the structure, thereby increasing the optical path length for light-trapping capability to enhance infrared absorption. The proposed solar cell features low material cost and relaxed fabrication Technology, National Taiwan University, Taipei 10617, Taiwan*

Abstract:

To reduce the negative impact of greenhouse effect, people pay increasing attention to solar energy. While most Si solar cells mainly absorb solar radiation in the spectrum below 1.1 μm, we have extended their spectral range by developing a solar cell that can convert more infrared solar energy, aiming to enhance the overall utilization of solar power. We have developed an infrared solar cell with hot carrier effect by utilizing the metal/silicon interface, combined with inverted pyramid arrays (IPAs) fabricated on the substrate. requirements. For measurement, a 700 μm-thick silicon substrate is used as a filter to block solar radiation below 1.1 μm to verify the effect is from the thin metal on the IPAs. Under solar illumination with wavelengths above 1100 nm, the device achieves a power conversion efficiency of 5.9%. Furthermore, spatially resolved efficiency measurements demonstrate favorable photovoltaic performance, with 5 mm × 5 mm region achieving over 6% power conversion efficiency, highlighting the potential for harvesting more infrared solar energy.

Key words: hot-carrier effect, inverted pyramid arrays, light-trapping, infrared solar energy

Biography:

Prof. Ching-Fuh Lin obtained the gree from National Taiwan University in 1983, and the M.S. and Ph.D. degrees from Cornell University, Ithaca, NY, in 1989 and 1993, respectively, all in electrical engineering. He is a Fellow of IEEE, a Fellow of SPIE, and a joint distinguished professor in the Graduate Institute of Photonics and Optoelectronics, Graduate Institute of Electronics Engineering, Department of Electrical Engineering and Graduate School of Advanced Technology at National Taiwan University. He has published over 200 journal papers and 600 conference papers and holds about 100 patents. He has served as the Vice President of National Applied Research Laboratories (NarLabs) of Taiwan, CTO of Taiwan Nano & Micro-Photonics Co., Ltd., visiting scientist (Consultant) of Palo Alto Research Center (PARC), and the International Scientific Committee of 27th-41st European Photovoltaic Solar Energy Conference and Exhibition (2012-

2024). His major research area includes Si-based photonics, solar cells, micro-LED technologies, etc.

Analysis of a Hybrid Solar–Battery System

Jannatun Naiem*, **Naimul Haque and Xingwu Wang**

Alfred University, NY

Abstract:

Increasing electricity demand forces us to explore new energy resources. This feasibility study examines a proposed 100-MW solar farm near Alfred, NY. The primary objective is to seek local consumption with suitable battery storage capacity. The average power consumption in the surrounding community, including the new sports complex, is estimated at 9 MW. Harvested electricity can meet heating, cooling, and hot water requirements. In contrast to studies that use generic simulation tools, this investigation employs GE Vernova's Advanced Distribution Management System (ADMS) to accurately model utility operations, feeder topologies, and distribution constraints. Seasonal power flow analyses are conducted for both grid-tied and off-grid scenarios. The analysis incorporates four seasons, utilizing historical weather data and operational controls. Hardware simulations are performed using the EDIBON smart grid platform. The findings indicate that utility-scale solar–battery systems can reliably support both local and regional loads under realistic conditions, with notable effectiveness during winter.

Biography:

Jannatun Naiem received the B.Sc. degree in electrical and electronic engineering from Ahsanullah University of Science and Technology, Dhaka, Bangladesh in 2020. She is currently pursuing the M.Sc. degree in electrical engineering at the Alfred University, NY, USA. Her current research is inspired by planned 100 MW solar with a 20 MWhr battery storage system in Alfred, NY, and evaluates its potential to support local community and institutional loads. Her research interests include smart grids, renewable energy integration, and optimization-based control of distributed energy resources.

The Effect of EV Load Growth across the US on the distribution-side Grid Infrastructure

Vladimir Abdelnour*, **Nathan Johnson and Brighton Ombuki**

Arizona State University, United States

Abstract:

Rapid electric vehicle (EV) adoption presents a significant, unquantified threat to the U.S. distribution grid. This growth, marked by 14 million new registrations in 2023 alone, introduces unprecedented, concentrated demand that threatens to overload local distribution substations and risk premature equipment failure. Previous research lacks a nationwide, substation-level assessment of these new stresses. This paper addresses this gap by developing a high-granularity, national-scale model to quantify EV-induced loading and reinforcement costs. The methodology integrates a bottom-up EV adoption model at the 84,414 census-tract level, calibrated by socioeconomic factors, with a geospatial analysis that allocates projected loads to nearly 42,000 substations across 215 utilities. Four charging scenarios (Regular, Smart 25%, 50%, 95%) are simulated to determine capital expenditure requirements using a utility-specific Marginal Distribution Capacity Cost (MCC).

The unmanaged "Regular" charging scenario necessitates $5.17 billion in cumulative capital investment by 2050, overloading 10,112 (24.21%) substations. The analysis reveals that managed charging offers non-linear benefits, with an optimal 50% smart charging penetration reducing required investment by 40.7% to $3.06 billion. Beyond 50%, it is hard to quantify algorithmically how smart charging would like relative to a smart controllable load. The findings also show that risk is not uniform but concentrated in a "long tail," with the 99th percentile of substations facing catastrophic overloads (>190%) while the median substation remains resilient. This study provides a strategic, data-driven roadmap for policymakers, demonstrating that while smart charging is a powerful tool, targeted, multi-billion-dollar grid reinforcements are still essential.

Biography:

Vladimir Abdelnour is a PhD candidate in Systems Engineering at Arizona State University's Laboratory for Energy & Power Solutions (LEAPS). His research focuses on grid modernization, particularly modeling electric vehicle adoption and its impacts on substation loading and distribution capacity. He has led projects integrating AI, machine learning, and digital twins to improve grid forecasting and planning efficiency. Before joining ASU, Vladimir founded Takatcom, developing advanced metering and microgrid control solutions, and served as Head of Solar Sales and Engineering at NovaEnergia during Lebanon's solar market expansion. His work bridges field implementation and data-driven energy research.

Advanced deep learning techniques for time series: Application to diagnostics and forecasting for photo-voltaic power plants

Oumayma Mabrouk*, Abdérafi Charki, Nizar Chatti and Xavier Sidambarompoulé

LARIS Laboratory, University of Angers, France

Abstract:

According to the IEA, solar PV will account for about 80% of renewable capacity additions by 2030("Solar," n.d.), under-scoring the need for robust, industrial, data-driven monitoring. We present an AI-based predictive-maintenance frame-work for utility-scale PV plants that integrates real-time fault detection with short-horizon performance forecasting. Using multivariate operational time series—meteorology, power, voltage, current…—we conduct a comparative study of time-series models: Recurrent Neural Networks RNNs(Fatima et al., 2024), Long Short-Term Memory LSTMs(Lim et al., 2022; Yadav and Thakkar, 2024), and Gated Recurrent Unit GRUs(Khayat et al., 2025). Models are trained and fine-tuned with explicit environmental inputs to learn the plant's expected power response and dynamics. Physics-informed modeling of environmental drivers, combined with rigorous preprocessing (time alignment, outlier handling, imputation, normalization) and adaptive updating under evolving data regimes, improve robustness and enables real-time deploy-ment. The models capture temporal dependencies, lags and regime shifts. Probabilistic outputs support calibrated early-warning alerts for incipient degradations (soiling, mismatch, partial shading, inverter faults). Using operational plant data, the framework prompts earlier interventions than corrective maintenance and is more cost-effective than preventive maintenance, reducing downtime and increasing energy yield.

Techno-Economic Assessment of Ammonia & Methanol as Hydrogen Carriers

Sajag Poudel*, Tanveer Sheik, Zilong Fang, Hla Tun, Kyuha Lee, Yi Ran Lu, Krishna Reddi, Pingping Sun and Amgad Elgowainy

Argonne National Laboratory

Abstract:

Ammonia and methanol enable hydrogen transport at lower pressures and in a higher energy density form, making them an efficient hydrogen carrier. Understanding of the efficiency and economics of hydrogen transport is crucial and requires a detailed techno-economic analysis (TEA) to benchmark the delivery cost via such carriers against conventional pathways. This study presents the Hydrogen Carrier Scenario Analysis Model (HCSAM), a TEA tool developed by Argonne National Laboratory. HCSAM incorporates data for the entire value chain of ammonia and methanol, including production, transport, and dehydrogenation processes. The model incorporates cost data from the original equipment manufacturers, government databases, open literature, and utilizes H2A platform to perform cash-flow analysis and estimates the levelized cost of delivered hydrogen $/kg across various technology pathways and scenarios. Key findings indicate that for shorter distances, truck-trailers are the most cost-effective mode. However, for longer distances and higher demands, pipeline transport becomes economically viable. Additionally, overseas transport of hydrogen carriers using ocean tankers offers a cost advantage over liquid hydrogen shipping. This study underscores that the economics of hydrogen delivery in pure form versus using carriers primarily hinges on factors such as delivery volume, distance, the chosen mode of transport, and the specific end-use applications

Biography:

Sajag Poudel, PhD, is an Energy Systems Scientist at the U.S. Department of Energy's Argonne National Laboratory. His work focuses on energy infrastructure analysis, thermodynamics and fluid modeling, and techno economic and life cycle assessment. He earned his PhD in Mechanical and Aerospace Engineering from Syracuse University in New York and has spent the past four years advancing research at Argonne. Dr. Poudel has authored or co authored more than three dozen peer reviewed publications and has delivered presentations at numerous national and international conferences.

Green Hydrogen Electricity Generation System

J. V. C. Vargas[1,2,3,7]*, H. P. Guerra[1,2], A. M. Silveira[1,2], D. M. Taher[1,2], C. H. Matiolo[1,2], L. S. Martins[4], S. H. Och[1,2], D. B. Pitz[1,2], A. B. Mariano[1,2,3,5], L. Cardozo-Filho[6], G. S. Venter[1,2], J. C. Ordonez[7]

[1]*Graduate Program in Mechanical Engineering (PGMEC), and Department of Mechanical Engineering, Federal University of Parana (UFPR), Curitiba, 81531-980, Brazil*
[2]*Sustainable Energy Research and Development Center (NPDEAS), Federal University of Parana (UFPR), Curitiba, 81531-980, Brazil*
[3]*Graduate Program in Materials Science Engineering (PIPE), Federal University of Parana (UFPR), Curitiba, 81531-980, Brazil*
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[6]*Department of Chemical Engineering, Maringá State University (UEM), Maringá, 87020-900, Brazil*
[7]*Department of Mechanical Engineering, Energy and Sustainability Center, and Center for Advanced Power Systems, Florida State University, Tallahassee, Florida 32310-6046, USA*

Abstract:

This work introduces a sustainable electricity generation system driven by green hydrogen, produced from aluminum and water. The system consists of a hydrogen batch reactor, a buffer tank, a booster, a compressor, a storage tank and a proton exchange membrane fuel cell (PEMFC) stack, mounted on a car trailer for compacity and mobility. The Alkaline Aqueous Redox Reaction of Aluminum (AARRA) allows for the production of H2 to supply the PEMFC stack. Since residual aluminum from a well-established recycling chain, seawater or degraded water could be utilized, the system is expected to be fully sustainable. A prototype was built in the laboratory and system characterization was carried out considering the hydrogen production, storage, and power generation with the PEMFC stack that uses the green hydrogen generated in the reactor as fuel. The results show that the system was capable of generating up to 20.5 g of hydrogen in each batch. Experimental power and polarization curves characterizing the operation of a 5-kW Horizon PEMFC stack were obtained, which showed good qualitative and quantitative agreement with the nominal curves provided by the fuel cell manufacturer. The produced H2 had the necessary purity to supply the PEMFC stack up to 90% of its maximum nominal power with no need of extra energy consumption for H2 purification, which is an advantage in comparison to other green H2 production methods, such as electrolysis that requires extra-energy consumption for H2 dehumidification. A prototype of an electric vehicle (EV) range extender (REX) was built with the proposed system and tested, showing that the EV nominal range was increased by 16%. Hence, possible future direct applications include

electric vehicles, all electric ships and stationery distributed power generation.

Keywords: Green Hydrogen, Fuel Cell, Renewable Energy, Aluminum-to-Hydrogen, Catalysis

An Empirical Study of the Economic viability of Fuel Cell Vehicles in Korea: A case of Fuel Cell forklift

Deok-Joo Lee

Seoul National University
Republic of Korea

Abstract:

As low-carbon transition in construction equipment is required, interest in fuel cell forklifts is increasing in many countries, including Korea. Most of the studies for economic feasibility analysis of fuel cell forklifts estimate costs based on data through statistics and expert interviews. However, in order for companies to decide investing fuel cell forklifts, more realistic economic feasibility analysis based on empirical data is necessary. Also, in addition to analyzing the ownership cost of the forklift, it is needed to evaluate the economic value on carbon emission reduction brought by fuel cell forklift. This paper studies the economic feasibility of fuel cell forklifts and the economic effect of reducing carbon emissions based on Korean empirical data. We examine the cost in terms of CAPEX, OPEX, and the economic value of carbon reduction. Purchase, installation, subsidies, etc. are considered for CAPEX, and fuel costs, operation, maintenance, labor costs, etc. are considered for OPEX. In the context of fuel cell forklifts, fuel cells constitute a substantial proportion of the overall expenses, thus emphasizing the need for meticulous maintenance. Moreover, fuel cell forklifts experience degradation under harsh operating conditions, leading to reduced fuel efficiency. However, research on maintenance costs reflecting this degradation is limited. This study introduces a novel Markov decision process (MDP) model that aims to optimize both the interval to the next inspection and maintenance decisions, while effectively considering the degradation of fuel efficiency. Our economic feasibility analysis takes into account changes in costs depending on a cost-effective condition-based maintenance (CBM) policy that aligns with the distinctive attribute of fuel cell forklifts. In particular, generation of hydrogen has a great influence on both carbon emissions and costs. Whether a company chooses to produce hydrogen on-site or off-site and to use hydrogen generated by water electrolysis is an important issue. In addition, we analyze the economic feasibility analysis that will change as the technology maturity of fuel cell forklift and hydrogen increases over time. Finally, based on the results of our analysis, we discuss how the policy makers can effectively intervene in a company's decisions on the purchase of fuel cell forklift to speed up the low-carbon transition.

Electrochemical Hydrogen Storage in Metal Oxides Anchored on Carbon

Ajeet Kumar[1], Rahul Gupta[1], Nishith Verma[1,2]**

[1]*Department of Chemical Engineering, Indian Institute of Technology Kanpur, Kanpur, 208016, India*
[2]*Centre for Environmental Science and Engineering, Indian Institute of Technology Kanpur, 208016, India*

Abstract:

:Hydrogen gas is a promising energy carrier for the next-generation renewable technologies, but its use is limited by low energy density, high production cost, and complex storage methods. Solid-state hydrogen storage can overcome some of these limitations; yet several unresolved issues persist, particularly concerning the behavior of metal oxides during hydrogen sorption. Layered and porous materials offer a promising pathway to overcome these limitations, as their unique structures facilitate efficient hydrogen uptake. Nanostructured bimetallic oxides anchored on graphitic carbon nitride (g-C3N4) show strong potential as candidates for solid-state hydrogen storage. We consider two such systems for electrochemical hydrogen storage in this study.

Perovskite-based bimetallic oxides are known for their crystalline inorganic structure and exceptional mechanical hardness, making them promising materials for robust hydrogen storage applications. Concurrently, g-C3N4 exhibits attractive properties, layered structure with porosity, good chemical stability, and low-cost synthesis routes. These features also make g-C3N4 a strong candidate for use in energy storage devices such as supercapacitors and batteries. NiSnO3 nanostructure, a perovskite bimetallic oxide, was synthesized via the sol-gel method, while g-C3N4 was prepared by thermal polymerization at 550 °C for 4 h. The second system consisted of a hierarchical porous structured carbon micro-nanofiber (CNF/ACF) containing the bimetallic configuration of the nickel (Ni) and ceria (CeO2) nanoparticles (NPs). Both the systems, namely NiSnO3−g-C3N4 and Ni-CeO2-CNF/ACF exhibited a high H2 storage capacity of 400 - 500 mAh/g or 1.8 - 2% (w/w) at the charge-discharge current density of 500 mA/g.

The carbon-supported metal oxides hybrid demonstrates enhanced hydrogen storage performance, driven by synergistic interactions that improve conductivity, surface area, and charge transfer efficiency. The integration of the electrocatalytic activity of bimetallic oxides with the high surface functionality of carbon substrates positions the composites as a promising material for electrochemical hydrogen storage systems. The talk will include the latest data on the electrochemical hydrogen storage of the hybrid composites.

Biography:

Ajeet Kumar: Ajeet Kumar is a Ph.D. student in the Department of Chemical Engineering at the Indian Institute of Technology Kanpur, India. His thesis focuses on photocatalytic hydrogen evolution and electrochemical hydrogen storage over carbon-supported metallic nanocomposites.

Rahul Gupta: Rahul Gupta is a Ph.D. student in the Department of Chemical Engineering at the Indian Institute of Technology Kanpur, India. His thesis focuses on the development of novel carbon-based materials for energy and environmental applications.

**Nishith Verma (presenter): Nishith Verma is a professor of Chemical Engineering Department at the Indian Institute of Technology Kanpur, India. His research interests are the development of carbon-based materials, especially nanofibers and nanoparticles in microbial fuel cells, photocatalysis, electrocatalysis, sensors, and agricultural applications

NH3-Dual Fuel Combustion for Future Sustainability

Abstract:

Ammonia is emerging as a compelling energy carrier in the global transition toward decarbonization, serving both as a carbon-free fuel and an efficient hydrogen vector. With an established production and distribution infrastructure, ammonia offers a practical pathway for large-scale energy deployment. Our research focuses on ammonia as a future combustion fuel, particularly in blends with renewable compounds such as methanol, ethanol, dimethyl ether, and dimethoxymethane. These blends overcome key limitations of neat ammonia by improving ignition characteristics, enhancing combustion stability, and reducing emissions. We have conducted extensive high-pressure, high-temperature experiments representative of real engine environments. By integrating experimental measurements with theoretical chemistry and detailed chemical kinetics modeling, we uncover reaction pathways and emission formation mechanisms governing ammonia−renewable fuel combustion. These insights enable optimization of ammonia-based blends for advanced engine platforms, including spark-ignition systems, supporting scalable, low-carbon solutions for transportation and power generation.

Multi-Domain Temporal Wind-to-Hydrogen Production Forecasting and LCOH Analysis

Doha Bounaim, Sara Mouafik, Gang Li[*]

Mississippi State University, USA

Abstract:

This paper presents an enhanced time-series forecasting framework for wind-to-hydrogen production that integrates multi-domain data for wind speed forecasting with a proton exchange membrane (PEM) electrolyzer and a comprehensive cost analysis. This work extends the forecasting horizon to enable strategic planning for hydrogen production systems. The proposed multivariate Transformer model performs multi-domain ahead wind speed forecasting using supervisory control and data acquisition data. The model is validated on a comprehensive dataset of 50,530 samples collected at 10-minute intervals, with an extended multi-domain forecasting horizon. This multi-domain forecasting capability provides a lead time for electrolyzer operation adjustments, storage management, and grid interaction optimization. The PEM electrolyzer design will be optimized considering membrane thickness and operating temperature to maximize system efficiency. A key contribution is the comprehensive levelized cost of hydrogen (LCOH) analysis that quantifies the economic impact of improved forecasting accuracy on wind-to-hydrogen production costs. The LCOH assessment demonstrates how multi-domain forecasting impacts hydrogen production costs through minimizing energy waste and optimizing electrolyzer operating schedules. This integrated approach advances practical implementation of deep learning-assisted renewable hydrogen production by connecting the gap between forecasting performance and real-world economic considerations, providing quantifiable metrics for system deployment decisions in wind-to-hydrogen integrated systems.

Cross-Scale Modeling of Hydrogen Resistance and Microstructure Design for Enhanced Hydrogen Tolerance

Berk Tekkaya[1*], Junhe Lian[1], Sebastian Münstermann[1] and Nikolaos Aravas[2,3]

[1]*Institute of Metal Forming, RWTH Aachen University, Germany*
[2]*Department of Mechanical Engineering, University of Thessaly, Greece*
[3]*International Institute for Carbon Neutral Energy Research (WPI-I2CNER), Kyushu University, Japan*

Abstract:

Geopolitical instability, climate change, and net-zero targets threaten energy security. Hydrogen offers a promising energy carrier, but requires robust transport and storage infrastructure. To address material-related challenges, a cross-scale

numerical framework is developed to characterize the hydrogen resistance of steels, spanning from the microscale to the component scale. On the microscale, the influence of microstructure including reagent grade (inclusions and voids) are investigated based on the representative volume elements (RVE) using a two-way coupled crystal plasticity model. This approach captures the interaction between plastic deformation, hydrogen transport, and trapping mechanisms. On the macroscale, a coupled chemical-mechanical stress-state-dependent damage mechanics model is implemented to simulate hydrogen diffusion as well as hydrogen-induced damage initiation, evolution and fracture. On the component scale, the UOE pipe-forming process is modeled to predict residual stress distributions, which are subsequently transferred to the microscale via sub-modeling. This enables the identification of critical locations for hydrogen-induced-cracking (HIC) under realistic stress and microstructural conditions. As a use case, the standardized HIC-Test is numerically reproduced. The framework supports computational microstructure design, which provides insight into the complex interplay between hydrogen trapping and microstructural characteristics. Through parametric numerical studies, two X70 pipeline steel grades with ferritic-pearlitic and ferritic-bainitic microstructures are investigated.

Biography:

Berk Tekkaya studied Mechanical Engineering at TU Dortmund University, where he obtained both his Bachelor's and Master's degrees. He earned his PhD in 2025 from RWTH Aachen University. He subsequently led the Material Integrity group at the Institute of Metal Forming (IBF), RWTH Aachen University and is currently working there as an independent postdoctoral researcher. His research area includes multiscale modeling of hydrogen diffusion and coupled damage modeling, microstructure design, multiscale description of crack-edge sensitivity, modeling of rim zone modifications in terms of dynamic recrystallization when hard machining, strength assessment of high-strength welded joints using transverse tensile tests and nuclear safety.

Unlocking Next-Gen Energy: An AI-Powered Approach to Accelerate Fuel Cell Optimization

Omid Babaie Rizvandi[1*], Robert Braun[2]

Mechanical Engineering, Colorado School of Mines

Abstract:

Solid oxide fuel cells (SOFCs) offer high efficiency and fuel flexibility (natural gas, propane, biogas, methanol, hydrogen, and syngas) for numerous power generation applications. SOFC technology is rapidly scaling to MW applications for distributed generation, and systems are comprised of SOFC stacks and balance-of-plant equipment. The design of the fuel cell stacks themselves is still being optimized.

The optimization of complex energy systems, such as SOFC stacks, presents a significant challenge due to the immense computational time required by traditional models. A transformative approach is introduced in this work, leveraging artificial intelligence to overcome this barrier. A neural network-based surrogate model was developed and trained on data from high-fidelity multi-physics simulations to predict complex stack behavior in real time. The power of this method is demonstrated by its ability to accelerate optimization. A complex, multi-objective optimization that would take an estimated 300 years with a full physics model is completed in just 1.5 minutes using an AI-driven framework.

This approach provides a blueprint for accelerating design, analysis, and commercialization of next-generation energy systems, from fuel cells to thermal management and beyond.

Biography:

Dr. Omid Babaie Rizvandi is a Research Assistant Professor in the Department of Mechanical Engineering at the Colorado School of Mines. He earned his Ph.D. in Mechatronics Engineering from Sabanci University in 2019 and was a Postdoctoral Research Fellow at the Technical University of Denmark (DTU) until 2023. His research is dedicated to advancing sustainable energy through the numerical modeling of fuel cells and electrolysis technologies. His work has spanned various technologies, including PEMFCs, MFCs, and SOCs, with a focus on improving performance, efficiency, and durability. Currently, Dr. Rizvandi is developing multi-stack module models and integrating machine learning to optimize SOC performance. His contributions are key to refining the design and accelerating the commercialization of next-generation energy systems.

Methane Pyrolysis – Low-emission Hydrogen for Industrial Applications and Solid Carbon as Soil Amendment for Agriculture

Robert Obenaus-Emler[*], David Scheiblehner, Markus Lehner and Helmut Antrekowitsch Montanuniversität Leoben, Austria

Abstract:

Hydrogen will play a key role in future process technologies and energy systems, provided that it can be produced with a low carbon footprint. In industrial contexts, the utilisation of low-emission hydrogen as a feedstock material (e.g. reduction processes in metallurgy) or as an energy source (e.g. high-temperature processes) holds significant potential for mitigating greenhouse gas emissions. Consequently, low-emission hydrogen emerges as a pivotal element in the

transformation of diverse industrial processes, and thus also contributes significantly to the reduction of greenhouse gas emissions.

A range of process pathways for the generation of low-emission hydrogen are currently considered. These include the steam reforming of natural gas (SMR), accompanied by additional separation and storage, or utilisation of CO_2 (SMR + CCS), on the one hand, and water electrolysis based on the use of renewable electrical energy, on the other. Methane pyrolysis is one additional production pathway, if methane can be obtained from sources with a low CO_2-footprint and if the process can be carried out using electricity from renewable sources. The primary benefits of methane pyrolysis for the large-scale production of low-emission hydrogen for industrial applications are threefold. Firstly, it requires a lower specific electrical energy, in comparison to electrolysis. Secondly, it can utilise existing infrastructure for the transportation of natural gas. Thirdly, it produces solid carbon, which is suitable for a wide variety of applications. However, it should be noted that the technological maturity of methane pyrolysis does not yet allow for its industrial implementation on a commercial scale.
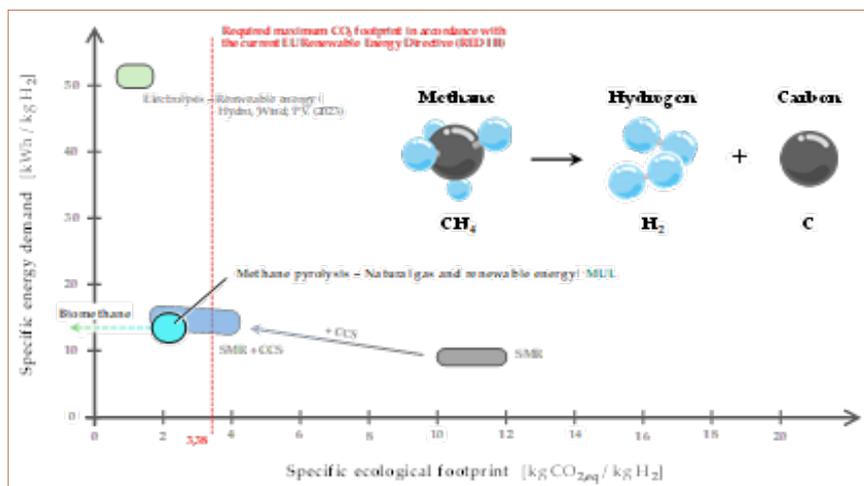

Figure 1: Specific energy demand and ecological footprint of selected hydrogen production technologies.

The specific energy demand refers only to the energy required by the respective hydrogen production process and does not include the energy content of the methane for SMR or pyrolysis.

With regard to the effective utilisation of natural gas, Montanuniversität Leoben is conducting intensive research into the entire methane pyrolysis process chain, the scaling up of various methane pyrolysis technologies to demonstration scale and, in particular, the use of solid carbon from methane pyrolysis as a soil additive in agriculture where carbon has the potential to enhance the resilience of crops to drought stress, increases the water retention capacity of soils, and contributes to humus formation.

Biography:

Robert Obenaus-Emler, Montanuniversität Leoben, Head of Resources Innovation Centre, Coordinator of the Strategic Core Research Area SCoRe A+ Hydrogen and Carbon Montanuniversität Leoben places a strong emphasis on the development of responsible practices and sustainable technologies throughout the entire value chain. The Resources Innovation Centre (RIC) is a strategic organisational unit of the university, addressing global challenges related to the environmental and climate impact we are imposing on our planet.

Robert Obenaus-Emler heads a team of researchers whose work is focused on: (1) Coordination and implementation of research activities related to sustainable future technologies within the core competence areas of Montanuniversität, (2) Definition and structuring of research teams comprising different expertise within Montanuniversität, as well as with external research partners, industry and funding organisations, in order to tackle large research questions effectively and efficiently, (3) Development and implementation of new teaching & learning pathways that promote a transdisciplinary approach in connecting research, education, business, and society for the future of T-shaped raw material engineers, and (4) Raising awareness among the general public and especially among young people with regard to possible technical solutions, their benefits and realisation as an essential contribution to facilitating their attainment in terms of societal licence to operate.

Furthermore, Robert Obenaus-Emler oversees all operations at Montanuniversität Leoben related to the production, processing, transportation, and utilization of hydrogen and carbon. The Strategic Core Research Area (SCoRe A+) Hydrogen and Carbon encompasses approximately 120 researchers from 26 organisational units engaged in a diverse range of expertise.

Numerical and Experimental Investigation of Flame Dynamics Leading to Detonation in Hydrogen−Natural Gas Mixtures

Ramki Murugesan[1,2], Samaneh Miri[1], Kevin Cheevers[1], Hongxia Yang[3], Dhevathi Rajan Rajagopalan Kannan[2], Vinay Premnath[2], Judy Jeevarajan[2], Matei I. Radulescu[1], Brian Maxwell[1]

[1]*Department of Mechanical Engineering, University of Ottawa, Canada*
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[3]*Department of Mechanical and Mechatronics Engineering, University of Waterloo, Canada*

Abstract:

Keywords: Deflagration-to-detonation transition, Hydrogen-natural gas mixtures, Shock-flame interaction, Explosion safety, Reactive flow simulation

Blending hydrogen with natural gas is a promising decarbonization strategy. However, it raises safety concerns due to hydrogen's high reactivity and its influence on flame acceleration and deflagration-todetonation transition (DDT). Understanding DDT thresholds is crucial for establishing safe blending limits and effective explosion mitigation. This study investigates DDT in hydrogen-enriched mixtures using a 3.4-meter shock tube (203 mm × 19 mm cross-section). To isolate the re-initiation phase, a detonation wave passes through obstacles with 75% blockage, creating a shock−flame complex. Flow evolution was recorded using schlieren and shadowgraph imaging, complemented by six pressure transducers capturing transient wave behavior. Experiments reveal two distinct DDT modes governed by the post-shock specific heat ratio (γ_{ps}): turbulence-driven re-initiation in methane-rich mixtures ($\gamma_{ps} < 1.25$) and chain-branching dominated reinitiation in hydrogen-rich mixtures ($\gamma_{ps} > 1.25$). These findings align with prior work linking jet formation and chain-branching chemistry to re-initiation sensitivity. Numerical simulations with a four-step mechanism and PaSR turbulence model closely matched experiments by capturing localized ignition and asymmetric flame evolution—features underpredicted by Euler models. Euler simulations capture large-scale shock−flame dynamics but underestimate run-up distances due to unresolved small-scale turbulence. PaSR better resolves sub-grid mixing, especially in low-γ mixtures critical for re-initiation. This study identifies two re-initiation pathways—thermodynamic (γ-driven) and chemical (chainbranching)—and underscores the need for turbulence-resolving models. Future work will clarify their relative roles in hydrogen-rich mixtures. Biography: Ramki Murugesan is a Research Scientist at UL Research Institutes with expertise in combustion and hydrogen safety. He recently completed his postdoctoral fellowship at the University of Ottawa, where his research focused on the deflagration-to-detonation transition (DDT) in hydrogen-natural gas mixtures, using both experimental diagnostics and numerical modeling. His work contributes to advancing safety standards in emerging clean energy technologies.

A theoretical reaction rate model of a chemical decomposition surface from an external gas

Eimund Smestad

Nammo Raufoss As

Abstract:

In this study, kinetic theory was used to derive an equation of state for an decomposition surface caused by an external gas, both exothermic and endothermic reaction. The new model is physical, and its quantities have been physically interpreted. A new concept of interaction probability was used to describe the co-volume. This concept describes the interaction between the decomposition surface and the external gas to derive an expression for the linear reaction rate based on kinetic theory. The interaction probability is associated with the particle density of the gases provided by the Lennard--Jones potential and temperature. The Maxwell--Boltzmann distribution was used to establish the initial decomposition conditions based on the concepts of autoignition and activation energy.

The aim of this study was to investigate when burning is a decomposition reaction in which the decomposing molecule contains oxygen and can be used as input to designing fuel cells, rocket motors, and propellants. Therefore, HMX and PETN were used as empirical data, and the new linear reaction rate model provided a good approximation and predicted the burn rate data. The model was compared with Vieille's law $v\_b = a\, P^n$ for the normal pressure range. However, the model goes beyond the law and provides good predictions of burn rates with high pressures found in diamond anvil experiments.

Current Distribution Analysis on PEMFC Using Magnetic Sensors

Sumito Kanazawa[1*], Yutaro Akimoto[1], Keiichi Okajima[1]

[1]*University of Tsukuba, Japan*

Abstract:

Proton Exchange Membrane Fuel Cells (PEMFCs) are compact and lightweight, making them suitable for a wide range of applications and contributing to the realization of a low-carbon society. However, PEMFCs can experience issues

such as flooding and dry-out due to various factors, leading to nonuniform current distribution within the cell. Therefore, understanding the internal current distribution is essential for preventing such malfunctions. In this study, magnetic sensors were used to measure the magnetic field generated by the current flowing through the fuel cell. Based on the Biot−Savart law, the current distribution was analyzed and compared with the measured values to evaluate and discuss the accuracy and implications of the analysis. Biography: {Max words limit 150} Sumito Kanazawa received his BEng. degrees from the University of Tsukuba in 2025. He is now a master course student of University of Tsukuba. His research work focuses on diagnosis of fuel cell.

STUDY OF REAL-TIME FUEL CELL DIAGNOSIS BY USING EIS FOR DYNAMIC LOAD APPLICATIONS

Izamu Kawahara*, Yutaro Akimoto, Keiichi Okajima1 Affiliation

University of Tsukuba, Japan

Abstract:

In proton exchange membrane fuel cell (PEMFC), output voltage changes depending on the membrane's hydration state. Therefore, it's crucial to control operating parameters and maintain an appropriate internal environment by evaluating internal conditions of fuel cells. Electrochemical impedance spectroscopy (EIS) is a method that allows for internal diagnosis while the fuel cell is operating. However, its long measurement time makes it unsuitable when the load fluctuates, as internal conditions can change considerably during the measurement. In order to diagnose internal conditions of fuel cells by using EIS, it is necessary to shorten the measurement time. In this study, we aimed to reduce measurement time by limiting the range of measured frequencies and decreasing the number of measured frequencies, and then compared these results with those obtained without such limitations. The research suggests that by carefully selecting combinations of frequencies, the error rate of the calculated equivalent circuit parameters can be minimized compared to measurements taken without frequency limitations. Biography: {Max words limit 150} -Izamu Kawahara received his BEng. degrees from the University of Tsukuba in 2025. He is now a master course student of University of Tsukuba. His research work focuses on diagnosis of fuel cells.

Kick-Starting Hydrogen Mobility: Technical Principles and Practical Steps for Building the First Refuelling Network for Cars, Buses and Heavy-Duty Vehicles

Vasco Amorim

UTAD | INESC TEC, Portugal

Abstract:

Hydrogen mobility depends on the early deployment of a reliable, scalable and cost-efficient refuelling network. This presentation outlines a practical, technically grounded roadmap for establishing the first wave of Hydrogen Refuelling Stations (HRS) capable of serving passenger cars (700 bar), urban buses, and regional heavy-duty trucks (350 bar).

The session combines strategic and engineering perspectives, explaining how to identify priority vehicle clusters, select optimal station locations based on logistics flows and urban mobility patterns, and dimension HRS to meet multi-segment demand. Presentation will walk through the key infrastructure choices — from compression architecture and storage design to station redundancy and high-throughput dispensing for trucks.

Drawing on real-world benchmarks from leading European pilot regions, the presentation highlights the value of phased deployment, anchor fleets, shared-use hubs and integration with industrial energy systems. Participants will gain actionable guidance on how to launch an initial hydrogen infrastructure, mitigate early-stage operational risks and create the foundation for a national H_2 network aligned with AFIR and Europe's 2030 climate goals.

Quantum Mapping: Molecular Hamiltonian Eigenvalues to Macroscopic Darcy Flow

Demetrius Maxey

Blackstone Texas Inc., San Antonio Texas

Abstract:

Current petrophysical analysis relies on Newtonian, macroscopic frameworks that enhance recovery but do not resolve quantum-mechanical behavior at the atomic scale, where pore−fluid interactions and electronic structure ultimately govern macroscopic petrophysical responses. This research develops theoretical and mathematical frameworks that bridge quantum and Newtonian mechanics, enabling multiscale prediction of petrophysical properties and guiding enhanced hydrocarbon recovery strategies. Examination of the theoretical framework demonstrates that macroscopic hydrocarbon flow governed by Darcy's Law and interfacial processes governed by the Gibbs adsorption mechanism both emerge from the same Hamiltonian eigenvalue calculations. To operationalize this framework, Density Functional Theory (DFT) calculations provided a rigorous computational approach for determining the Hamiltonian eigenvalues

corresponding to hydrocarbon molecular ground state energies (GSE). ORCA-based DFT calculations derived total electronic energy, orbital energies (ε_i), optimized geometry, and thermochemical data. The DFT-calculated GSE is then used to determine the component-level Quantum Energy Unit (QEU), which characterizes the compositional binding energy of the hydrocarbon molecular composition within a defined hydraulic fracture volume. Finally, the mapping of the Hamiltonian eigenvalue to Darcy's Law is mathematically derived using DFT-computed compositional GSE values. Future work will advance this framework through laboratory validation of partition function corrections, direct experimental measurement of activation parameters and adsorption isotherms for reservoir fluids, and mathematical proof of the quantum-to-classical linkage.

Toward Optimizing Passive Flow Disturbers for Enhanced Heat and Mass Transfer in Methanol Steam Reforming

Yen Chun Chou[*]

Paul Erickson University of California Davis, CA, USA

Abstract:

Hydrogen for transportation and distributed power requires high conversion and low carbon monoxide (CO) in compact reformers. However, fixed-bed methanol steam reforming often encounters strong axial temperature gradients, which can degrade performance and increase CO formation at elevated temperatures. This study investigates ring- and disk-shaped flow disturbers as a passive mixing approach to enhance radial transport and mitigate thermal gradients through experimental and numerical analyses. Experiments were conducted in packed-bed reactors at liquid hourly space velocities of $1-6$ h^{-1} and wall temperatures of $400-540$ °C. Without flow disturbances, increasing temperature raised methanol conversion to 98.5% but also increased CO to 4.5%, lowering H_2 yield. With flow disturbers, conversion remained high ($96-98\%$) while CO was suppressed to $3.0-3.5\%$ and H_2 productivity improved from 8.87 to 9.6 kg day^{-1} per reactor. Complementary CFD-guided geometry optimization further indicates that improved mixing can enhance fuel and lead to higher hydrogen production. Overall, optimized passive mixing enables higher-temperature operation with improved H_2 yields and reduced CO-related H_2 losses in practical reforming systems. Keywords: Steam Reformation, Carbon Monoxide, Hydrogen Yield

Biography:

Yen Chun Chou is a Ph.D. student in the Department of Mechanical and Aerospace Engineering at the University of California, Davis. His research focuses on renewable energy systems, specifically the hydrogen production through steam reforming. Utilizing Computational Fluid Dynamics (CFD) and experimental validation, he designs and analyzes optimal passive flow disturbance systems to improve heat transfer and overall reactor efficienc

Application of Renewable Hydrogen-Based Energy Systems in Buildings and the Residential Sector

Alfredo Ortiz[*]**, Victor Manuel Maestre, Inmaculada Ortiz**

Universidad de Cantabria, Santander, Spain

Abstract:

Utilizing surplus renewable energy to produce and store green hydrogen can help meet energy demands during periods of low renewable energy production, and thus contributing greatly to decarbonize emission-intensive sectors, such as the residential and building sector [1,2]. In this context, this work reports the design, construction and operation of a hybrid PV-hydrogen demonstrative pilot (PVHyP) for the 100% electrical self-sufficiency of a social housing in the town Novales (Spain) [3]. The project addresses i) the collection of real consumption data from the dwelling, ii) the design considering real characteristics and market availability of the devices, iii) final balance of plant implementation, and iv) the energy management strategy followed. The implemented control system allows the facility to be tracked and operated remotely. Besides, this flagship implementation in the SUDOE region (Spain, Portugal and southwest of France) has achieved the electrical independence from the grid under diverse climate conditions, eliminating 2260 kg of CO2 emissions associated to electricity consumption, saving almost 15,200 kWh of primary energy during two years of monitoring. Thus, around 1170 € where avoided in electricity bills (100% savings), resulting on multiple benefits for social dwellers in risk of energy poverty [4].

Electrified Catalytic Reactorsfor Low-Carbon Hydrogen

Mohammad Latifi[1,2*], Gholamreza Roohollahi[1,2]

[1]*Critical Resources for Energy and Environmental Sustainability via Scalable Processes (CRESSP Lab); Chemical Engineering Department, Polytechnique Montreal, Montreal, Quebec, Canada*
[2]*NeoCtech Corp., Candiac, Quebec, Canada*

Abstract:

Hydrogen production is expanding rapidly, but many current routes remain constrained by combustionbased heat supply, slow thermal response, and limited compatibility with variable renewable electricity. Process electrification offers a direct opportunity to decarbonize reactor heat duties while improving controllability and intensification. This work presents an non-invasive electrified-heating approach for catalytic hydrogen production from alternative energy resources. The core concept is to couple volumetric, rapidly controllable electro/magnetic heating with catalyst/reactor architectures that enable efficient heat transfer to active sites while minimizing temperature gradients and hot spots. We discuss reactor configurations suitable for electrification of gas-solid reactors (e.g., packed or fluidized catalytic beds incorporating magnetic susceptors or magnetically responsive structured supports) and outline operating strategies that leverage fast power modulation for start-up/shut-down, load-following, and integration with intermittent electricity. Key outcomes include a practical framework to (a) reduce reliance on external fired heaters, (b) improve energy efficiency through targeted heat delivery, and (c) create pathways toward lower-carbon hydrogen with potential for reduced CO_2 footprint when paired with renewable electricity and appropriate carbon management. The approach is positioned as a scalable platform for intensified hydrogen production and for hybrid energy systems where electrified reactors serve as flexible, dispatchable chemical units.

Biography:

Dr. Mohammad Latifi is a Research Associate Professor in Chemical Engineering at Polytechnique Montréal and Director of the CRESSP Lab (Critical Resources for Energy and Environmental Sustainability via Scalable Processes). His research focuses on process electrification, catalytic hydrogen and syngas production, and low-carbon energy systems, with particular emphasis on induction- and microwave-heated multiphase reactors. He has pioneered electrified fluidized-bed and jiggle-bed reactors for hydrogen production from natural gas, biomass, lignin, and waste plastics, enabling rapid heat delivery, process intensification, and reduced carbon intensity. Dr. Latifi is also Co-Founder and CTO of NeoCtech Corp., where he develops carbon-neutral technologies for critical minerals and clean energy supply chains. He has secured over \$14 M in competitive research funding, authored more than 100 publications, holds multiple patents, and has trained over 40 highly qualified personnel in hydrogen, electrification, and sustainable energy technologies.

Credit-Price Thresholds and Infrastructure in Oregon's Clean Fuels Program: Evidence from Ethanol Carbon Intensity, with Implications for Clean Hydrogen

Chukwuemeka Okolo*, Andres Susaeta

Oregon State University, Corvallis, OR

Abstract:

Oregon's Clean Fuels Program (CFP) is designed around the idea that higher credit prices should strengthen incentives to lower the lifecycle carbon intensity (CI) of transportation fuels. That price signal operates alongside rapid infrastructure change, especially the build-out of electric vehicle (EV) charging, and the growing interest in clean hydrogen as another low-CI pathway. This ongoing study examines whether the credit price and ethanol CI relationship is nonlinear, and whether EV charging conditions the strength of the response. Using monthly data from CFP public reports and related market sources, we model ethanol CI (gCO2e/MJ) as a function of average CFP credit price, EV charging deployment, B5 and E10 cost indices, and lagged CI dynamics. We apply Hansen-style endogenous threshold regression to estimate credit-price turning points, compare the results with linear and quadratic benchmarks, and test interaction effects between credit prices and charging deployment across regimes. Results will report the estimated thresholds, regime-specific marginal effects, and policy implications for CFP design, including benchmarking and cost-containment. Although hydrogen isn't directly modeled because of data limitations, the findings still provide useful guidance on how new infrastructure-based compliance options, like clean hydrogen, could influence where credit prices end up and how existing fuels respond.

Keywords: Clean Fuels Program; credit prices; threshold regression; EV charging; clean hydrogen

Biography:

Chukwuemeka Valentine Okolo is a Research Assistant and Applied Economist at Oregon State University, working at the intersection of energy policy, environmental markets, and transportation decarbonization. His research focuses on how market-based programs translate into real emissions outcomes, with particular emphasis on low-carbon fuel standards, clean fuels credit markets, and the infrastructure that enables compliance. Using applied econometrics, he studies nonlinear incentive responses, credit-price dynamics, and how technology deployment, such as electric vehicle charging networks, can strengthen or weaken policy impacts. His broader interests include clean fuels policy design,

clean hydrogen, bioenergy and forest-based renewable fuels, energy (clean) sustainability, and practical pathways for scaling low-carbon fuels and technologies. He is motivated by work that connects rigorous analysis to real-world decisions made by agencies, industry, and investors, and he is especially interested in roles that combine data-driven evaluation with policy and strategy.

Study of Real-Time Fuel Cell Diagnosis by Using Eis for Dynamic Load Applications

Izamu Kawahara[1]*, Yutaro Akimoto[1], Keiichi Okajima[1]

[1]*University of Tsukuba, Japan*

Abstract:

In proton exchange membrane fuel cell (PEMFC), output voltage changes depending on the membrane's hydration state. Therefore, it's crucial to control operating parameters and maintain an appropriate internal environment by evaluating internal conditions of fuel cells. Electrochemical impedance spectroscopy (EIS) is a method that allows for internal diagnosis while the fuel cell is operating. However, its long measurement time makes it unsuitable when the load fluctuates, as internal conditions can change considerably during the measurement. In order to diagnose internal conditions of fuel cells by using EIS, it is necessary to shorten the measurement time. In this study, we aimed to reduce measurement time by limiting the range of measured frequencies and decreasing the number of measured frequencies, and then compared these results with those obtained without such limitations. The research suggests that by carefully selecting combinations of frequencies, the error rate of the calculated equivalent circuit parameters can be minimized compared to measurements taken without frequency limitations.

Biography:

Izamu Kawahara received his BEng. degrees from the University of Tsukuba in 2025. He is now a master course student of University of Tsukuba. His research work focuses on diagnosis of fuel cells.

A Comparative Analysis of Energy Transition Barriers: A Systematic Literature Review of Malaysia and Singapore

Vikramathithan Govindasamy[1], Sarmila Muthukrishnan[1*], Ng Boon-Kwee[1], Raveen Kantha Kumar[1]

[1]Department of Science & Technology, Faculty of Science, Universiti Malaya, 50603 Kuala Lumpur, Malaysia

Abstract:

Malaysia's low-carbon energy transition is vital to achieve the 2050 net-zero goal and to mitigate climate related risks. However, Malaysia continue to face persistent financial, knowledge, political and technological barrier that affects the pace of the energy transition. Hence, this study aims to identify the key barriers in Malaysia's low-carbon energy transition and compare them with Singapore as a regional peer to propose actionable recommendations. A systematic literature review was conducted using the PICo method, retrieving articles from journals such as IEEE Xplore, Web of Science, Springer Nature, and Scopus. From 2,358 initial records, 12 studies were critically reviewed based upon relevance to Malaysia's energy transition. As a result, four major themes such as (1) financial barrier, (2) knowledge barrier, (3) political barrier and (4) technological and infrastructure barrier were identified. Comparisons against Singapore highlights effective strategies such as centralized governance, mandatory carbon pricing, robust green finance ecosystems, public education programs, and advanced grid modernization. Addressing these barriers through targeted reforms and adopting proven practices from Singapore can accelerate Malaysia's transition toward a resilient, inclusive and low-carbon energy future. These barriers and proposed recommendation could also serve other nations or emerging economies who are keen in pursing low-carbon energy transition.

Keywords: Low-carbon energy, Energy transition, Malaysia, Climate change, Energy security

Biography:

Vikramathitan is a sustainability professional with four years of experience spanning the energy and consulting sectors, with a specialization in ESG strategy and energy transition. He currently serves as a Sustainability Strategy Specialist at Baker Hughes, where he leads decarbonization initiatives that support the sector's net-zero ambitions. His work includes coordinating ESRS and AASB S2-related projects to strengthen compliance and strategic alignment with emerging sustainability disclosure requirements, as well as contributing to climate-risk assessments with a focus on TCFD physical-risk analysis. Vikrama is also pursuing a Master of Science (by research) at the Universiti Malaya, where his work centers on sustainability and climate change. Beyond his professional and academic roles, he contributes to industry innovation as a member of the Innovation Working Committee under the Malaysian Oil & Gas Services Council, supporting collaborative efforts to advance low-carbon solutions.

Assessing Advanced Fuels and Chemical Pathways with the R&D GREET Life-Cycle Tool

Pahola Thathiana

Benavides LCA and Technology Assessment Department, Energy Systems and Infrastructure Assessment Division, Argonne National Laboratory

Petroleum and natural gas are widely used to produce fuels and chemicals, including plastics. However, these fossil resources can be supplemented with biobased and wastederived feedstocks that support domestic energy production and chemical manufacturing while improving the environmental performance of fuels and chemical products. This presentation highlights case studies using Argonne's R&D Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies (GREET) model, focusing on marine fuel applications and the production of chemicals and plastics. The R&D GREET model is a life cycle assessment (LCA) tool that quantifies energy use, greenhouse gas (GHG) emissions, criteria air pollutants, and other indicators across transportation fuels, vehicles, and diverse supply chains. We use R&D GREET to assess emerging and evolving advanced biofuel technologies for marine and chemical pathways, relying on transparent, engineering-based mass and energy balances and a wide range of biomass and waste conversion technologies. For marine fuels, we examine "drop-in" liquid biofuel pathways, including biodiesel (FAME), renewable diesel (HEFA), and renewable gasoline. For chemicals, we demonstrate how enhancing the titer, rate, and yield (TRY) of fermentation in biochemical conversion can improve both energy efficiency and environmental performance. Finally, for plastics, we discuss how advanced recycling technologies can complement mechanical recycling to reduce waste generation and virgin material use, while also producing new intermediate products for fuels and chemicals.

Hydroprocessed Ester and Fatty Acids to Jet: Are We Heading in the Right Direction for Sustainable Aviation Fuel Production?

Mathieu Pominville-Racette[1*], Ralph Overend[2], Inès Esma Achouri[1], and Nicolas Abatzoglou[1],

University Sherbrooke, Canada
[2]Nextfuels LCC, USA

Abstract:

Hydrotreated ester and fatty acids to jet (HEFA-tJ) is presently the most developed and economically attractive pathway to produce sustainable aviation fuel (SAF). An ongoing systematic study of the critical variables of different pathways to SAF has revealed significantly lower greenhouse gas (GHG) reduction potential for the HEFA-tJ pathway compared to competing markets using the same resources for road diesel production. Moderate yield variations between air and road pathways lead to several hundred thousand tons less GHG reduction per project, which is generally not evaluated thoroughly in standard environmental assessments. This work demonstrates that, although the HEFA-tJ market seems to have more attractive features than biodiesel/renewable diesel, considerable viability risks might manifest as HEFA-tJ fuel market integration rises. The need for more transparent data and effort in this regard, before envisaging making decisions regarding the volume of HEFA-tJ production, is emphasized. Overall, reducing the carbon intensity of road diesel appears to be less capital-intensive, less risky, and several times more efficient in reducing GHG emissions.

Keywords: SAF, HEFA-tJ, Technico-economic analysis, Sustainability Evaluation

Biography:

Mathieu is a PhD candidate in chemical engineering at the Université de Sherbrooke, supervised by Pr. Inès Achouri and Pr. Nicolas Abatzoglou. His research focuses on techno economic evaluation for emerging bioenergy and low carbon technologies, with a strong emphasis on developing computer tools for economic and environmental assessment. He previously completed a master's degree under Pr. Patrice Mangin at the Université du Québec à Trois Rivières and Grenoble INP Pagora, where he analyzed the BiotFuel and IH2 conversion processes. Alongside his doctoral work, Mathieu contributes part time to the Government of Québec's Bioenergy and Hydrogen Office, supporting strategic evaluations of biomass projects through integrated economic and geomatic analysis. His work bridges academic research, digital modeling and public sector decision making, with a particular interest in biomass valorization and greenhouse gas reduction technologies.

Phytoremediation Pilot Study in a Mississippi Community Impacted by Petrochemical Refining

Naira Ibrahim[1], Utsab Basnet[1], Zavier Smith[1], Christian Sutton[1] & Vaughn Reed[2]

[1]Department of Biology, Collage of Science, Technology and Engineering, Jackson State University, USA, MS
[2]Department of Plant and Soil Sciences, Mississippi State University, USA, MS

Abstract:

Communities in Mississippi located near petrochemical refining facilities face ongoing risks from heavy metal contamination in soils, posing threats to environmental quality, food safety, and public health. Phytoremediation offers a sustainable and low-cost strategy to mitigate these risks under realworld conditions. This pilot study evaluated the phytoremediation potential of Nerium oleander and cabbage (Brassica oleracea) in a fence-line residential community within the Cherokee Forest subdivision of East Pascagoula, Mississippi, an area impacted by long-term petrochemical and shipyard activities. Plants were cultivated directly in contaminated garden soils under natural field conditions. Concentrations of lead (Pb), cadmium (Cd), zinc (Zn), and nickel (Ni) in soils and plant tissues were quantified using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES). Phytoremediation effectiveness was assessed using removal efficiency, translocation factor, and bioaccumulation factor. Results showed significant reductions ($p < 0.01$) in all tested soil metals following the intervention, with cadmium removal exceeding 97%. N. oleander demonstrated substantially higher metal uptake and translocation capacity than cabbage, achieving a maximum cadmium translocation factor of 9.99 and bioaccumulation factors up to 5.67 for priority metals. In contrast, cabbage exhibited lower translocation efficiency, indicating limited remediation potential but supporting its use as a food crop only after soil treatment. These findings identify N. oleander as an effective and community-acceptable phytoremediation species for petrochemical-impacted soils. The study highlights the importance of field-scale validation of phytoremediation strategies and supports their application as sustainable, community-centered solutions for reducing environmental contamination and exposure risks. Keywords: Phytoremediation; Heavy metal contamination; Nerium oleander; Brassica oleracea; Bioaccumulation factor; Translocation factor; Petrochemical-impacted soils; Fence-line communities.

Smart Battery Passports: AI-Driven Solutions for Reuse and Recycling in the Energy Sector

Anitha Subburaj[1*], Vinitha Subburaj[2]

1,2West Texas A&M University, Canyon, Texas

Abstract:

The integration of Artificial Intelligence (AI) with digital passports for battery components offers a powerful solution to address key challenges in battery lifecycle management, second-life applications, and recyclability. Digital passports are structured, digital records containing detailed information about a battery's manufacturing origin, material composition, usage patterns, and current health status. By leveraging AI tools, this data can be analyzed in real time to predict remaining useful life (RUL), detect degradation trends, and assess the feasibility of second-life deployment or recycling. This approach enables informed decisions on reuse, repurposing, or material recovery, supporting a circular economy for battery technologies. AI enhances digital passports by enabling adaptive diagnostics, data-driven prognostics, and intelligent classification of components based on performance and safety metrics. These capabilities not only reduce waste and environmental impact but also unlock economic value by extending battery usability. AI techniques—including machine learning, deep learning, and predictive modeling—and their role in optimizing battery reuse and recycling pathways will be explored. Additionally, the need for standardized data formats, secure data sharing frameworks, and interoperable platforms will be discussed to maximize the benefits of AI-enhanced digital passports. This fusion of AI and digital documentation marks a critical step toward sustainable, data-driven battery management in next-generation energy systems.

Biography:

Dr. Anitha Subburaj is an Associate Professor of Electrical Engineering at West Texas A&M University (WT). She joined WT in 2016 and has been named the inaugural appointee to the McFather Professorship of Engineering, Computer Science and Mathematics at WT, 2022. Dr. Subburaj received her M.E. in Applied Electronics from the Anna University in 2007, India and her Ph.D. in Electrical Engineering at the Texas Tech University (TTU) in 2014. She was a post-doctoral research associate at TTU before coming to WT. Dr. Subburaj is a Senior Member of the IEEE society. She teaches electrical circuits design, signals, control systems, renewables, and electric power systems. Dr. Subburaj has several publications in Renewable & Sustainable Energy Review Journal, IEEE Transactions on Industry Applications, and International Journal of Renewable Energy Research. Her research interests include education research methods, renewable energy, control systems, battery energy storage system, and battery connected to grid applications.

Potential of CO_2 Geological Storage in Sedimentary Rocks: Petrophysical Evolution and Environmental Implications

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Abstract:

The mitigation of greenhouse gas emissions is a major challenge in the transition to cleaner energy sources. Geological storage of CO_2 in sedimentary formations has emerged as a viable strategy for carbon sequestration, particularly in depleted hydrocarbon reservoirs and deep saline aquifers. However, the interactions between injected CO_2, formation water, and reservoir rocks can lead to significant petrophysical changes that affect storage efficiency and long-term stability. This study evaluates the impact of CO_2 injection on the petrophysical properties of two representative lithologies: sandstone and carbonate rocks. Experimental coreflooding tests were conducted under controlled conditions at 10 MPa and 50°C, simulating reservoir conditions. Results indicate that carbonate rocks experienced an increase in porosity of up to 12% due to mineral dissolution, with a corresponding permeability enhancement of 25%, which may improve storage capacity but also pose risks such as wormhole formation and structural weakening. In contrast, sandstone formations exhibited only a 3% change in porosity and remained structurally stable, making them more suitable for long-term CO_2 storage. Understanding these petrophysical transformations is crucial for optimizing CO_2 storage strategies and ensuring environmental sustainability. This research provides valuable insights into the feasibility of geological carbon sequestration and its role in climate change mitigation.

Biography:

Professor Jimena Gómez is a Petroleum Engineer and holds a Ph.D. in Chemistry, with a solid background in applied research for sustainability and energy transition. She is a full-time faculty member at the School of Petroleum Engineering, Faculty of Physicochemical Engineering, Universidad Industrial de Santander (Colombia). Her expertise focuses on the characterization and comprehensive analysis of geological systems for underground CO_2 storage, particularly in saline aquifers and depleted reservoirs. She has conducted research on enhanced recovery of heavy crude oils using nanomaterials, including the synthesis, characterization, and evaluation of nanoparticles in porous media aimed at wettability

alteration and production process improvement. In addition, she has participated in hydrogeology and aquifer interconnection projects, incorporating isotopic analyses of water and gases to better understand subsurface dynamics.

Gas Adsorption Behavior of CH_4 and CO_2 in Organic-Rich Shales from the CesarRanchería Basin: Implications for CO_2 Storage and Gas-in-Place Estimation

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Abstract:

Reliable gas-in-place estimation and evaluation of CO_2 storage potential require understanding gas adsorption in shales. The Cesar-Ranchería Basin in northern Colombia is a promising but underexplored unconventional play with high total organic carbon (TOC) and low maturity. This study investigates methane (CH_4) and carbon dioxide (CO_2) adsorption in four shallow shale samples (TOC: 33.44−69.63 wt%; Ro: 0.36−0.53%). Samples were characterized by Rock-Eval pyrolysis, X-ray diffraction, and N_2-BET analysis (1−7 m²/g). High-pressure manometric adsorption experiments were conducted at 50 °C and 80 °C up to 3 MPa, and data were fitted with the Langmuir model. All samples showed significant adsorption despite low surface area. CO_2 displayed higher adsorption than CH_4, with nL up to 1.6 mol/kg versus 0.49 mol/kg for CH_4. Adsorption decreased with temperature, confirming exothermic physisorption. These results highlight the combined influence of organic matter and mineralogy on gas uptake and demonstrate the potential of these formations for gas storage and CO_2 sequestration, contributing to carbon management and net-zero initiatives. Keywords: Shale gas; methane adsorption; CO_2 sequestration; Langmuir model; carbon management

Biography:

Dr. Olga Ortiz-Cancino is a Professor of Petroleum Engineering and Director of Graduate Programs at Universidad Industrial de Santander (UIS), Colombia. She holds a Ph.D. in Process Engineering with emphasis in Petroleum Engineering and has more than 20 years of experience in reservoir engineering, enhanced oil recovery, and water management for the oil and gas industry. Her research focuses on gas adsorption in unconventional reservoirs, CO_2 sequestration. Dr. Ortiz-Cancino has led multiple industryacademia collaborative projects. She has published extensively in peer-reviewed journals and presented at international conferences, contributing to the understanding of gas−shale interactions in immature formations. Her work aims to bridge experimental research with practical field applications, supporting energy transition strategies and carbon management initiatives.

Phytoremediation Potential of Nerium oleander for Heavy Metal−Contaminated and Saline Soils

Zavier Smith

Jackson State University, Jackson, MS

Abstract:

Soil contamination by heavy metals such as lead (Pb) poses considerable ecological risk, weakens soil fertility, and increases potential toxicity to human wellbeing. Phytoremediation is a feasible technique that exploits plant uptake and metabolic pathways to extract or stabilize pollutants in contaminated soils. Nerium oleander demonstrates substantial resilience to heavy metal stress. The objective of this study is to determine how bacterial inoculation with Pseudomonas putida influences lead (Pb) uptake in Nerium oleander compared to uninoculated plants. To measure this, several approaches were used, including ICP analysis, X-ray fluorescence imaging, and UV fluorescence microscopy. Across all treatments, the results indicated that plants absorbed more lead as the concentration in the soil increased. The bacteria appeared to reduce the amount of lead available in the soil, suggesting a potential remediation effect. Leaf production followed the same concentration-dependent trend. All treatment groups exhibited a decline in soil pH. These observations support concentrationdependent Pb uptake and suggest that microbial inoculation supports Pb removal from the soil. This study supports Brookhaven National Laboratory's environmental focus and provides valuable insights into Pb ingestion, solubility influences, and X-ray imaging for visualizing metal distribution.

Evaluating Pennisetum purpureum for Soil Remediation, Stress Tolerance, and Bioenergy Applications

Hayleigh Harrison[1], Naira Ibrahim[2]

Jackon State University, USA

Abstract:

Heavy metal contamination is a persistent threat to soil quality, ecosystem health, and food security. Phytoremedia-

tion provides a sustainable and cost-effective solution, with Pennisetum purpureum (Napier grass) or (Elephant grass) showing strong potential due to its vigorous growth, stress resilience, and bioenergy value. This study evaluated the ability of P. purpureum to remediate nickel (Ni)- and zinc (Zn)-contaminated soils under greenhouse conditions at Jackson State University. Plants were grown under drought and non-drought conditions for three- and six-month intervals. Research objectives were to (1) quantify metal uptake and translocation, (2) assess drought tolerance and physiological adaptation, and (3) examine its potential as a bioenergy crop and contributor to soil carbon sequestration. Results showed that P. purpureum-maintained shoot growth under Ni and Zn stress, with shoot height increasing despite some biomass decline. Leaf production was greater under non-drought conditions, yet drought-stressed plants sustained measurable growth. Chlorophyll content rose significantly under metal exposure and drought, indicating adaptive mechanisms that supported photosynthesis. Soil moisture retention increased by up to 20.83% with Ni compared to 7.03% in the control, whereas Zn reduced retention to 4.08%. Ongoing ICP-MS analyses are expected to confirm Ni accumulation in roots and Zn translocation to shoots. Overall, P. purpureum demonstrated resilience under combined metal and drought stress, sustaining biomass production, photosynthesis, and soil improvement potential. Its dual role in heavy metal stabilization and bioenergy production highlights its value as a model species for sustainable soil remediation and renewable energy systems.

Biography:

My name is Hayleigh Harrison, and I am a scientist with a passion for using biology to address real-world challenges. I earned my Bachelor of Science degree in Biology from Tougaloo College in May 2024, where I explored my interest in connecting science to everyday life through research on Alzheimer's disease. This experience taught me the importance of research that not only advances knowledge but also has the potential to improve human health and quality of life. I am now pursuing a Master of Science in Biology at Jackson State University. My current focus is on understanding how plants respond to environmental stress and how they can play a role in restoring ecosystems affected by pollution. By studying the effects of pollution, I aim to contribute to healthier ecosystems and stronger communities

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