# PROGRAM AND ABSTRACT BOOK

## 5TH ENERGY, EFFICIENCY AND ENVIRONMENTAL SUSTAINABILITY CONFERENCE

NOVEMBER 12-14, 2025
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# Welcome from the Executive Committee President

Dear participants,

It is a great pleasure to welcome you to the 5th Conference on Energy, Efficiency, and Environmental Sustainability (CEES 2025) on behalf of the Executive Committee and all the institutions that have made this event possible. We sincerely thank you for your participation, interest, and commitment to advancing our discipline, both in Chile and internationally.

The Universidad Diego Portales, host of this edition, is undergoing a strong process of consolidation focused on strengthening research, innovation, and the training of advanced human capital in the fields that bring us together today. A key example of this effort is the recent creation of the PhD Program in Engineering Sciences, aimed at developing researchers capable of generating, applying, and transferring cutting-edge knowledge in three priority areas: Intelligent systems, analytics and operations management; Climate, energy, and infrastructure resilience; and Advanced materials.

We also celebrate the recent funding award for the Center for Nanoscience and Nanotechnology (CEDENNA), led by Dr. Dora Altbir, 2019 National Prize in Exact Sciences and Director of Institutional Projects at UDP, through the 2025 National Competition for Applied Research Centers (ANID). This achievement reinforces our university's commitment to scientific excellence, technological innovation, and sustainable development.

This year's edition of CEES carries a special meaning: it is the first time the conference is held outside the University of La Serena, its founding institution. Hosting CEES 2025 in Santiago reflects the maturity of our academic community and the growing interest of multiple universities in contributing to the discussion and progress on these crucial topics.

Finally, I would like to acknowledge the collective effort of the Organizing Committee, formed by the universities of La Serena, Federico Santa María, La Frontera, and Diego Portales, as well as the Scientific Committee, whose dedication and rigor have been essential in shaping a diverse and high-quality program. Thanks to their work, we can meet here to share our research, exchange experiences, and strengthen collaborations that will surely bear fruit in the years to come.

Welcome, and may this conference be a stimulating space for dialogue, inspiration, and collective knowledge building.

**Dr. Andrés J. Díaz**
Director, School of Industrial Engineering
Associate Researcher, Center for Energy and Sustainable Development (CEDS)
Universidad Diego Portales, Chile

# Committees

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# CONFERENCE SCHEDULE

**BNP: Biblioteca Nicanor Parra**

Please note that:

1. Session times are not evenly spaced
2. Pending registrations will be processed at the registration desk in the auditorium hall (level –1)

**Wednesday 12/11: Afternonn sessions**

| | | |
|---|---|---|
| 14:00 | Registration / BNP Auditorium hall (level -1) | |
| 15:00 | Welcome / BNP Auditorium (level -1) | |
| 16:00 | **Keynote: Dr. Vítor Jorge Pais Vilar<br>BNP Auditorium (level -1)** | |
| | Room: 401 (level 4)<br>Chair:<br>Danilo Carvajal | Room: 501 (level 5)<br>Chair:<br>Luis Silva Llanca |
| 17:00 | WTM 01 | REC 01 |
| 17:15 | WTM 02 | REC 02 |
| 17:30 | WTM 03 | REC 03 |
| 17:45 | WTM 04 | REC 04 |
| 18:00 | Cocktail: BNP Rooftop Terrace (level 6) | |

**Thursday 13/11: Morning sessions**

| | | |
|---|---|---|
| | Room: 401 (level 4)<br>Chair:<br>Norberto Abreu | Room: 501 (level 5)<br>Chair:<br>Cristóbal Sarmiento |
| 9:00 | WTM 05 | EE 01 |
| 9:15 | WTM 06 | EE 02 |
| 9:30 | WTM 07 | EE 03 |
| 9:45 | Coffee break / BNP Auditorium hall (level -1) | |
| 10:30 | **Keynote 2: Dr. Gianluca Li Puma<br>BNP Auditorium (level -1)** | |
| | Room: 401<br>Chair:<br>Rodrigo Cáceres | Room: 501<br>Chair:<br>Cristóbal Sarmiento |
| 11:30 | SCC 01 | EE 04 |
| 11:45 | SCC 02 | EE 05 |
| 12:00 | SCC 03 | |
| 12:15 | **Award for excellence ceremony<br>BNP Auditorium (level -1)** | |
| 13:15 | Lunch: BNP Dining Hall (level –1) | |

**Thursday 13/11: Afternoon sessions**

| | | |
|---|---|---|
| | Room: 401 (level 4)<br>Chair:<br>Felipe Puga | Room: 501 (level 5)<br>Chair:<br>Arulraj Arunachalam |
| 14:30 | MEE 01 | SES 01 |
| 14:45 | MEE 02 | SES 02 |
| 15:00 | Poster session / Coffee break<br>BNP main hall (level 1) | |
| 17:00 | MEE 03 | SES 03 |
| 17:15 | MEE 04 | SES 04 |
| 20:00 | Conference Dinner<br>Club 50, Las Condes | |

**Friday 14/11: Morning sessions**

| | | |
|---|---|---|
| | Room: 401 (level 4)<br>Chair:<br>Rodrigo Cáceres | Room: 501 (level 5)<br>Chair:<br>Thais González |
| 9:45 | EE 06 | BMS 01 |
| 10:00 | EE 07 | BMS 02 |
| 10:15 | WTM 08 | MEE 05 |
| 10:30 | Coffee break / BNP Auditorium hall (level -1) | |
| 11:00 | **Scientific Publications in the Age of AI<br>(Hosted by Journal Editors)<br>BNP Auditorium (level -1)** | |
| 11:45 | **Keynote: Dr. Mangalaraja Ramalinga<br>BNP Auditorium (level -1)** | |
| 12:45 | Conference end<br>BNP Auditorium (level -1) | |

| | |
|---|---|
| EE: | Energy Efficiency |
| SES: | Sustainable Energy Systems |
| REC: | Renewable Energy Conversion |
| MEE: | Materials for Energy and Environmental Applications |
| BMS: | Bioprocess and Biomaterials for Sustainability |
| WTM: | Wastewater Treatment and Sustainable Water Management |
| SCC: | Sustainability and Climate Change |

# Keynote Presentations

Keynote presentation

# Advanced Treatment Technologies for Wastewater/Waste-Streams Resources Recovery

Dr. Vítor Jorge Pais Vilar

**Biography:**

Dr. Vítor Jorge Pais Vilar is a Principal Investigator at the Associated Laboratory in Chemical Engineering (ALiCE) and a Professor at the Department of Chemical Engineering, Faculty of Engineering, University of Porto (FEUP), Portugal.

Dr. Vilar is coordinator of the “Environmental Engineering” research group at the Separation and Reaction Engineering Laboratory – Catalysis and Materials Laboratory (LSRE-LCM) the same University.

He is an expert in chemical and environmental engineering. His work focuses on sustainable technologies.

Author of more than 600 scientific publications (h-index 59, +13,000 citations), 4 patents, and winner of 10 awards. Recognized among the most cited scientists in the world (Stanford University, 2021-2023). He has given over 70 international conferences and is an editor in prestigious scientific journals such as Environmental Science and Pollution Research (Springer), Chemical Engineering Journal and Journal of Environmental Chemical Engineering (Elsevier).

Keynote presentation

# Environmental Sustainability by Intensification of Advanced Oxidation Processes and Conversion of $CO_2$ to Platform Chemicals

Dr. Gianluca Li Puma

**Biography:**

Dr. Gianluca Li Puma serves as Professor of Chemical and Environmental Engineering at the University of Palermo, Italy. Before joining Palermo, he held academic positions at Loughborough University and the University of Nottingham in the United Kingdom, after completing his PhD and postdoctoral research at the Hong Kong University of Science & Technology.

His research spans Environmental Nanocatalysis and Heterogeneous Photocatalysis; Advanced Disinfection, Water Detoxification and Reuse Technologies; Photo- and Microbial-Electrosynthesis Systems and Solar Fuels; as well as Photoreaction and Solar Engineering supported by advanced mathematical modeling. Altogether, these research lines aim to address globally significant challenges, including water scarcity and reuse, renewable energy generation, and environmental sustainability.

Dr. Gianluca Li Puma serves as Editor of Applied Catalysis B: Environmental and previously held the same role at the Journal of Hazardous Materials. He has contributed as a committee member and programme chair to the organization of more than 80 international conferences in catalysis, engineering, and environmental science.

He is a member of the International Advisory Board of the Water Research Centre (NIREAS) in Cyprus and of the EPSRC Solar-Chemical Network in the United Kingdom.

Keynote presentation

# Innovative Approaches in Green Energy Generation: Harnessing Nanotechnology for the Sustainable Energy Solutions

Dr. Mangalaraja Ramalinga Viswanathan

**Biography:**

Dr. Mangalaraja Ramalinga Viswanathan is the Full Professor in the Facutly of Engineering and Architecture, Vicerrectoría de Investigación e Innovación, Universidad Arturo Prat (University of Arturo Prat), Iquique, Chile, and Full Professor (Part-Time) in the University Institute of Technological Research and Development (IDT), Universidad Tecnológica Metropolitana (UTEM, Metropolitan Technological University), Santiago, Chile, Previously, he served as the Full Professor in the Faculty of Engineering and Sciences, Adolfo Ibáñez University, Santiago, Chile, and in the Department of Materials Engineering, University of Concepción at Concepción, Chile.

He has worked as the Director of International Relations at the University of Concepción for the period of two years from 2018 to 2019. He served as the Director of the Department of Materials Engineering for the period of six years from 2010 to 2016. He also served as the President of the Chilean Metallurgy and Materials Society (SOCHIMM) for the period of 2015-2017. Life-Member of Indian Ceramic Society (ICS) and Fellow of Indian Institute of Ceramics (IIC). Also, member of the Mineral, Metals and Materials Society (TMS) and Singapore Materials Research Society (MRS-S); and American Ceramic Societies (ACerS) and founder member of PAN American Ceramic Society.

He authored/coauthored over 360 research articles in the refereed international scientific indexing (ISI) journal publications, more than 70 book chapters, four patents, Editor in eight Books, and more than 200 research presentations in several International Conferences/Seminars. He has been ranked as second position by the Ministry of Science and Technology-Chile in the national level Engineering and Technology stream.

# ABSTRACTS INDEX

## BMS: Bioprocess and Biomaterials for Sustainability



## EE: Energy Efficiency

## SCC: Sustainability and Climate Change



## SES: Sustainable Energy Systems

## WTM: Wastewater Treatment and Sustainable Water Management

# POSTERS SUMMARY

# BMS: Bioprocess and Biomaterials for Sustainability

5th Energy, Efficiency and Environmental Sustainability Conference 2025

**Production and characterization of syngas and biochar from gasification of heterogeneous feedstocks: a practical step toward the circular bioeconomy**

Gerardo Diaz[1*], Ziad Nasef[1], Isaias A. Teran[1], Alex Hammer[1], Ikenna Emechete[1]

[1]Departament of Mechanical and Aerospace Engineering, University of California, Merced, U.S.A.

Developing the Circular Bioeconomy requires the ability to cost-effectively convert a wide range of future feedstocks into valuable bioproducts. With a surface area of roughly 26000 km$^2$, the North San Joaquin Valley (NSJV) of California is a leader in volume and diversity of crop production, that generates around 4.1M BDT of future feedstocks annually. Local community members at NSJV have partnered with Lawrence Berkeley National Lab, UC Berkeley, UC Merced, UC Davis/UCANR, and USDA to develop a regional ecosystem for the circular bioeconomy under project BioCircular Valley (BioCirV). Due to the wide variety of feedstocks available in the region, Aim 2 of this project intends to analyze feedstock-flexible conversion routes for future feedstocks, that include one-pot solvent processing, gasification, and autoclave processing technologies, among others. The report "Getting to Neutral: Options for Negative Carbon Emissions in California" published in 2020 identified biomass gasification as having the maximum negative emissions potential compared to other conversion technologies analyzed. Gasification converts carbonaceous material into a product gas with a large fraction of hydrogen and carbon monoxide and produces biochar as a byproduct. The current trend is to optimize this thermochemical process for handling heterogenous feedstocks. This work intends to analyze product gas composition and biochar characteristics in gasification tests of mixtures of locally-sourced almond shells and hemp hurd to analyze variability of the outputs as a function of feedstock heterogeneity. Biochar is a carbon-rich material with enormous potential for agriculture and industrial applications, and it provides a stable form of carbon sequestration.

**Acknowledgments:**

The authors acknowledge the partial funding support from the Virtual Institute on Feedstocks of the Future, a partnership between Schmidt Sciences and the Foundation for Food & Agriculture Research, and from the CITRIS Workforce Innovation Program.

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**Track:**

BMS: Bioprocess and Biomaterials for Sustainability

5th Energy, Efficiency and Environmental Sustainability Conference 2025

**Rational solvent design and selection framework for in-situ product recovery in bioprocesses**

Nicolas F. Gajardo-Parra [1,*], Andrés Arroyo [1], Junior Lorenzo [1], Roberto I. Canales [1].
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The flavors and fragrances markets are growing because of the diversity of their applications in food, and pharmaceuticals. Despite the purity and natural-like grade of synthetic products, the perception of consumers is towards purchasing products that are natural and potentially free of any undesirable compound, increasing the natural product price. An interesting alternative to the chemical-produced flavors is the biotechnological synthesis, specifically, the fermentation with engineered yeasts that overproduce the target solutes. The challenge is that at low concentrations, β-ionone is toxic to Saccharomyces Cerevisiae. However, a process such as in-situ liquid-liquid extraction can alleviate the toxicity problem.
This work used COSMO-RS to screen 6012 organic solvents for extracting aroma from water by calculating the solute partition coefficient of this solute in the solvent and water two-phase system. The best eight solvents for β-ionone were selected after filtering for thermodynamic properties, price, toxicity, and boiling temperature. Life cycle analysis of the selected solvents was performed following regulations and guidelines on environmental, health, and safety aspects. Then, the downstream process was simulated in Aspen Plus. This framework could be also extended to tailor-made solvents such as deep eutectic solvents. The in-situ extraction was simulated as liquid-liquid separation and purification in two distillation towers. The solvent properties and their performance in the extraction/purification processes were assessed to select the best alternatives based on a multi-criteria decision-making analysis. To this end, two scenarios were considered: recovering at least 99% of β-ionone or obtaining a purity of β-ionone of 99% in the exit stream. This framework allows the optimal solvent selection for different scenarios, reducing the experimental effort in designing new processes.

**Acknowledgments:**

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**Track:** BMS: Bioprocess and Biomaterials for Sustainability

# EE: Energy Efficiency

5th Energy, Efficiency and Environmental Sustainability Conference 2025

**Analysis of energy consumption in data centers using Computational Fluid Dynamics and Machine Learning**

Juan Pablo Agudelo Escobar[1], Andrés J. Díaz[1], Rodrigo Cáceres Gonzales[1], Karla Aroca[1]

[1]Escuela de Ingeniería Industrial, Facultad de Ingeniería y Ciencias, Universidad Diego Portales, Chile

The exponential growth of artificial intelligence and cloud services has led to a sharp increase in the energy demand of data centers, reaching between 240 and 340 TWh annually and representing approximately 1% of global electricity consumption [1]. Of this total, up to 50% corresponds to cooling systems, whose operation also entails intensive water use, resulting in high operational costs and considerable environmental impact [2]. In response to this scenario, this research proposes a methodological strategy that integrates physical simulations and machine learning models to predict power consumption in data centers under diverse operating conditions. A two-dimensional model was developed using Computational Fluid Dynamics (CFD) to simulate the thermal behavior of the room, considering inlet temperature, airflow velocity, relative humidity, and thermal load. Among the phenomena identified, the bypass of airflow stands out, as it undermines cooling efficiency. Based on the CFD results, a refrigeration system was modeled using Engineering Equation Solver (EES), generating a dataset that served as input for training machine learning models (Linear, Ridge, Lasso, SVR, GPR, XGBoost, and LightGBM). The latter achieved 97.64% accuracy in predicting total power consumption. These findings demonstrate that integrating physical models with machine learning algorithms not only significantly enhances predictive accuracy but also provides a reliable and scalable tool for intelligent energy management in data centers, with strong potential for application in real-world scenarios characterized by high demand and operational complexity.

*** Corresponding author:** juan.agudelo@mail.udp.cl

**Track:** EE: Energy Efficiency

[1] G. Kamiya, Bertoldi, P., "Energy Consumption in Data Centres and Broadband Communication Networks in the EU," *European commission,* 2024.
[2] H. M. Daraghmeh and C.-C. Wang, "A review of current status of free cooling in datacenters," *Applied Thermal Engineering,* vol. 114, pp. 1224-1239, 2017.

5th Energy, Efficiency and Environmental Sustainability Conference 2025

**Exergy destruction analysis of a large wind farm over a 24-hour diurnal cycle using the Johns Hopkins Turbulence Database**

Andrea Torrejón-Fontana[1,*], Fabián Aguirre-Villegas[1], Luis Silva-Llanca[1]

[1]Departamento de Ingeniería Mecánica, Universidad de La Serena, Chile.

Understanding the spatial distribution and evolution of inefficiencies in wind energy systems is essential for optimizing wind farm design and operation. Exergy analysis provides a framework for identifying and quantifying irreversibilities—namely, the destruction of useful work potential due to turbulence, mixing, and wake interactions. In this study, we investigate Exergy Destruction in a high-resolution Large Eddy Simulation (LES) of a wind farm over flat terrain, as provided by the Johns Hopkins Turbulence Database (JHTDB). The dataset represents a 2×4 aligned array of horizontal wind turbines operating under neutral atmospheric conditions. We implement an exergy-based approach to evaluate exergy destruction across the three-dimensional domain and within each turbine row, accounting for the irreversibilities associated with turbulent kinetic energy dissipation, viscous effects, and heat transfer. Our results show that the Exergy Destruction increases with downstream turbine rows due to intensified wake interactions, representing, on average, 16% of the total power produced by the wind farm. The framework developed herein enables a deeper understanding of loss mechanisms in wind farms and offers valuable insights for the exergy-based optimization of turbine placement and array configurations.

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**Track:** EE: Energy Efficiency

5th Energy, Efficiency and Environmental Sustainability Conference 2025

**Real-time optimization of data center cooling using thermodynamic modeling and machine learning**

Ignacio Leyton Valenzuela[1], Andrés J. Díaz[1], Rodrigo Cáceres Gonzales[1]

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This research aims to optimize the cooling system of data centers using machine learning, enabling autonomous and efficient operation without human intervention. To achieve this, the Engineering Equation Solver (EES) software is used to thermodynamically model the behavior of the HVAC system under different combinations of parameters, such as the chiller outlet temperature, the fan speed of the AHUs, and the temperature of the supplied cold air. Based on these models, a machine learning algorithm is trained to automatically predict and adjust the optimal configuration of these parameters, with the goal of minimizing total energy consumption without compromising the thermal conditions of the room. Preliminary results show that in all scenarios, the chiller's COP is higher than the overall system COP, highlighting the energy impact of auxiliary components such as pumps, cooling towers, and AHUs. The scenario with the highest energy use ($\dot{W}_{ch}$ = 23.95 kW; $\dot{W}_{total}$ = 112.1 kW) also shows the highest heat rejection in the cooling tower (212.1 kW). In contrast, the scenario with the lowest energy use ($\dot{W}_{ch}$ = 22.32 kW; $\dot{W}_{total}$ = 66.71 kW) achieves the highest system COP, reflecting better overall efficiency. Interestingly, the scenario with the highest chiller COP (6.94) results in the lowest system COP (1.48). These results highlight the value of combining thermodynamic modeling and artificial intelligence. Given the large number of possible configuration settings, predictive models become especially useful in environments where real-time decision-making is required, offering a promising path toward more energy-efficient and sustainable data centers.

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**Track:** EE: Energy Efficiency

5th Energy, Efficiency and Environmental Sustainability Conference 2025

# Dynamic insights of a Liquid Air Energy Storage/Organic Rankine Cycle system under weather variations

Luciano I. Poblete[1,*], Sebastián Espíndola[1], Luis Silva-Llanca[1]

[1]Departamento de Ingeniería Mecánica, Universidad de La Serena, Chile.

**Abstract:**

Liquid Air Energy Storage (LAES) has emerged as a promising alternative for large-scale energy storage, offering high energy density without the need for extensive storage volumes and enabling scalability without geographical limitations. In this work, we present a dynamic analysis of a standalone LAES system and a hybrid configuration that couples it with an Organic Rankine Cycle (ORC) as a waste heat recovery unit. The dynamic model is developed in Matlab/Simscape and validated using theoretical data from the literature. We evaluate the system's performance under challenging environmental conditions—specifically variations in ambient pressure, temperature, and humidity—across five Chilean locations (Calama, Andacollo, Quintero, Maullín, and Punta Arenas) during both summer and winter. Our results aim to identify potential improvements in energy storage capacity, round-trip efficiency, and the waste heat recovery contribution of the ORC subsystem. This research contributes to a deeper understanding of how ready LAES systems are for deployment globally, particularly in regions subject to high weather variability, such as Chile.

**Acknowledgments:**

The authors thank ANID-Chile for supporting this work under project FONDECYT regular 1220503.

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**Track:** EE: Energy Efficiency

# Numerical simulation: A key tool for the energy transition

**Léa Décultot**

**Assessment of energy efficiency of Heat Pump-powered central plant of a district heating system for dwellings with PCM-enhanced floor heating.**

Tomas Venegas[1], Natalia Osorio Álvarez[1], Diego Vasco-Calle[1*], Erick Saavedra[2]

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Energy poverty is a significant issue in cold regions of southern Chile. Houses are typically built with wood, featuring low levels of thermal insulation, and heated by burning low-grade wood in stoves, which causes high particulate pollution and poor thermal comfort inside the homes. The authors hypothesize that heated floors could be particularly suitable for Coyhaique [1]. Heated floors utilize low-temperature water as the heating medium and heat pumps to generate hot water, further reducing particulate matter pollution. To increase the thermal inertia of wood-based houses, the use of phase change materials inside the heated floor construction has been considered. Using the energy demand curve for a single representative home—either with radiators or heated floors, developed in previous work—a synthetic curve for a housing development was created. A heat pump-powered district heating system was designed and simulated using Modelica to meet the heating demands of the development. For comparison, a fuel-combustion-based district heating system was also implemented. The results will clarify the energy efficiency benefits of the heat pump system over the combustion-based one and determine if lower-temperature heating systems integrated with phase change materials can save energy, reduce particulate emissions, and improve thermal comfort for occupants.

**References**

[1] N. Osorio Álvarez, A. Cabrera-Bobenrieth, and D. Vasco-Calle, “Thermal simulation of a house with a PCM-modified envelope located in the south of Chile,” Conference on Energy, Efficiency, and Environmental Sustainability (CEES-2023), La Serena, Chile, Nov. 29–Dec. 1, 2023.

**Acknowledgments:**

The authors acknowledge the support provided by Proyecto FONDECYT N° 1201520 and Proyecto ANILLO N° ACT240015, Agencia Nacional de Investigación y Desarrollo, ANID Chile. Tomás Venegas would like to acknowledge the financial support of the Postdoctoral Research project POSTDOC_DICYT, Código 092416VC_Postdoc Vicerrectoría de Investigación, Innovación y Creación, Universidad de Santiago de Chile.

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**Track:** EE: Energy Efficiency

5th Energy, Efficiency and Environmental Sustainability Conference 2025

**Thermal Behavior Analysis of CLT Buildings Enhanced with Phase Change Materials (PCMs) through Computational Simulation**

Natalia Osorio Álvarez[1], Tomas Venegas[1], Nicolas Muñoz Cabezas[2], Carlos Salinas Lira[2], Erick I. Saavedra Flores[3], Diego Vasco-Calle[1*]

[1]Departamento de Ingeniería Mecánica, Universidad de Santiago de Chile, Chile.
[2]Departamento de Ingeniería Mecánica, Universidad del Bío-Bío, Chile.
[3]Departamento de Ingeniería en Obras Civiles, Universidad de Santiago de Chile, Chile.

Wood has long been used in housing construction due to its low cost and ease of processing. Recent advances in engineered wood products, such as Cross-Laminated Timber (CLT), have positioned timber as a structurally efficient and sustainable alternative for buildings, competing with steel, brick, and concrete in multi-family applications [1]. CLT is a prefabricated solid wood panel composed of at least three orthogonally bonded layers of solid-sawn lumber, laminated with structural adhesives to form a rectangular structural element [2].

This study aims to evaluate the thermal performance in terms of annual heating demand and internal temperatures of low-rise buildings constructed with three-layer CLT panels enhanced with shape-stabilized phase change materials (SSPCMs) integrated into the central layer (**Fig. 1**). The analysis will be conducted using dynamic simulations in DesignBuilder v6.1.5.002, for a house located in Santiago, Chile.

The impact of incorporating PCM-modified CLT into various components of the building envelope will be assessed in terms of thermal inertia and overall energy performance. Key indicators include heating energy demand, associated carbon emissions, and variations in indoor thermal comfort hours. This research builds upon prior experimental work conducted by the authors [3] and seeks to inform the development of more efficient and sustainable timber construction systems through optimized PCM integration.

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***Fig. 1. Three layer CLT, central layer impregnated with PCM [3].***

**References**

[1] O. Espinoza, U. Buehlmann, R. Smith, and M. Bumgardner, "Cross-laminated timber: Status and research needs in the United States," *BioResources*, vol. 11, no. 1, pp. 281–295, 2016. DOI: 10.15376/biores.11.1.281-295.

[2] ANSI/APA PRG 320-2012, *Standard for Performance-Rated Cross-Laminated Timber*, APA – The Engineered Wood Association, 2012.

[3] N. A. Muñoz Cabezas, *Evaluación de propiedades térmicas de tableros CLT con PCM macro encapsulado*, Undergraduate thesis, Dept. Ing. Mecánica, Univ. del Bío-Bío, 2022.

**Acknowledgments:**

The authors acknowledge the support provided by Proyecto FONDECYT N° 1201520 and Proyecto ANILLO N° ACT240015, Agencia Nacional de Investigación y Desarrollo, ANID Chile. Tomás Venegas would like to acknowledge the financial support of the Postdoctoral Research project POSTDOC_DICYT, Código 092416VC_Postdoc Vicerrectoría de Investigación, Innovación y Creación, Universidad de Santiago de Chile.

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**Track:** EE: Energy Efficiency

# MEE: Materials for Energy and Environmental Applications

5th Energy, Efficiency and Environmental Sustainability Conference 2025

**Development of BiOCl/CuO heterostructured photocatalyst supported on zeolite for the removal of recalcitrant organic compounds under solar-like irradiation.**

María F. M. Guiñez[1], Andrés F. Jaramillo[2,3], Norberto J. Abreu[4,5], Adriana C. Mera[6], Claudia Campos[2], Juan Carlos Durán[7], Amauri Serrano[7]

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This study presents the development of a heterostructured photocatalyst composed of bismuth oxychloride (BiOCl) microspheres doped with copper oxide (CuO) and supported on zeolite. The Preliminary results using BiOCl/CuO photocatalyst conduced to 49.3% removal efficiency of methyl orange (10 ppm) in one hour under simulated solar irradiation. A Synthetic zeolite was selected as a support due to its high surface area, adsorption properties, and the ability to enhance photocatalyst dispersion and charge separation.

The material was synthesized via a solvothermal method. SEM-EDS analysis confirmed a uniform distribution of BiOCl/CuO across the zeolite matrix. BET-BJH results indicated that the porous structure and surface area of the support were preserved after the integration of the active material. FTIR spectra showed the appearance of new functional groups, suggesting strong chemical interactions between the photocatalyst and the support.

Photocatalytic performance was evaluated using ciprofloxacin as a model emerging contaminant in a batch reactor under simulated solar light. The supported BiOCl/CuO material exhibited superior degradation activity compared to the pristine heterostructure, which is attributed to improved pollutant adsorption and reduced electron-hole recombination. The reaction followed pseudo-first-order kinetics, indicating a stable and predictable degradation process.

These results highlight the potential of the BiOCl/CuO-zeolite composite as an efficient photocatalyst for the removal of pharmaceutical pollutants in wastewater. Current efforts are focused on identifying intermediate degradation products and assessing the long-term stability and reusability of the material under continuous operation conditions.

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**Track:**

MEE: Materials for Energy and Environmental Applications

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**MXene - {001}-Facet Anatase $TiO_2$ nanostructures: Sunlight-Driven Photocatalytic Degradation of Endocrine Disruptors**

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The present work aimed to overcome the limitations of $TiO_2$ photocatalyst through modification of it's bandgap, crystal facet, size, and shape by simple solvothermal and solid face reaction. More specifically, anatase {001} $TiO_2$ nanostructures (NSTs) were synthesized and it's surface was modified with MXene. Synthesized photocatalysts were characterized in detail using different characterization techniques (HRTEM, SEM, XRD, Raman spectroscopy, DRS, FT-IR, and BET). The valorization of photocatalytic efficiency of synthesized photocatalysts was assessed with a fixed bed photocatalytic reactor using Bisphenol-A as a target pollutant under natural solar light irradiation. In addition, photocatalytic activity was compared to benchmark $TiO_2$ (DegussaP25). The experimental results indicate that ~87% of the Bisphenol-A (BPA) is oxidized within 60 min of solar light irradiation in the presence of MXene-$TiO_2$ NSTs having higher photocatalytic efficiency than benchmarked $TiO_2$ nanoparticles(Degussa P25). Moreover, the results also show that the addition of peroxymonosulfate (PMS) boosts the photocatalytic oxidation and achieves ~99% BPA oxidation within 25 min of solar light irradiation by the generation of $SO_4^{\bullet-}$ and $^{\bullet}OH$ radicals. The MXene modified {001} $TiO_2$ NSTs boost the photocatalytic activity through their virtue of visible-light absorption properties and the rapid electron-hole separation at the MXene {001} $TiO_2$ NSTs interfaces. The novel synthesized MXene-$TiO_2$ NSTs with exposed {001} facets result to be highly stable 20 consecutive operating cycles. The observed results suggested that the MXene modified anatase $TiO_2$ nanostructures with exposed {001} facets could be used for the effective removal of various EDCs in large wastewater treatment plants by exploiting the natural solar light.

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**Track:** MEE: Materials for Energy and Environmental Applications

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## High-energy product rare-earth-free permanent magnets for wind turbine applications.

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Owing to global demands for sustainable energy, wind energy has emerged as a reliable and environmentally friendly alternative. It is estimated globally the power generated by wind energy is increasing by 10 % every year. Traditionally, rare-earth-based NdFeB and SmCo magnets have been largely used for wind turbines due to their high magnetic strength and power-to-weight ratio. However, these materials suffer from several drawbacks, including poor thermal stability, high fabrication cost and corrosion susceptibility. Moreover, the mining and refining of rare-earth elements generate toxic byproducts and radioactive waste, leading to severe ecological degradation and long-term environmental hazards. To overcome these limitations, hexaferrite—a hard ferrimagnetic material with a stable hexagonal structure—has gained attention due to its low cost, excellent thermal stability, resistance to oxidation and tunable energy product with an environmental friendly alternative. In the current study, aluminium-substituted barium hexaferrite MFe12-xAlxO19 (M = Ba & Sr, x =1.0 & 2.0) materials were synthesized by the auto-combustion method and their magnetic properties and potential applications in wind turbine applications were explored. Structural and magnetic properties were characterized using X-ray diffraction, scanning electron microscope and vibrating sample magnetometry. Scanning electron microscopy confirms that the addition of $Al_2O_3$ in the complex magnetoplumbite system promotes enhanced hexagonality in the microstructure, a critical requirement for achieving high magnetocrystalline anisotropy and energy product in hexagonal-phase permanent magnets. Magnetic study shows giant coercivity of 9.9kG and Curie temperature (Tc) of 436 °C for 16% Al substitution in barium hexaferrite crystal system. The reported coercive force value is highest among all the known hexagonal ferrites reported elsewhere. This remarkable magnetic performance and environmental resilience establish it as a highly viable and sustainable alternative to rare-earth magnets for permanent magnet applications in wind energy systems.

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**Track:** MEE: Materials for Energy and Environmental Applications

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**Thermal and mechanical properties of recycled UBC aluminium foams fabricated by sand casting.**

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Metal foams are a class of cellular materials characterised by a solid metallic matrix that contains a significant proportion of gas-filled pores. Their unique combination of intrinsic base metal properties, such as strength and conductivity, and a porous structure confers exceptional properties, including low density, a high specific surface area, remarkable energy absorption capacity and excellent acoustic damping.
In this study, a commercial A380 aluminium alloy, used beverage cans (UBC) and a 50/50 wt.% alloy of the two were sand-cast to obtain aluminium metal foams (AMF), using salt (NaCl) as a spaceholder. The hardness (HV), heat capacity ($C_p$) and thermal conductivity (k) of the foams were measured, as was their porosity. Thermal diffusivity (α) was calculated and SEM-EDS analysis was performed to characterise the microstructure of the alloys.
The results show that the UBC alloy has the best thermal and mechanical properties, although there is more variation in the obtained data. This is attributed to the alloy's lower castability, which generates AMF with more variable porosities. When it comes to A380 aluminium-based alloys, the form in which the alloying elements are present — either in solid solution or as a secondary phase — is a determining factor in analysing their properties.

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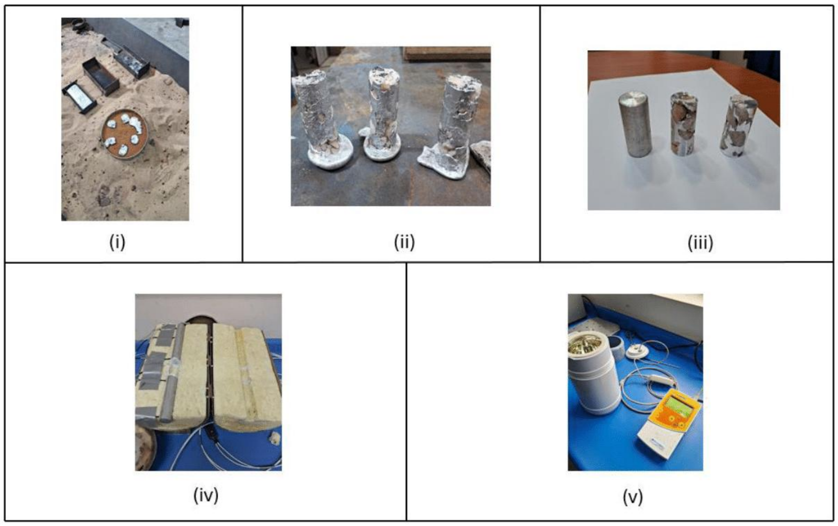
**Track:**
MEE: Materials for Energy and Environmental Applications

FIGURES




Sand Casting of alloys (i), AMF as cast (ii) and mechanised (iii), Thermal conductivity (iv) and specific heat (v) experimental setups.

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# Hierarchical $MoS_2/Ti_3C_2$ Heterojunction: A High-Performance and Durable Catalyst for Solar-Powered Hydrogen Production

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**Abstract:**

Development of an efficient solar-driven catalyst for hydrogen ($H_2$) production is crucial for addressing global energy demands. Transition metal dichalcogenides (TMDs) and two-dimensional (2D) materials, especially MXenes, are getting a lot of interest because they have outstanding electronic and catalytic features. A simple one-step hydrothermal method was used to fabricate nanocomposites like $MoS_2/Ti_3C_2$ (X) (where X = 1, 3, 5, 7, 9%), and they were characterized using different sophisticated analytical methods. Photocatalytic $H_2$ production experiments were conducted in a methanol-water solution under visible light, demonstrating that the $MoS_2$ /$Ti_3C_2$ 3 % heterostructure exhibits superior activity compared to pure $Ti_3C_2$, $MoS_2$ and other composites. The better photocatalytic performance of $MoS_2/Ti_3C_2$ happens because electrons can move between the $MoS_2$ and $Ti_3C_2$ layers, which helps create more electron-hole pairs. The $MoS_2$ /$Ti_3C_2$ 3 % composite achieved a highest $H_2$ evolution rate in, which attributed to enhanced interfacial electron transfer and reduced recombination. Electrochemical impedance spectroscopy (EIS) and photoluminescence (PL) studies confirmed improved charge separation kinetics. This work highlights the potential of 2D $MoS_2$/ $Ti_3C_2$ as a high-performance, cost-effective photocatalyst for renewable $H_2$ production, offering insights into the design of advanced MXene-based hybrid materials for solar energy conversion.

**Keywords:** Solar-Driven, Hydrogen production, $Ti_3C_2$, $MoS_2$, 2D heterostructure, Electron-hole pair.

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**Track:** MEE: Materials for Energy and Environmental Applications

# REC: Renewable Energy Conversion

5th Energy, Efficiency and Environmental Sustainability Conference 2025

**Complementarity of Renewable Solar and Wind Resources as a Driver of Stable and Cost-Effective Green Hydrogen in Coastal Chile.**

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Green hydrogen produced from renewable energy is recognized by the International Energy Agency (IEA) as a scalable pathway to decarbonize hard-to-abate sectors, though 95 % of 97 Mt produced in 2023 was from unabated fossil fuels. Net-zero pathways demand a ten-fold increase in low-emission supply by 2030, highlighting the need for rapid cost cuts [1]. In off-grid hydrogen projects, long-duration batteries have become the dominant cost component. Even at 2024's record-low pack price, 12 h autonomy may still add over 1 USD/kg to LCOH [2].

This work assesses the solar-wind renewable energy complementarity at Mejillones in northern Chile using historical hourly irradiance and wind-speed data from the NASA POWER Hourly [3]. Typical season profiles show daytime irradiance near 1000 W/m² in summer and 700 W/m² in winter, yet zero after sunset, while coastal winds strengthen to 6-8 m/s. The annual hourly Pearson correlation is -0.75, evidencing strong complementarity over time. A preliminary energy-balance indicates that replacing half of the photovoltaic capacity with wind generation reduces battery energy demand for continuous alkaline electrolysis by ~60 % versus a solar-only design. This storage benefit aligns with nationwide studies that rank Chile's Pacific coast among the world's strongest solar-wind complementarities. This pronounced diurnal and seasonal synergy at Mejillones offers an example of a pathway to overcome key challenges in delivering cost-competitive and stable green hydrogen from variable renewable energy sources.

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**Track:** REC: Renewable Energy Conversion

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## Engineering 2D Nanostructured Nickel Chalcogenide Nanocatalysts for Hydrogen-based Renewable Energy Conversion

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The pursuit of efficient and affordable nanostructured catalysts for water splitting has attracted considerable interest in the recent years, given their crucial role in advancing the renewable energy technologies, especially for sustainable hydrogen production. Among the various transition metal chalcogenides, nickel sulfoselenide (NiSSe) has emerged as a strong candidate for catalyzing the electrochemical water splitting reactions, due to its adjustable composition and favorable electronic structure. This study underscores the multifunctionality of NiSSe synthesized via a hydrothermal method, which offers precise control over its morphology and composition to optimize performance for water splitting applications. The structural analyses using X-ray diffraction and Raman spectroscopy confirmed the material's crystallinity and phase composition, while FESEM imaging revealed a two-dimensional (2D) lamellar nanosheet morphology. The NiSSe-based electrode demonstrated overpotentials of 267 mV for the oxygen evolution reaction (OER) and 122 mV for the hydrogen evolution reaction (HER). Its outstanding electrocatalytic activity and stability are attributed to the material's high surface area, excellent electrical conductivity, abundant active sites, and the synergistic interaction between sulfur and selenium atoms within the NiSSe nanocatalysts.

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## Chemical engineering perspective on data-driven opportunities for ammonia and e-fuels hubs: Chile as a use-case.

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Decarbonisation is a target for many countries, yet its implementation is complex and resource-intensive, with local factors affecting the effectiveness of solutions. The complexity of the problem makes it difficult to compare different projects, and data is key to enabling a better understanding of the problem and thus elaborating on better questions and strategies. Chile offers unique advantages for solar and wind energy production in specific regions. However, abundant renewable energy production is challenging. In this work, we analyze the opportunities for Chile to become a renewable energy exporter in the context of international initiatives. First, we collect available energy-related data about Chile. Second, we examine the evolution of the energy transition in Chile. Available resources are geographically analyzed to assess cross-domain inferences. Digital tools, including 2D/3D visualizations, facilitate the understanding of the global context and visualisation of potential synergies. Advantages and disadvantages are examined in light of national and international projects. Then, we propose options for targeted infrastructure investments focusing on ammonia and e-fuels hubs. These include strategic deployment of infrastructure and the possibility of using circular maritime transportation of reactants and products. These options aim to facilitate access to abundant renewable energy sources while enhancing synergies between projects. Further economic and energy-related analysis is recommended. Our study raises questions about how limited resources are best deployed and how multiple initiatives could be implemented to produce synergies. Finally, our work enables a vision for a more sustainable future where technological-and-infrastructural developments are crucial to accelerating access to renewable energy.

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# Substrate Temperature Impact and High White Light Sensitivity of RF Magnetron Sputtered $Cu_2ZnSnS_4$ Thin Films for Solar Cell Applications

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The copper zinc tin sulfide ($Cu_2ZnSnS_4$ or CZTS) has been recognized as a very promising absorber material for inorganic thin film solar cells owing to its suitable optical and electrical properties. However, the facile deposition of ternary semiconducting CZTS thin films has been a challenge due to a very narrow range of single-phase stability. While sputtering has been a very efficient method for the growth of various optoelectronic thin films, the formation of secondary phases should be suppressed during sputter deposition of CZTS films. However, in this study, as a different approach, deposition of a precursor film followed by a delicately-controlled sulfurization process required for the formation of the kesterite CZTS phase has been carried out to demonstrate a single-step synthesis route to grow phase-pure CZTS thin films using a compound target. The films were deposited on soda-lime glass substrates at different substrate temperatures. The role of substrate temperature in CZTS phase growth and its influence on the properties of the thin film have been studied using various techniques. The XRD results reveal the evolution of a dominant kesterite phase of CZTS at 450ºC, which was further verified by Raman measurements. Further, the phase purity of the CZTS thin film was confirmed by Raman spectroscopy. The electrical resistivity and bandgap of the CZTS film grown at 450ºC substrate temperature were 0.16 Ω-cm and 1.57 eV, respectively. The film shows favorable white light sensitivity (~200%), which is suitable for the solar cell applications.

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**Track:** REC: Renewable Energy Conversion

# SCC: Sustainability and Climate Change

5th Energy, Efficiency and Environmental Sustainability Conference 2025

**Effects of heat waves on electricity demand in Chile in a context of Climate Change**

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2. Data Observatory

Climate change is intensifying the frequency, severity, and duration of heat waves, generating unprecedented pressure on urban electrical systems. However, most demand studies have focused on aggregated residential data and low-resolution climatological models that can present significant biases, leaving a significant gap in understanding the behavior of individual industrial and commercial customers.

Our research addresses this gap by analyzing the effects of heat waves on electricity consumption at the meter level for residential, commercial, and industrial customers. To do this, we use high-resolution climate projections (12.5 km hourly) for the historical period (1979-2020) and the future anthropogenic forcing scenarios SSP585 and SSP370 (2020-2100), with a bias adjustment based on observations from local weather stations, which allows for a more precise capture of microclimates and the urban heat island (UHI) effect. We quantify the differential sensitivity of electricity demand to temperature and other meteorological variables for different consumer types. These findings are crucial for the development of more effective energy efficiency policies and for planning an electrical infrastructure that is resilient to extreme climate events.

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**Track: SCC: Sustainability and Climate Change**

5th Energy, Efficiency and Environmental Sustainability Conference 2025

**Impact of Climate Change on photovoltaic power availability: Differences between subtropical and temperate Chile**

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Chile has seen significant growth in solar energy and is now a leader in South America for the use of solar power. However, for solar energy to remain important in Chile's energy mix, it must be able to cope with the effects of climate change. This study examines how climate change over this century could affect photovoltaic potential in different parts of Chile. Two regional climate models (RegCM47 and REMO2015), each forced by three different global models, are used to study two possible futures: low emissions scenario (RCP2.6) and high emissions scenario (RCP8.5), for middle- and end of century periods. To calculate photovoltaic potential, solar radiation, surface air temperature, and wind speed are combined, and the contribution of each of these three factors to future changes is analysed. Results show that northern Chile, one of the best zones for solar energy, could lose a moderate amount of its solar potential, especially in summer in high emission scenarios. This is mainly due to less radiation and higher temperatures making solar panels less efficient. Southern Chile might see a slight improvement for solar potential, but not enough to make up for the losses in the north. The study also finds that "solar droughts"—several consecutive days with very low solar power—are expected to happen more often and last longer in the north, which could make it harder to keep the electricity grid stable. These results present useful information for policymaking in the energy sector.

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**Track:** SCC: Sustainability and Climate Change

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**Integrated Indicator Monitoring Systems for Sustainable Local Management: Lessons from Rural Municipalities in Chile**

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Abstract

This study proposes and validates an Integrated Indicator Monitoring System (IIMS) to enhance sustainable local management in rural Chilean municipalities. The research addresses key barriers—administrative centralization, fragmented competencies, limited financial and technical resources, and insufficient citizen participation—that impede effective integration of sustainability into municipal governance, despite Chile's commitments to the 2030 Agenda and Sustainable Development Goals (Filho et al., 2016; Gustafsson & Mignon, 2019; WCED, 1987). The IIMS incorporates environmental, social, economic, and institutional indicators, providing practical tools for decision-making, accountability, and intervention prioritization. Using a mixed-methods approach—literature review, participatory workshops, and case studies from 16 rural municipalities—the system ensures indicator validity, reliability, and adaptability (Daly, 1999; Schlosberg, 2013; Hernández Sampieri et al., 2014). The IIMS is structured around four pillars: participatory governance, green financing, technical capacity, and regulatory frameworks. Each indicator has clear measurement methods, data sources, and sustainability targets aligned with national and international standards. The system's flexibility allows for methodological adjustments without losing comparability, making it suitable for diverse municipal contexts. Empirical validation demonstrates that the IIMS enables identification of territorial gaps, comparison of progress, and replication of best practices. Municipalities with stronger participatory mechanisms and inter-municipal cooperation achieve greater advances in sustainable project implementation, even under resource constraints. The study recommends strengthening institutional capacity, fostering citizen participation and environmental education, promoting green jobs, and periodically reviewing indicators to ensure legitimacy and sustainability. The IIMS offers a replicable model for advancing resilience and sustainability in rural municipalities.

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practical relevance and applicability of the proposed model for sustainable management in rural municipalities

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**Track:**

SCC: Sustainability and Climate Change

# SES: Sustainable Energy Systems

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# Microclimatic Assessment and Thermal Comfort in Low-Infrastructure Housing: A Case Study in Valdivia, Chile

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This study focuses on the southern region of Chile, investigating the behavior of thermal comfort in relation to diverse meteorological variables. Factors such as ambient temperature, solar irradiance, and wind velocity are analyzed for their direct influence on environmental perception of thermal comfort. Using the microclimate simulation software ENVI-met, this research models detailed urban and natural scenarios at a pedestrian scale, integrating these variables and their behavior across different temporal scales, including various hours of the day and distinct seasons, based on local meteorological data.

The modeling accurately replicates local environmental conditions, capturing the profound influence of both built and natural surroundings. It quantifies perceived thermal comfort through advanced indices like the Physiological Equivalent Temperature (PET) and Mean Radiant Temperature (MRT), effectively demonstrating how comfort levels fluctuate spatially and over time within the study area. Furthermore, ENVI-met visually illustrates how the morphology of structures and the use of diverse materialities impact air behavior and the distribution of surface temperatures, directly affecting overall thermal comfort. These simulated dynamics are showcased to identify key environmental variables that are most significant for thermal comfort in the study area, revealing their specific effects. Ultimately, the simulation results are leveraged to pinpoint discomfort zones and provide robust evidence for conclusions regarding the influence of urban configuration and material selection on the environmental quality and human comfort.

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**Track:** SES: Sustainable Energy Systems
SCC: Sustainability and Climate change

5th Energy, Efficiency and Environmental Sustainability Conference 2025

# Identification of Optimal Areas for Green Hydrogen Production in Chile Using Random Forest and Spatial Data

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Green hydrogen (GH2) is essential in shifting toward a low-emission energy matrix and thus moving forward in accomplishing carbon neutrality. Due to its abundance of natural resources, Chile has enormous potential for the development of this industry. However, we still need accurate and geographically detailed information on where to install GH2 projects in an effective and sustainable manner. The aim of this study is to map the best production locations for $GH_2$ at a 10 km spatial resolution across continental Chile, using a random forest machine learning model and multiple predictors from geospatial data.

The response variable is based on current non-conventional renewable energy projects, like solar PV and wind farms, as well as known $GH_2$ production facilities, which serve as examples of where it is technically feasible to produce. The model uses as predictor variables critical infrastructure, geographic, environmental, climatic, and socioeconomic data. Additionally, future climate projections (CMIP6) are incorporated under two climatic scenarios: SSP2-4.5 and SSP5-8.5 for 2081-2100. The methodology is based on the approach developed by Sun et al. (2024), due to its effectiveness on territorial assessment of large-scale wind energy using machine learning techniques.

The expected outcome is to generate maps that spatially represent areas with the current and projected highest suitability, providing guidance for investment decisions, public policies, and energy planning. Although the research is still underway, its findings are anticipated to provide a reproducible and data-driven tool with a territorial focus that will contribute to promoting the development of the GH2 industry in Chile.

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5th Energy, Efficiency and Environmental Sustainability Conference 2025

# Thermodynamic and Multi-Objective Optimization of Solar-Assisted Brayton and $sCO_2$ Cycles for Cogeneration-Based Desalination

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This study presents a comprehensive comparative evaluation of desalination systems integrated with cogeneration technologies, emphasizing thermal energy recovery and the integration of multiple energy sources. The analysis focuses on solar-assisted configurations coupled with advanced power cycles, including Brayton and supercritical $CO_2$ systems. The proposed methodology combines thermodynamic modeling, numerical simulation (developed in Python and EES), and multi-objective optimization to improve both freshwater production and power generation efficiency in cogeneration-based desalination plants. A range of performance metrics, such as thermal efficiency, specific energy consumption (SEC), levelized cost of water (LCOW), and $CO_2$ emissions, are used to assess and compare the behavior of each configuration under different operating conditions. By exploring the interaction between desalination demands and power cycle performance, the study aims to identify optimal system designs that offer a technical and environmentally viable path toward sustainable water and energy production in arid and semi-arid regions.

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**Track:** SES: Sustainable Energy Systems
SCC: Sustainability and Climate change

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**Exergoeconomic Assessment of a Solar Desalination System with Auxiliary Gas Boiler: HDH Technology Applied in the Coquimbo Region, Chile**

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This study presents an exergoeconomic evaluation of a solar-powered humidification-dehumidification (HDH) desalination system, considering two operational scenarios. In the Base Case, the system was modeled under ideal conditions: 1 kWh/m² of solar radiation and 25 °C ambient temperature, without including auxiliary heating. In the Locality-Based Case, Typical Meteorological Year (TMY) data were used for five cities in the Coquimbo Region, Chile, including hourly solar radiation and ambient temperature. In this second case, a natural gas auxiliary boiler was included to meet thermal demand when solar radiation was insufficient.

The thermodynamic model was developed using Engineering Equation Solver (EES), integrating mass, energy, exergy, and concentration balances, along with economic equations to assess key performance indicators. In the Base Case, the Levelized Cost of Water (LCOW) was 3.24 USD/m³, and the Specific Exergetic Cost of Water was 3.379 USD/m³. The solar collector was identified as the main contributor to exergy destruction, accounting for 90% of the total, and reached an exergoeconomic cost of 372.70 USD/h. In the Locality-Based Case, the LCOW ranged from 46.73 to 51.79 USD/m³ depending on the city.

This dual-scenario approach highlights the importance of incorporating regional climatic variability and hybrid operation into exergoeconomic assessments. The findings support the identification of optimal implementation zones and the development of design strategies for sustainable and decentralized freshwater production.

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**Track:** SES: Sustainable Energy Systems
REC: Renewable Energy Conversion
WTM: Wastewater Treatment and Sustainable Water Management.
SCC: Sustainability and Climate change

# WTM: Wastewater Treatment and Sustainable Water Management

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## Numerical analysis of fixed-bed adsorption columns for direct lithium extraction

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Lithium has emerged as a strategic resource in the context of the global energy transition. This alkali metal is found in continental brines, mineral ores (rocks), and seawater, with brines from salt lakes being the primary source, concentrating approximately 50% of global reserves [1]. Currently, solar evaporation is the main extraction method from brines, which results in the loss of up to 95% of the contained water, raising concerns about its impact on water sustainability [2,3]. In this scenario, Direct Lithium Extraction (DLE) technologies have emerged as an alternative to reduce water footprint, achieving recovery rates above 90% [4]. However, these technologies still face technical and economic challenges to ensure efficiency at an industrial scale. Among DLE methods, column adsorption stands out for its scalability, although its performance in lithium-rich brines remains understudied, and freshwater consumption for the process has yet to be resolved at scale. This study presents a numerical differential-scale analysis of the ion exchange process under transient conditions for lithium salt extraction, using Computational Fluid Dynamics (CFD) simulations. The analysis aims to characterize mass transport phenomena and the differential-scale concentration distribution within an adsorbent bed, in order to evaluate the dynamic performance of adsorption columns under varying operating conditions, including flow rate, concentration, and adsorbent bed properties.

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**Track:** WTM: Wastewater Treatment and Sustainable Water Management.
SES: Sustainable Energy Systems

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## Optimization of Synthesis and Evaluation of BiOCl/CuO Heterostructure for Photocatalytic Degradation of Pharmaceutical Micropollutants by Photocatalytic Ozonation.

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This study presents the optimization of the co-precipitation synthesis of the BiOCl/CuO heterostructure and its application in photocatalytic ozonation (PO) processes for the degradation of pharmaceutical micropollutants in water, such as paracetamol. The material was synthesized by varying the concentrations of CuO (0.1–1%) and polyvinylpyrrolidone (PVP) (0.05–0.15 g). The central composite design (CCD), implemented with MODDE PRO SOFTWARE, determined that the optimal conditions within the studied ranges were 0.22% CuO and 0.078 g PVP, synthesis conditions that maximize photocatalyst efficiency.

The characterization of the powdered materials obtained included techniques such as SEM and EDX, which confirmed the morphology and elemental distribution of copper and bismuth. In addition, techniques such as XRD, FT-IR, DRS, BET, and BJH were employed to evaluate the crystal structure, functional groups, as well as optical and textural properties of the obtained materials, particularly those obtained under optimal conditions. DRS analysis revealed a change in reflectance, indicating an increase in the generation of reactive oxygen species under simulated solar radiation. This improvement in photocatalytic activity is attributed to the combination of the semiconductor BiOCl (3.2-3.6 eV) and CuO (1.5-1.7 eV), which favors efficient separation of photoinduced charges.

Degradation tests of the target compound (paracetamol) showed an efficiency of 85.7% with the BiOCl/CuO + ozono ($O_3$)+ simulated solar radiation system, compared to 65.7% with BiOCl and 47.2% using ozone alone. These results confirm the potential of the PO system, utilizing BiOCl/CuO as an efficient catalyst for removing pharmaceutical micropollutants from water.

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**Track:** MEE: Materials for Energy and Environmental Applications
WTM: Wastewater Treatment and Sustainable Water Management.

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**Photodegradation Mechanism of Alizarin Dye on Fe, Co, Ni-Encapsulated Graphene/h-AlN: A DFT Study.**

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This study employs DFT computational methods at B3LYP-GD3(BJ)/def2svp level of theory to investigate the photodegradation potential of alizarin dye when interacting with Fe, Co, Ni encapsulated graphene/h-aluminum nitride hetero-structure surfaces (alz@FeGP_AlN, alz@CoGP_AlN, and alz@NiGP_AlN). Structural analysis of the optimized geometry revealed that alz@CoGP_AlN and alz@NiGP_AlN exhibit longer bond lengths ($N_{25}$-$Co_{104}$ = 4.71813 Å and $N_{25}$-$Ni_{104}$ = 2.04170 Å) compared to alz@FeGP_AlN ($N_{25}$-$Fe_{104}$ = 1.97341 Å), rendering them more susceptible to photodegradation. FMO analysis indicates that alz@CoGP_AlN and alz@NiGP_AlN exhibits higher reactivity than alz@FeGP_AlN with Eg values of 1.6776 eV, 0.9051 eV and 2.3005 eV respectively. NBO analysis reveals that alz@CoGP_AlN and alz@NiGP_AlN exhibit higher perturbation energies (E(2) = 558.59 kcal/mol) and (E(2) = 484.99 kcal/mol) with donor-acceptor transition from $\delta^* \; to \; \delta^*$ and $LP^* \; to \; LP^*$, demonstrating their susceptibility to photodegradation. NCI analysis demonstrated strong interactions due to steric repulsion spotted between the nanosheet and alizarin dye in alz@CoGP_AlN and alz@NiGP_AlN, indicative of their photodegradation potential. Adsorption energy indicates that alz@NiGP_AlN has the strongest binding of the adsorbate, with an $E_{ad}$ of -0.7451 eV making it the best candidate for photodegradation. Low BSSE values and negative solvation energies confirm the accuracy of the computational methods used. According to frank Condon principle, vertical excitations were observed with alz@NiGP_AlN having the highest excitation energy ranging from $S_0$-$S_1$ (1.0021 eV), $S_0$-$S_2$ (1.9872 eV) and $S_0$-$S_3$ (1.9973 eV) followed by alz@CoGP_AlN spanning $S_0$-$S_1$ (0.9971 eV), $S_0$-$S_2$ (1.7197 eV) and $S_0$-$S_3$ (1.7922 eV) making them more sensitive to UV light and likely to undergo photodegradation.

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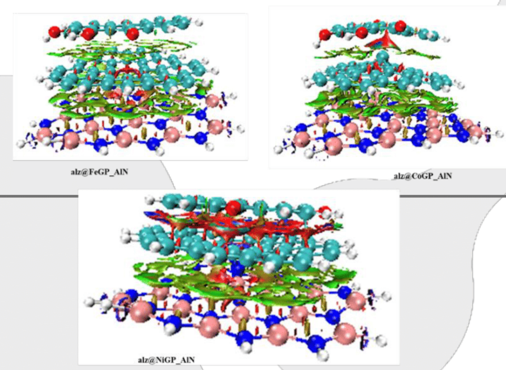


**Fig. 1**. Pictorial representation of Non covalent interactions in the systems

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**Track:** WTM: Wastewater Treatment and Sustainable Water Management.

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**Transient Numerical Analysis of Reject-Brine Reinjection from Direct Lithium Extraction: A Case Study in the Salar de Atacama Aquifer**

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Lithium has emerged as a critical metal to drive the energy transition due to its central role in battery manufacturing [1]. Chile holds one of the world's largest lithium reserves, approximately 31 % of the global total [2], primarily in salt flats, where lithium occurs dissolved in brines [2]. Conventional extraction via solar evaporation ponds entails losing 85 % to 95 % of the extracted water, which cannot be recovered in the process [3][4], thereby progressively depleting the regional hydrogeological system and disrupting fragile ecosystems [5]. As an alternative, direct lithium extraction (DLE) technologies aim to selectively recover lithium salts and then reinject most of the treated brine back into the salt flats. Yet the hydrogeological effects of reinjecting processed brines into endorheic basins remain an open question, as changes in density gradients may shift the saline interface and modify subsurface flow patterns. This study presents a transient numerical analysis of DLE reject-brine reinjection in the Salar de Atacama using OpenFOAM. The model accounts for brine density variability, local hydrogeological parameters, and multiple reinjection scenarios to assess their impact on groundwater flow distribution, mixing-zone migration, and concentration fields. These results are expected to inform projections of the hydrogeological impact and characterize potential shifts of the saline interface under different DLE reinjection regimes in Chilean salt flats.

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SCC: Sustainability and Climate Change
The final decision rests with the review committee, as the content may contribute to any of these tracks.

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**Estimating Water Demand for the Green Hydrogen Industry in Chile by 2040**

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Chile has an extensive coastline of 6,435 km, which allows it to have a reserve of seawater available to be treated by various technologies such as desalination. Likewise, Chile has been identified as one of the most competitive producers of lowest-cost green-hydrogen globally, starting in 2030. Although the country already has a national green-hydrogen strategy to accelerate deployment of this industry, which aims to install 25 GW of electrolysis capacity by 2030 and reach 188 GW by 2050, the volume of water it will require and the potential impacts remain uncertain. This work presents an estimation of the water demand of Chile's green-hydrogen industry by 2040, with the aim of providing information to assess the possible consequences of that demand and to discuss mitigation measures. Based on the green-hydrogen production for domestic use and export reported by the Long-Term Energy Planning (about 2,000 kton/year) [1] , we estimate water requirements for both electricity generation to power hydrogen production (between 0.002-0.017 m³ of water per kg of hydrogen) and for the electrolysis process itself (0.01 m³ of pure water per kg of hydrogen), including cooling water (up to 0.022 m³ of water per kg of hydrogen)[2]. These results are compared with current water use in other sectors—such as human consumption, agriculture, mining, and industry—in regions expected to host the highest levels of green-hydrogen production. Finally, assuming that the necessary water is obtained through seawater desalination, we identify the potential environmental and social impacts that could arise.

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**Track:** WTM: Wastewater Treatment and Sustainable Water Management.

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**Mining tailings for the treatment of wastewater from the Pisco production industry**

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The design of advanced, efficient, reusable and environmentally sustainable photocatalysts is essential to address the growing presence of persistent organic pollutants in wastewater. This study proposes an innovative approach through the synthesis of heterostructures based on BiOI and magnetic materials, using both synthetic magnetite and magnetic materials derived from mining tailings. This strategy transforms environmental liabilities into active supports, integrating the principles of circular economy and environmental remediation.

It was determined that a 6% weight proportion of the magnetic phase is optimal for forming heterostructures with high photocatalytic efficiency. The resulting materials were evaluated for the degradation of caffeic acid, a model contaminant of agro-industrial origin, under simulated solar radiation for 120 minutes. In particular, the heterostructure BiOI/MMA (tailing A) achieved a degradation rate above 89%, attributed to efficient charge separation, high active surface area, and well-integrated functional interfaces.

The BiOI/MMA material also showed excellent structural stability and magnetic recovery, maintaining its activity over several reuse cycles. Structural and magnetic analyses confirmed that the properties of the tailing-derived support influence the heterostructure's efficiency, highlighting the importance of proper characterization of these residues prior to their valorization.

This study provides concrete evidence on the technical feasibility of reusing mining waste as raw material in environmental decontamination technologies. The proposed approach contributes to the development of functional, sustainable, and scalable photocatalytic systems, reinforcing the synergy between water treatment, technological innovation and the circular economy.

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**Track:** WTM: Wastewater Treatment and Sustainable Water Management.

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**An experimental study of pressure drop for different fog collector meshes**

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Water scarcity is increasing concerns among the population, such as in northern Chile. Fog water collection rises as a promising idea for water collection. Fog collectors consist on a mesh that is installed in a way that fog passes through it harvesting water.

Mesh parameters, such as pressure drop, pressure drop coefficient, and permeability, are important because they determine the aerodynamic efficiency (AE) of the fog collector. Different type of meshes can be used for fog collection. Despite various type of meshes has been studied on literature, information of parameters on fog meshes and experiments measuring these parameters are almost nonexistent. These parameters are relevant because these could help in the decision-making of what type of mesh to use for different locations. Also, they are needed as input parameters to model the mesh behavior in computational fluid dynamics simulations, such as when using the porous jump model.

This study addresses this gap by conducting experiments in a wind tunnel with different types of meshes, estimating their shade coefficients (S), pressure drops at different velocities, pressure drop coefficients and permeability. As preliminary results, at velocity of 11 m/s, the double layer Raschel mesh ($S = 56.2\%$) generated a pressure drop of 106 Pa and a pressure drop coefficient of 1.406, meanwhile the monofilament ($S = 26.7\%$), for a velocity of 13 m/s, generated a pressure drop of 27 Pa with a pressure drop coefficient of 0.244. The AE estimated for the double layer Raschel mesh was 27%, meanwhile for the monofilament was 18%.

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**Track:**

**WTM: Wastewater Treatment and Sustainable Water Management.**

# POSTERS SUMMARY

5th Energy, Efficiency and Environmental Sustainability Conference 2025

# Physicochemical and Functional Properties of Poly(3-hydroxybutyrate) Bionanocomposites Reinforced with Clay, Biochar, and Essential Oils

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The use of biodegradable active materials is being explored as a strategy to reduce food loss and waste. The aim is to extend the shelf life of food and to ensure biodegradation when these materials are discarded. The utilization of biodegradable polymers remains limited due to their inherent properties and cost-effectiveness. An alternative approach involves the fabrication of bionanocomposites, which offer a potential solution to address these challenges.

The objective of this study is to develop new antioxidant materials with improved thermal and mechanical properties compared to PHB, using a mixture of PHB, biochar, clay, and essential oils (Tepa:Eugenol) through a solvent evaporation technique. The physicochemical (FTIR, surface wettability, TGA), morphological (FESEM) and functional (ABTS-DPPH) properties of the bionanocomposite and PHB films are evaluated.

The bionanocomposites exhibited higher WCA values (>71°) compared to PHB (68°), indicating enhanced hydrophobicity due to the porous and intrinsically hydrophobic nature of biochar. This feature contributes to improved compatibility with polymeric matrices. FTIR-ATR spectra confirmed the characteristic absorption bands of PHB, along with an additional band at 1511 $cm^{-1}$ attributed to eugenol, while the minimal variations in band intensity and position suggested only physical interactions among the components, in agreement with previous studies. Furthermore, bionanocomposites containing 3% (w/w) Tepa–eugenol (70:30) demonstrated strong antioxidant activity (≈99% ABTS, 94% DPPH), comparable to ascorbic acid. The antioxidant activity was independent of biochar concentration. Also, this result also confirms the stability of the essential oil mixture during the film formation process.

The PHB/biochar/clay/Tepa–eugenol bionanocomposite demonstrates its potential as a novel material for food packaging applications, particularly for products prone to oxidative degradation.

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**Track:** BMS: Bioprocess and Biomaterials for Sustainability

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## Development of a bifunctional catalyst based on residual brewer's yeast for the conversion of glucose to 5-hydroxymethylfurfural

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The recovery of agro-industrial waste such as brewer's spent yeast (BSY) represents a key strategy for the development of sustainable processes in the context of green chemistry and the circular economy. This research proposes the synthesis of bifunctional catalysts from carbonized BSY, functionalized with copper salts and organic acids (formic acid and p-toluene sulfonic acid) with the aim of promoting the conversion of organic acids into organic acids and organic acids into organic acids. The synthesis of bifunctional catalysts from carbonized BSY was carried out by adding copper salts ($CuCl_3$) and organic acids (formic acid and p-toluene sulfonic acid) to the carbonized BSY. The resulting catalysts were characterized by XRD, FTIR, and TGA. The catalytic activity of the catalysts (as a source of Lewis acid sites) and organic acids (formic acid and p-toluene sulfonic acid) to introduce Brønsted sites, with the aim of promoting the catalytic conversion of glucose to 5- hydroxymethylfurfural (5-HMF), a high-value platform molecule.

Three synthetic routes combining different sequences of chemical functionalization and thermal activation conditions (inert atmosphere or air, 300°C) were evaluated. Characterization of the BSY revealed a moisture content of 71.1%, carbon content of 47.5%, and nitrogen content of 9.5% on a dry basis, as well as a compact morphology with no visible pores. TXRF analysis showed a significant capacity of BSY without hydrothermal treatment to adsorb $Cu^{2+}$ (up to 56.5% removal in 120 min, 10% w/w), while FTIR and XRD confirmed the incorporation of oxygenated functional groups and the formation of metal oxides (CuO and $Cu_2O$).

Catalysts sulfonated with p-TsOH (1:1 ratio) and activated in an oxidizing atmosphere achieved the highest values for mass yield (43.3%), sulfur content (24.5 g/kg), and pore volume (1.415 $cm^3/g$). On the other hand, materials functionalized with formic acid showed a higher specific surface area (up to 238 $m^2/g$) .

These differences reflect the impact of the synthetic sequence and the functionalizing agent on the porous structure, thermal stability, and acid site density.

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**Track: BMS: Bioprocess and Biomaterials for Sustainability**

**Aerobic composting with goat manure to degrade ciprofloxacin waste**

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Proper disposal of household pharmaceutical waste is a global challenge, particularly in arid regions with limited economic resources and sanitation infrastructure. In these areas, com-posting with goat manure could offer an alternative for treating household pharmaceutical waste, especially antibiotics like ciprofloxacin, which are linked to microorganism resistance. In this study, we evaluated whether aerobic composting with goat manure promotes the bio-degradation of ciprofloxacin from household pharmaceutical waste. The experiment was conducted over seven weeks, during which environmental conditions, physicochemical parameters, and antibiotic concentration were monitored in 18 composting reactors. Data was analyzed using descriptive statistics, Kaplan-Meier curves, and a Cox proportional hazards analysis using R. The results indicated that the probability of achieving at least 70% CIP degradation increased over time, and under high concentration conditions (CIP=100 ppm), goat manure accelerated the risk of achieving 70% CIP degradation by nearly nine times. These findings suggest that using goat manure in aerobic composting could be a viable and low-cost strategy to reduce contamination from household pharmaceutical waste in arid regions with limited access to conventional treatment options.

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**Track:** BMS: Bioprocess and Biomaterials for Sustainability

5th Energy, Efficiency and Environmental Sustainability Conference 2025

# Optimization of LED Light Spectrum in Mizuna Microgreens: Energy Efficiency and Functional Quality in Vertical Farming Systems.

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Vertical farming (VF) has emerged as a key strategy to address the challenges associated with climate change, water scarcity, and food security. It enables year-round crop production through precise control of critical parameters such as temperature and artificial lighting, the latter representing the main source of energy consumption in these systems. Microgreens, young shoots with high nutritional value, are particularly well suited to this production model due to their rapid growth and low resource requirements. The objective of this study is to develop lighting strategies to reduce electricity consumption in mizuna microgreens (*Brassica rapa* var. *nipposinica*) cultivation systems. Different LED light treatments were evaluated to assess their influence on anthocyanin accumulation, biomass yield, and energy use efficiency. A multivariate experimental design was implemented with various combinations of spectra, intensities, and photoperiods. Anthocyanin content was determined using high-performance liquid chromatography (HPLC), while energy consumption was recorded in real time to estimate energy use efficiency (EUE). Preliminary results indicate that light intensity is the primary factor influencing both energy efficiency and nutritional quality in mizuna microgreens. This research aims to contribute to the development of sustainable lighting management strategies that simultaneously improve crop quality and energy performance, aligning with the sustainability goals demanded by the agriculture of the future.

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**Track:** EE: Energy Efficiency

## A Novel AuNPs/$Ti_3C_2T_x$ MXene Platform for Enhanced Electrochemical Detection of Guanine and Adenine

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**Abstract:**

A novel electrochemical biosensor platform is introduced for the simultaneous detection of DNA nucleotides guanine (GA) and adenine (AD). This biosensor uses a nanocomposite of gold nanoparticles (AuNPs) supported on $Ti_3C_2T_x$ MXene nanosheets. The unique layered structure and metallic properties of the synthesized $Ti_3C_2T_x$ MXene enable efficient immobilization of AuNPs, creating a highly effective sensing interface. Screen-printed carbon electrodes (SPEs) were modified with this AuNPs/$Ti_3C_2T_x$ MXene nanocomposite and tested for detecting purine bases using cyclic voltammetry (CV) and differential pulse voltammetry (DPV). The addition of $Ti_3C_2T_x$ MXene significantly increased the anodic peak currents and shifted the oxidation potentials of adenine and guanine to less positive values compared to unmodified electrodes. This shows improved electrochemical behavior toward the target analytes. Under optimized conditions, the DPV calibration curves displayed linear responses in the concentration ranges of 10-150 nM for guanine and 10-200 nM for adenine. Remarkably, low detection limits of 10 nM were achieved for both guanine and adenine. The biosensor's enhanced performance is attributed to the synergistic effects of the AuNPs/$Ti_3C_2T_x$ MXene nanocomposite, which benefits from a large specific surface area, excellent electrical conductivity, and inherent electrocatalytic properties. This innovative biosensor has significant potential for use in clinical diagnostics and nucleic acid analysis.

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**Track:** MEE: Materials for Energy and Environmental Applications

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**Boosting Energy Harvesting Performance of Highly Flexible PVDF-$Fe_3O_4$ Magnetoelectric Composites**

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The investigation into energy harvesting involves exploring a wide variety of unconventional energy sources, with a particular emphasis on capturing mechanical and magnetic energy from often overlooked areas. This innovative research aims to develop advanced nanogenerators that demonstrate exceptional flexibility and efficiency by utilizing poly(vinylidene fluoride)-magnetite (PVDF-$Fe_3O_4$) composites. These devices are specifically designed for use in self-powered and wireless sensor networks, which are crucial for the advancement of Internet of Things (IoT) applications. Initially, highly crystalline $Fe_3O_4$ nanoparticles were synthesized using a sol-gel technique, known for its ability to yield uniform and high-quality nanoparticles. These nanoparticles were then incorporated as fillers within the PVDF matrix, enhancing its electrical and mechanical properties. Detailed analyses utilizing X-ray diffraction (XRD) revealed a substantial presence of the ferroelectric β-phase in the PVDF composites, which was further enhanced by the addition of $Fe_3O_4$. Notably, the composite containing 10 wt% $Fe_3O_4$ displayed an impressive β-phase content of around 80%, critical for maximizing the piezoelectric properties essential for effective energy harvesting. Scanning electron microscopy (SEM) images showed a well-defined and uniform distribution of $Fe_3O_4$ fillers throughout the PVDF matrix, an important factor for achieving consistent performance and optimizing energy conversion efficiency. Additionally, vibrating sample magnetometry (VSM) analysis validated the ferrimagnetic properties of the composites. When exposed to mechanical tapping, the nanogenerator produced an output voltage of 15 V, highlighting its practical application potential. Additionally, the nanogenerator has shown the capability to charge various capacitors, highlighting its potential for use in self-powered, non-contact, and implantable devices.

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**Track:** MEE: Materials for Energy and Environmental Applications

5th Energy, Efficiency and Environmental Sustainability Conference 2025

**High-Temperature Fuel Cells for Decarbonizing Combined-Cycle Power Plants in Chile**

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Currently, there is a growing emphasis on researching new hydrogen technologies with the goal of producing clean electric power, thereby contributing to the reduction of global $CO_2$-equivalent emissions. To achieve carbon neutrality in Chile, it is essential to lower emissions in the energy sector, as this sector accounts for 75% of the country's $CO_2$-equivalent emissions. Thermal power plants that use hydrocarbons as a heat source generate large amounts of $CO_2$; therefore, the focus of this project is on these types of power plants. Theoretically, by integrating fuel cells (FCs), overall efficiency can be increased to values close to 80% with low $CO_2$ emissions when using green hydrogen. To successfully integrate FCs into a thermal power plant and adapt the process, it is necessary to develop models and analyze the viability and optimal operating point from a multidimensional perspective (technical, economic, and environmental). This will help assess the actual impact of technology and its integration into the green hydrogen value chain, with the aim of guiding public policy strategies regarding the potential use of green hydrogen.

The objective of this proposal is to establish a baseline for integrating high-temperature fuel cells—solid oxide (SOFC) and molten carbonate (MCFC)—as support or replacement for combustion systems in order to repurpose these plants. The analysis will focus on a case study: the Atacama combined-cycle thermal power plant.

The article will present representative integration schemes for incorporating these fuel cells into thermal plants, along with preliminary results from a thermodynamic and efficiency standpoint, compared to the baseline case. The intention is to demonstrate that thermal power plants can be repurposed by leveraging existing infrastructure and largely replacing combustion processes with high-temperature fuel cells. Acknowledgments:

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**Track:** SES: Sustainable Energy Systems

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**Synthesis of a high entropy alloy FeNiCoMnM (M=Cu, Cr) by mechanical alloying applied as a metallic support for MS-SOFC.**

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Solid oxide fuel cells (SOFCs) hold promise for generating power with low environmental impact. Still, their efficiency and durability are limited by the degradation of metallic support materials, such as ferritic steels and nickel-based alloys, which oxidize at high temperatures and generate corrosion products that deteriorate cell performance. This study investigates the effect of various control agents on the synthesis of an equimolar high-entropy alloy (HEA), FeNiCoMnM (M = Cu, Cr), produced through mechanical alloying, to develop a new metal support for SOFC.
The HEAs were synthesized by mechanical alloying in a PQ4 planetary mill using different control agents (stearic acid, n-hexane and n-heptane). The powders were characterized by X-ray diffraction (XRD) to identify the phases, scanning electron microscopy (SEM-EDS) to analyze morphology and composition, and particle size distribution by laser diffraction, as well as thermal analysis (DSC-TGA) to evaluate thermal stability in air and inert atmosphere.
The results showed that for FeNiCoMnCu with stearic acid, the FCC phase was obtained after 125 hours of milling time. In contrast, with hexane and heptane, the FCC phase is observed at 50 hours, without the presence of secondary phases. Notably, a wider particle size distribution was observed with heptane as the control agent, which is advantageous for the consolidation of metal powders used in metal-support applications.

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MEE: Materials for Energy and Environmental Applications

5th Energy, Efficiency and Environmental Sustainability Conference 2025

**Comparative Analysis of Conventional and Microwave Heating of Copper Slag for Thermal Energy Storage Applications.**

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In Chile, the annual curtailment of electricity from solar power plants has increased significantly in recent years, reaching 123% in 2024. This has driven the development of energy storage strategies such as thermal batteries, manufactured from industrial residues like copper slag. Conventional charging methods, based on electric resistance and forced convection, present limitations associated with long charging times and heat losses that reduce overall efficiency. As an alternative, microwave heating has emerged as a promising option, having demonstrated higher efficiency in various industrial processes. However, the electromagnetic interaction between copper slag and microwave radiation has not been extensively studied. Assessing this interaction is essential to determine the feasibility of integrating microwave heating as a charging method in thermal energy storage systems. This study aims to evaluate and compare the energy conversion efficiency of copper slag heating using microwave radiation versus conventional forced-air convection. The methodology involved heating slag samples in both a microwave-based and a conventional system. The microwave setup consisted of a $0.4 \times 0.3 \times 0.3$ m resonant cavity coupled to an array of 750 W magnetrons, as illustrated in Figure 1. The experimental design considered sample sizes ranging from 3 to 6 cm, heating durations from 5 to 15 minutes, and electric power inputs between 100 and 750 W. The results show that microwave heating reduced charging time by approximately 20% to 30%, depending on operating conditions. Moreover, conversion efficiency was consistently higher in the microwave system, particularly with larger sample sizes. This suggests microwave heating could be a viable charging alternative.

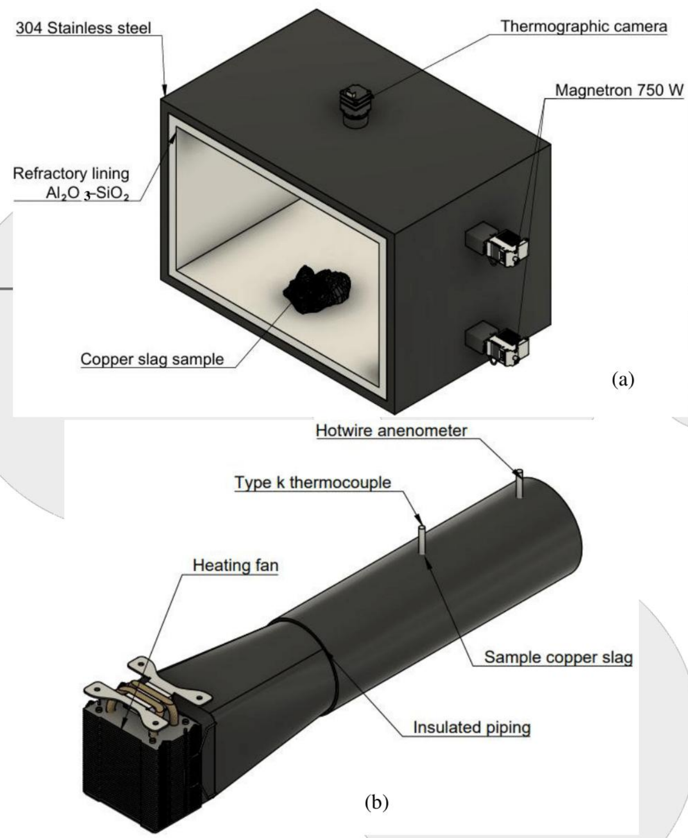


Figure 1. Schematic of the experimental heating system: (a) microwave and (b) conventional.

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## Design of High-Reliability Welds for Thermal Energy Storage Tanks in CSP systems

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This work addresses the vulnerability of welded stainless steel joints in thermal energy storage (TES) tanks used in concentrating solar power (CSP) plants. These components are exposed to high temperatures and molten salts, which promote the precipitation of $M_{23}C_6$ carbides, formation of σ-phase, and accumulation of residual stresses. These microstructural and mechanical changes can lead to damage mechanisms such as creep, low-cycle fatigue, and stress relaxation cracking (SRC), which remain insufficiently understood. This study proposes an improved welding procedure using ER 16-8-2 filler metal [1], which has a lower ferrite content and has shown reduced susceptibility to SRC and σ-phase formation compared to conventional E 347 consumables. The hypothesis is that this approach will produce a heat-affected zone (HAZ) with less degradation and lower residual stresses, thereby extending the service life of hot storage tanks. The experimental plan includes material characterization by X-ray diffraction, optical and SEM-EDS microscopy for microstructural analysis, and mechanical tests including tensile and creep behavior. Expected outcomes include a comparative microstructural evaluation of the HAZ and fusion zone, strength and ductility curves that demonstrate the superiority of the mixed welding route, and residual stress measurements that help explain the initiation of SRC under thermo-mechanical loading. Based on these results, metallurgical recommendations will be proposed to improve the reliability of molten salt TES tanks. This research aims to reduce design uncertainty and contribute original, high-value applied knowledge, providing preliminary guidelines for the safer design and operation of thermal storage tanks in CSP applications.

Preliminary results obtained during collaborative testing at UPC Barcelona support this proposal. Hot tensile tests at 570 °C on welded SS347H samples showed stable ductility with reduction of area values between 54–62%. After thermal aging at 750 °C for up to 200 h, ductile fracture behavior predominated, although signs of intergranular cracking appeared at longer exposures. These findings confirm the potential of ER 16-8-2 filler to improve welded joint stability under molten salt service conditions.

Me

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**Track:** MEE: Materials for Energy and Environmental Applications

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# Fabrication of Composite Material for Structural Applications Using Polymeric Waste and Oyster Shells from Northern Chile

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The accumulation of solid waste such as expanded polyethylene (PE) and scallop shells from northern Chile (SS) represents an environmental problem due to their low biodegradability and high ecological impact. This work presents the fabrication of a composite material for low-load structural applications, using recycled PE as a matrix and SS as reinforcement.

The experimental process was developed in three stages: (i) dissolution of PE in d-limonene as a green solvent, (ii) determination of the optimal matrix configuration through the evaluation of variables such as temperature, time, thickness, and compression, and (iii) fabrication of specimens with different proportions of PE and reinforcement, subjected to tensile tests.

Mechanical tests showed that the matrix reached an ultimate stress (Sut) of 3.6 MPa, while the incorporation of 10% SS as reinforcement increased this value to approximately 9.4 MPa, representing a 161% increase in strength compared to the matrix.

The results obtained in this study, when compared with other similar composites reported in the literature, show that, for example, Bello (2021) reported 10.64 MPa (+13%), Atuanya (2015) reached 19.4 MPa (+106%), and Farm (2022) described values of 32 MPa (+240%). These findings demonstrate that SS increases the strength of PE and can be used in industrial applications such as eco-friendly design prototypes and low-cost coatings, revalorizing waste and contributing to the circular economy.

Bello, S. A., Agunsoye, J. O., Hassan, S. B., Zebaze Kana, M. G. (2021). Eggshell nanoparticle reinforced recycled low-density polyethylene: A new material for automobile application. Journal of King Saud University – Engineering Sciences, 33(6), 406–414. https://doi.org/10.1016/j.jksues.2021.04.008

Atuanya, C. U., Ibhadode, A. O. A., Aigbodion, V. S. (2015). Empirical models for estimating the mechanical and morphological properties of recycled low density polyethylene/snail shell bio-composites. Journal of the Association of

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Farm, Y. Y., et al. (2022). Mechanical properties of eggshells powder reinforced recycled high-density polyethylene. IOP Conference Series: Materials Science and Engineering, 1217, 012003. https://doi.org/10.1088/1757-899X/1217/1/012003

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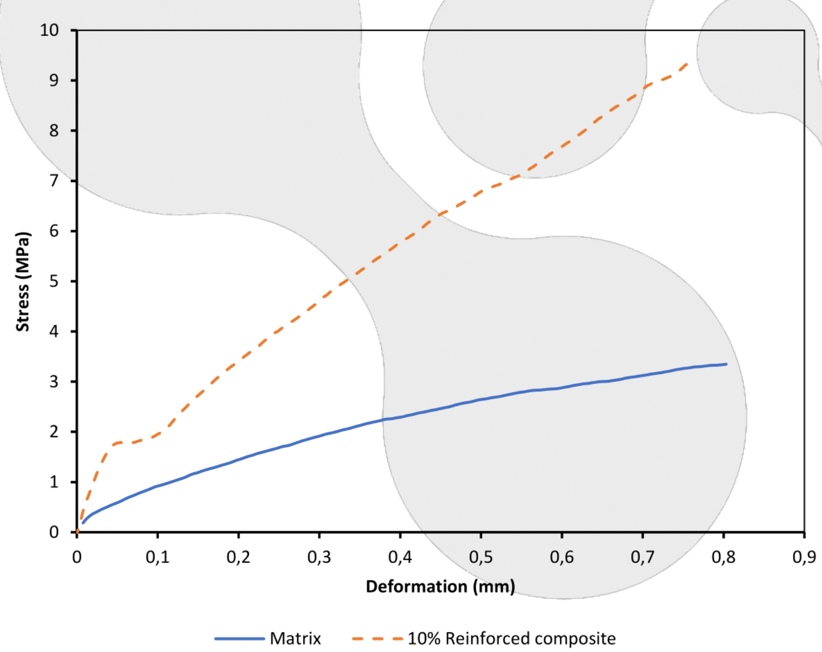


Figure 1. Comparison of stress–strain curves between the base sample without reinforcement and the sample with 10% scallop shells as reinforcement.

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**Synthetic zeolite modification for $CO_2$ capture: On the role of the compensation cations.**

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In this study, a synthetic ZSM–5 type zeolite was modified by an ion exchange procedure to study the effect of the compensation cations on $CO_2$ removal also from a gaseous stream. For such purpose, monovalent ($Na^+$ and $K^+$) and bivalent ($Cu^{2+}$ and $Zn^{2+}$) cations were transferred to the zeolite framework by an ion exchange procedure, as new compensation cations and compared to $NH_4^+$ cations present in the original zeolite for $CO_2$ removal. The physicochemical characterization developed verified the modification of the chemical composition of the zeolites as a consequence of the ionic exchange process using nitrates salts. SEM–EDS studies revealed the incorporation of the new compensating cations without modifying the zeolite morphology. Besides, nitrogen adsorption experiments verified that BET surface areas varied only slightly from 328 $m^2$/g (parent) to 274-317 $m^2$/g (exchanged), while pore volumes remained nearly constant at 0,135-0,163 $cm^3$/g. Additionally, FTIR experiments also confirmed that the zeolite functional groups remained after the modification process. Finally, adsorption experiments at 293 K revealed clear differences in $CO_2$ uptake. Langmuir maximum adsorption capacities (Qmax) were comparable across samples (105-106 mg/g), but the affinity constants (Kl) and Freundlich coefficients (Kf) highlighted the influence of the exchanged cations. Bivalent exchanged zeolites exhibited markedly higher $CO_2$ affinity (Kl = 0,133-0,128 $dm^3$/mg; Kf = 31,8-27,8 mg/g) compared with the parent and monovalent cation samples (Kl = 0,049-0,054 $dm^3$/mg; Kf = 9,8-10,7 mg/g), showing a preferential interaction of $CO_2$ with bivalent cations, enhances adsorption performance.

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**Track MEE**: Materials for Energy and Environmental Applications

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## Thermal Performance Assessment of a New Solid-State Energy Storage Material

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The search for new thermal energy storage materials is essential to advance efficient and competitive energy solutions, especially in applications such as solar concentration and process heat generation for industrial use. These materials must offer high thermal performance, operational stability, and low cost. Currently, solar salt (60% $NaNO_3$ – 40% $KNO_3$) is widely used [1], but presents operational limitations due to its high melting (221 °C) and crystallization (238 °C) points, which compromise system stability under thermal fluctuations. In this context, new formulations are being investigated to reduce costs and improve thermal performance [2].
This study presents a novel solid material with high potential for thermal energy storage, identified as A1. Its thermal behavior was evaluated through DSC (Differential Scanning Calorimetry) analysis up to 400 °C, with the aim of assessing its suitability as a thermal storage medium for industrial applications. The results show that material A1 exhibits no evident phase transitions or significant changes in its thermophysical properties up to 400 °C. Furthermore, cyclic tests, once the thermal history was removed, revealed a stable and homogeneous thermal behavior. These findings reinforce its potential as a solid-state thermal storage material, suitable for industrial applications within this temperature range, ensuring operational stability in systems that demand repetitive and consistent thermal cycles.

Complementary analysis performed by XRD confirmed that A1 is composed mainly of a single dominant phase (85.2%), with minor secondary phases. DSC cyclic tests demonstrated that the removal of thermal history results in homogeneous behavior across successive cycles, while a melting point of 801 °C was identified, which broadens its potential operating window beyond conventional nitrate salts. Compared to other solids investigated for TES, such as concrete [3], industrial waste salts [4], sands [5], and natural rocks like basalt and quartzite [6,7], which present limitations in thermal homogeneity and long-term stability, material A1 combines intermediate stability, absence of phase transitions up to 400 °C, and a wide operating margin. This originality reinforces its competitive potential as a sensible storage medium for CSP and industrial systems.

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**Track:** MEE: Materials for Energy and Environmental Applications

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**Iron-Doped Zeolite Modified Anodes as Advanced Materials for Enhanced Bioelectrochemical Energy Generation**

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Microbial fuel cells (MFCs) represent a promising technology for sustainable energy production while simultaneously treating wastewater. However, the efficiency of extracellular electron transfer (EET) remains a major limitation. This study evaluated the impact of carbon cloth anodes modified with iron-doped zeolite (ZA-Fe) on EET in electroactive biofilms to enhance current generation. Anodes were prepared using graphite and zeolite doped with varying iron concentrations (6%, 9%, and 15%), followed by characterization via scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS). Electrochemical activity was assessed using cyclic voltammetry (CV) and chronoamperometry (CA). Additionally, biofilm microbial communities were analyzed through high-throughput sequencing. Results demonstrated that the ZA-Fe 6% anode exhibited superior electrochemical performance, achieving a maximum current of 0.042 mA, ten times higher than the 9% modification. SEM images revealed more homogeneous and compact biofilm formation on the ZA-Fe 6% surface, promoting effective EET. Microbial community analysis indicated an enrichment of electroactive species such as Gammaproteobacteria and Clostridia, particularly under fumarate and ferric citrate enrichment conditions. These findings confirm that the strategic modification of anodes with iron-doped zeolite significantly enhances EET and current generation in MFCs. This approach provides a cost-effective and scalable strategy to improve MFC performance for energy recovery and environmental applications, contributing to more efficient bioelectrochemical systems aligned with circular economy and sustainability goals.

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**Optimization of Off-Grid Hybrid Renewable Energy Systems (HRES) with Wind–Solar Resources and Storage Using Genetic Algorithms: Impact of Temporal Complementarity**

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The transition toward more sustainable energy systems has driven the development of hybrid renewable energy systems, particularly those combining wind and solar resources with storage in off-grid or remote areas. However, the inherent variability and intermittency of these energy sources pose significant challenges to optimal system design. In this context, the temporal complementarity between solar radiation and wind speed emerges as a key factor for improving system reliability and reducing overall costs.

This work proposes a genetic algorithm-based optimization approach for the design of stand-alone wind–solar hybrid energy systems with storage, explicitly incorporating the analysis of temporal complementarity between renewable sources. The model aims to minimize the Net Present Cost (NPC) and the Loss of Power Supply Probability (LPSP), evaluating different complementarity scenarios based on representative hourly data.

The results show that greater temporal complementarity between wind and solar resources significantly reduces both the NPC and LPSP, enhancing the system's economic and operational efficiency. Furthermore, the findings demonstrate that the influence of complementarity becomes more pronounced under higher reliability requirements. These insights highlight the importance of including complementarity metrics as a technical criterion in energy planning and in the optimal design of stand-alone hybrid systems.

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**Track:** REC: Renewable Energy Conversion

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**Analysis of the electrical performance of a dye-sensitized solar cell through the incorporation of bacterial pigments applied as sensitizers**

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Studies have demonstrated the viability of using bacterial pigments applied to dye-sensitized cells (DSSC) as a promising option to replace traditional synthetic pigments, where performance depends on extraction conditions. This research evaluated the effect of pH variation on the extraction of pigment produced by the Antarctic bacterial strain *Streptomyces fildesensis*, with the aim of analyzing the optimal conditions for its application as a sensitizer in DSSCs. The pigment was extracted at pH 3 and 9 and subsequently characterized by UV-Vis spectroscopy. Electrical characterization was performed using a solar simulator under standard solar conditions (100 mW/cm$^2$, 1.5 AM, 25 ºC). Also, electrochemical impedance spectroscopy (EIS) was evaluated to determine the photovoltaic parameters and impedance characteristics of the cells. The results showed the best performance for the pigment extracted at pH 3, obtaining an efficiency of 0.0042 %, a voltage of 288 mV, a current density of 0.031 mA/cm$^2$, and a fill factor of 0.472. On the other hand, the EIS test showed that higher charge transfer resistance (Rp) suggests better adhesion of the pigment to $TiO_2$. This analysis demonstrates the importance of pigment extraction conditions, where pH modification directly influences cell performance, allowing functional devices to be obtained from pigments of biological origin.

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**Development of dye-sensitized solar cells based on *Aristotelia chilensis* pigments and iron oxide/biocarbon composite.**

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The integration of natural materials in the manufacture of dye-sensitized solar cells (DSSCs) has proven to be a promising option for the development of sustainable devices. In this context, this study evaluated the performance of a DSSC fabricated with anthocyanins extract from *Aristotelia chilensis* (maqui berry) as a sensitizer and an iron oxide/biochar composite material obtained from brewer's residue as a catalyst. The maqui berry pigment was evaluated based on its optical and electrochemical properties through UV-Vis and cyclic voltammetry. The iron oxide/biochar composite was obtained through thermochemical methods and characterized based on its physicochemical and electrochemical properties. The pigment showed maximum absorbance at 520 nm and an optical band gap of 2.6 eV. Electrochemical analyses revealed a HOMO-LUMO band of 1.73 eV, suitable for facilitating electron transfer to the semiconductor. The composite material showed a high carbon content and a mesoporous structure that favored adsorption thanks to its porosity. DSSC cells fabricated with both materials achieved an open-circuit voltage (Voc) of 484 mV and a conversion efficiency of 0.02%, results comparable to those reported for devices based on natural anthocyanins. This study validated the use of natural materials for the development of sustainable devices, promoting the valorization of waste in line with the circular economy.

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**Experimental and Comparative Evaluation of Vertical Axis Wind Turbines for Urban Applications**

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In recent years, computational modeling of wind potential in urban environments has emerged as a valuable complement to experimental wind measurement campaigns, enabling more accurate and localized characterization of wind resources. This synergy between simulation and experimentation paves the way for the short-term design and deployment of wind turbines optimized for complex urban conditions, with the goal of maximizing local distributed energy generation. This study presents an experimental analysis of the mechanical and electrical performance of a commercial five-blade vertical axis wind turbine operating on aerodynamic drag principles. Power curves were obtained as a function of the tip speed ratio (TSR), and electrical generation was evaluated under controlled conditions. Additionally, the effect of varying the number of blades on rotor performance was analyzed and compared to a reference H-Darrieus turbine model with straight blades operating on lift. The results highlight the advantages and limitations of each configuration in urban contexts, providing insights for the design of future small-scale wind energy systems.

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# Scalable Gas Sensors from Magnetron-Sputtered MAX/MXene Thin Films: Toward Energy-Efficient and Sustainable Solutions

m Amit Kumar Gangwar [1,2], Andreas Rosenkranz[1,2], Rodrigo Espinoza-González[1,2]

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**Abstract:** MXenes, a large family of emerging two-dimensional (2D) transition metal carbides, nitrides, and carbonitrides, have demonstrated significant potential in applications such as gas and humidity sensing, energy storage, water purification, and electromagnetic interference (EMI) shielding [1–4]. These materials are typically derived from MAX phases, a group of layered ternary compounds with the general formula $M_{n+1} AX_n$ (n = 1, 2, or 3), where M is an early transition metal, A is a group 13–14 element, and X is either carbon or nitrogen [6]. MAX phases exhibit a hexagonal structure composed of alternating MX and A layers.

In this study, we report a bottom-up fabrication method for the deposition and characterization of MAX and MXene thin films using magnetron sputtering, aiming at the development of miniaturized, high-performance gas sensors. $Ti_3AlC_2$ MAX phase thin films were deposited on Si substrates using DC magnetron sputtering with Ti, Al, C and Ti composite targets. Sputtering parameters such as power, working pressure, and gas flow rates were optimised to ensure phase purity and dense film growth. Post-deposition vacuum annealing improved crystallinity. Subsequent selective etching using hydrofluoric acid (HF) removed Al, producing multilayered $Ti_3C_2T_x$ MXene films.

X-ray diffraction (XRD) confirmed the formation of MAX and MXenes phases. Surface characterization using Scanning Electron Microscopy (SEM), Atomic Force Microscopy (AFM), and thickness measurements revealed smooth, layered morphologies, while Raman spectroscopy identified surface terminations such as –OH, –F, and –O. Interdigitated electrodes were patterned for gas sensing, and resistance changes were monitored upon exposure to $NH_3$, $NO_2$, and $H_2S$. The sensors showed fast response/recovery times, high sensitivity, and excellent repeatability, attributed to the large surface area and high conductivity of the MXenes layers [4-6].

This bottom-up fabrication approach offers a scalable and energy-efficient route to develop next-generation gas sensors. The use of magnetron sputtering not only supports uniform thin film deposition but also aligns with sustainable manufacturing goals. By combining high-performance sensing with environmentally conscious processing, this work contributes to the advancement of eco-friendly sensor technologies suitable for large-scale deployment.

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## Sustainable structural lightweight concrete using plastic waste aggregates and nanotechnology: A path to green construction

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Concrete is the most widely used construction material due to its compressive strength, durability, and low cost. However, its high thermal conductivity (0.8–1.7 W/mK) limits its energy efficiency, which poses a challenge in the current context of sustainable construction. This study presents an innovative approach that combines the partial replacement of natural fine aggregates with plastic waste such as recycled polyethylene terephthalate (RPET). Additionally, the incorporation of a nanoadditive with various types of nanomaterials aims to enhance the thermal performance without compromising the mechanical strength.

Mixtures were prepared by replacing natural sand with RPET in increments of 15%, ranging from 0% to 100%, with and without the incorporation of the nanoadditive. The results show that incorporating RPET reduces the density and mechanical strength but enables a significant decrease in thermal conductivity of up to 75% compared to the control (see Figure 1). Conversely, the incorporation of nanoadditives improved the workability and partially recovered the mechanical performance, reaching a compressive strength increase of up to 22% with nanosilica (NS) and 12% with multi-walled carbon nanotubes (MWCNT) compared to the control sample (see Figure 1(b)). Microstructural analysis revealed the homogeneity and stability of the dispersion, as well as an adequate aggregate–matrix interface in nanoparticle-doped samples.

The synergy between RPET and nanoadditives presents a viable pathway in the construction sector for developing lightweight structural concretes with enhanced thermal insulation, thereby supporting more energy-efficient buildings with a reduced environmental footprint, leading to greener construction.

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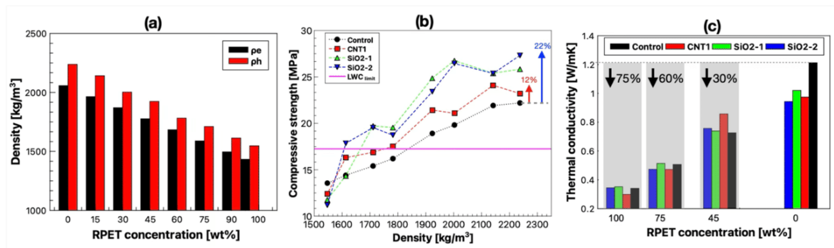


*Figure 1: (a)Physical; (b)Mechanical and; (c) Thermal performance of the HLEN samples.*

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**Track:** SCC: Sustainability and Climate Change

**LCA for Literature Review in Seashell Waste**

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The construction industry is exploring alternative materials to mitigate environmental impacts linked to the extraction and processing of conventional aggregates and cement. Mussel shells, a by-product of the aquaculture and food industries, present a promising solution due to their chemical similarity to limestone and their potential to improve concrete and mortar properties. This study conducts a systematic literature review and life cycle assessment (LCA) of seven scientific articles involving the use of mussel shells in concrete and mortar mixes. Following the PRISMA methodology, the environmental impacts were evaluated using the ReCiPe 2016 Midpoint method within SimaPro software, covering stages from shell collection to end of life. The results indicate that the pretreatment and transport stages contribute most significantly to environmental impacts, particularly in categories such as terrestrial ecotoxicity (TETP) and global warming potential (GWP). Despite variations in methodology, replacement ratios, and applications, the use of mussel shells demonstrates clear environmental advantages, especially in non-structural applications. This analysis supports the viability of incorporating mussel shells in construction materials as part of a circular economy strategy.

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**Track:** SCC: Sustainability and Climate Change

**Systemic Transition Pathways of Circular Business Models in Chile's Construction Sector**

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For more than a decade, circular economy (CE) has been a key concept behind the emergence of new business models. This study examines the emergence of circular business models (CBMs) in Chile's construction sector, a traditionally linear and fragmented industry. Drawing on 50 documented initiatives and 13 semi-structured interviews, we analyze the evolution of recovery, design, and use-based CBMs using a multi-level transition framework. Chile's construction sector is undergoing an early transition phase, where circular innovations are gradually incorporated without displacing the dominant regime. Findings indicate a differentiated reconfiguration pathway: recovery-based models gain traction due to regulatory and stakeholder alignment, while design- and use-based models face structural and institutional constraints. By combining insights from sustainability transition theory and business model innovation, this research offers a framework to understand how context shapes circularity pathways and highlights actionable implications for scaling circular practices in high-impact sectors through targeted institutional and organizational strategies.

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**Thermoeconomic assessment of poultry litter valorization for heat and power generation**

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[The steady growth of the poultry industry has led to the significant accumulation of organic waste, particularly poultry litter (PL), which, if improperly managed, can cause serious environmental impacts. This work evaluates a sustainable alternative for the energy recovery of PL through a combined heat and power system based on the co-combustion of PL and natural gas. A thermoeconomic model is developed to assess system performance from energy, exergy, and exergoeconomic perspectives, considering three typical PL compositions to evaluate their effect on system indicators. Results show that increasing the PL proportion in the fuel mixture can reduce the specific exergy cost of the product by up to 57%, representing a substantial improvement in the sustainability of the process, although at the expense of energy efficiency. The study also identifies the relevant impacts of PL composition on performance indicators, with variations of up to 16% in exergy cost and 8 percentage points in energy efficiency. This research highlights the potential of PL as a renewable energy source and promotes circular economy strategies in agro-industrial systems by transforming a problematic waste into a valuable resource. The methodology applied allows the identification of operating conditions that enhance the energy and economic recovery of this type of waste, contributing to the transition toward more sustainable systems.]

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**Track: SES**: Sustainable Energy Systems

**Understanding the main drivers of cloud evolution to support solar energy applications in coastal regions**

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The diurnal dynamics of coastal stratocumulus (Sc) clouds pose significant challenges to their predictability, particularly due to their thinning and fragmentation during morning hours, which induces abrupt fluctuations in incident solar radiation on photovoltaic (PV) systems. These variations result in transient energy deficits that can disrupt inverter performance, with variability occurring across timescales ranging from minutes to hours (Luccini & Rivas, 2021). These clouds typically form overnight, undergo thinning at sunrise, and eventually dissipate through fragmentation, with dissipation times modulated by initial cloud thickness, surface heat fluxes, and marine boundary layer dynamics.

A critical aspect lies in the fact that the response dynamics of each variable (radiation, turbulence, precipitation) are distinct and nonlinear, significantly increasing the complexity of modeling and forecasting. The interactions among these elements and their differential sensitivity to initial conditions further complicate the prediction of cloud behavior. Given that their radiative effects are comparable in magnitude to those of increasing greenhouse gases, their study is essential for climate change research (Zamora Zapata et al., 2019).

This study presents the effects of Sc on the available solar resource in Antofagasta, Chile. We employ advanced mathematical techniques, including Convergent Cross Mapping (CCM) and advanced statistical techniques, to analyze causal relationships and the nonlinear dynamics underlying Sc behavior. The methodology seeks to quantify how multiple temporal scales and asymmetric variable responses influence predictability, ultimately providing key insights to enhance solar energy management in coastal regions.

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**Photocatalytic Degradation of Naproxen in Aqueous Medium Using $MoO_3$/CuO and $MoO_3$/$Fe_2O_3$-Based Semiconductor Composites**

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We propose the synthesis of pure $MoO_3$ films and $MoO_3$ films loaded with $Fe_2O_3$ and/or CuO at different concentrations (1.0, 3.0, and 5.0 mol%) using a low-cost and easy-to-handle photochemical method. The photo-deposited films on silicon were annealed at 600 °C and subsequently characterized using surface analysis techniques such as XRD, XPS, SEM-EDS, and Raman spectroscopy. The results demonstrated uniform deposits and the presence of an orthorhombic crystal system of $MoO_3$ for the pure samples, as well as a monoclinic $Fe_2(MoO_4)_3$ phase and a triclinic $CuMoO_4$ phase in the samples loaded with $Fe_2O_3$ and CuO, respectively. The evaluation of the optical properties of the samples revealed a reduction in the band gap and a decrease in photoluminescent emission as the $Fe_2O_3$ or CuO loading in the $MoO_3$ matrix increased.

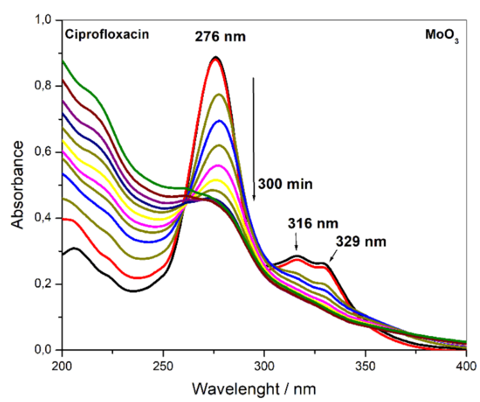


Fig. 1. Monitoring UV–Vis Spectra for degradation of ciprofloxacin solution with $MoO_3$ film

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The evaluation of its photocatalytic properties was carried out using ciprofloxacin as a contaminant in aqueous solutions, employing a UV-Vis lamp as the light source. As a representative example, Fig. 1 shows the spectra of a ciprofloxacin solution at different irradiation times in contact with the pure $MoO_3$ photocatalyst.

Preliminary results have shown that $MoO_3$ samples loaded with $Fe_2O_3$ or CuO exhibit higher efficiency than the pure sample, achieving 65% degradation of the drug for the $MoO_3$ sample loaded with 3 mol% $Fe_2O_3$, in contrast to 45% degradation observed for the pure $MoO_3$ sample.

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**Track:** WTM: Wastewater Treatment and Sustainable Water Management.

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## Upcycled Hybrid Ultrafiltration Membranes Incorporating Aquaporin Z and IPNs for Selective Ion Removal from Groundwater

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Groundwater represents a vital alternative water source but often contains high levels of dissolved ions that exceed drinking water standards. Although commercial nanofiltration membranes offer effective rejection, their high cost and energy requirements limit their application in decentralized settings. Thus, developing low-pressure, cost-effective membranes capable of selective ion removal remains a significant challenge. In this work, we developed a modification strategy for commercial and recycled ultrafiltration membranes by incorporating aquaporin Z (AqpZ)-based proteoliposomes using an interpenetrating polymer network (IPN). Recycled reverse osmosis membranes were regenerated to produce UF support with a molecular weight cut-off of approximately 33 kDa. The IPN method enabled stable immobilization of proteoliposomes and improved surface uniformity and hydrophilicity. Modified membranes initially showed moderate ion rejection in stirred-cell tests, with lower chloride and hardness removal. However, crossflow experiments using real groundwater demonstrated improved multivalent ion rejection, achieving 99.4 ± 0.5 % for iron, 99.3 ± 0.0 % for manganese, 52.5 ± 4.0 % for sulphate, and turbidity reduction below 0.1 NTU. Chloride rejection remained lower (37.6 ± 7.8 %), resulting in permeate concentrations near WHO limits. The permeate flux of the recycled membranes was lower than that of NF270 (74.1 ± 16.7 vs. 129.5 ± 18.7 L m-2 h-1), yet fouling assays confirmed comparable final normalized fluxes and faster stabilization behavior. These results demonstrate the potential of integrating AqpZ and IPN layers into recycled membranes to create sustainable, low-energy solutions for groundwater desalination in decentralized and resource-limited contexts.

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