AIH2RE

ANÁLISIS E IMPULSO DEL H2 RENOVABLE EN LA REGIÓN POCTEP
ANÁLISE E PROMOÇÃO DO H2 RENOVÁVEL NA REGIÃO POCTEP

RESUMEN PRODUCCIÓN CIENTÍFICA ACTIVIDAD 3.

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1. Alcance del entregable

Este entregable (E3.4) forma parte de la actividad 3.2 – "Validación de modelos y estrategias de gestión y operación desarrolladas para los sistemas de hidrógeno renovable".

A continuación, se recogen los principales resultados publicados en congresos, revistas u otras comunicaciones científicas vinculado con la actividad 3.

Estas comunicaciones abarcar investigaciones sobre tecnologías críticas tratadas en el proyecto como son:

- Investigación en electrólisis y otros métodos de producción de hidrógeno.
- Investigación en MEAS (pilas de combustible PEMFC).
- Investigación en purificación de corrientes gaseosas.
- Investigación en almacenamiento de hidrógeno en boruros.

2.Producción científica.

Investigación en electrólisis y otros métodos de producción de hidrógeno

Título	"TECNOLOGÍAS DE ELECTRÓLISIS DEL AGUA: FUNDAMENTOS, AVANCES Y DESAFIOS EN LA PRODUCCIÓN DE HIDRÓGENO"
Autores	Eduardo López (1), Miguel Ángel Ridao (2), María José Lavorante, Carlos Bordons (2), Rosa Rengel (1), Jordi Renau (INTA, US)
Medio	Capítulo del libro "LA ECONOMÍA DEL HIDRÓGENO EN IBEROAMÉRICA", editado por la Red H2TRANSEL del Programa CYTED -Área Energía (ISBN: 978-84-15413-72-1)
Abstract	Los electrolizadores, en particular, los de membrana de intercambio de protones y los alcalinos, son fundamentales para avanzar en la producción de hidrógeno bajo en emisiones en el contexto de la transición energética. Estas tecnologías aprovechan la electricidad renovable para dividir el agua en hidrógeno y oxígeno, ofreciendo una alternativa sostenible a los combustibles fósiles. Los electrolizadores con membrana de intercambio de protones, conocidos por su alta eficiencia y tiempos de respuesta rápidos, son considerados cruciales para integrar fuentes renovables como la eólica y la solar en la red. Sin embargo, su escalabilidad comercial enfrenta desafíos, incluidos los altos costos relacionados con los catalizadores escasos, como el iridio, y problemas de durabilidad que afectan la eficiencia a largo plazo. Los electrolizadores alcalinos, aunque tienen un costo de capital más bajo, suelen enfrentar limitaciones en el rendimiento, bajo altas corrientes y pueden sufrir una menor eficiencia a gran escala. En este capítulo se plantean los retos vinculados con las pérdidas energéticas, derivadas de resistencias eléctricas, de transporte y electroquímicas, así como las irreversibilidades inherentes al proceso. Se presenta la relevancia de los materiales críticos en la innovación y el desarrollo de estas tecnologías, con el objetivo de satisfacer la creciente demanda proyectada para los próximos años. Se abordan los desafíos asociados, incluyendo su limitada disponibilidad, el impacto ambiental y social de su extracción y procesamiento, y la vulnerabilidad de los países sin reservas propias. Asimismo, se examinan estrategias de gestión como el reciclaje y reutilización de materiales, la investigación en alternativas más sostenibles y la optimización de procesos tecnológicos para minimizar su uso. Finalmente, se presentan estrategias de operación para electrolizadores dedicados a la producción de hidrógeno renovable, que requiere de soluciones innovadoras que aborden la variabilidad inherente de las fuentes de energía sostenibles.

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Título	"Hybridization of water electrolysis and biomass gasification for renewable hydrogen production"
Autores	Eduardo López González (1), Diego Tejada Guzmán (1), Adrián Castro Calero (1), Alberto Monterroso Muñoz (1), Bruna Rijo (2) (INTA, IPP)
Medio	13. European Conference on Renewable Energy Systems (ECRES 2025)) – Perugia (Italia) 26-27 mayo 2025.
Abstract	Biomass gasification is a mature technology that produces renewable hydrogen and other products in a controlled process using heat and a gasification medium, typically air, steam or oxygen. The main product of biomass gasification is a mixture of gases, called synthesis gas or syngas, whose composition and calorific value depend on, among other factors, the feedstock and the gasifying agent. Typical components of such syngas are carbon monoxide, hydrogen, methane, nitrogen (especially when air is used as the gasification agent), carbon dioxide, other lighter hydrocarbons and traces of heavier hydrocarbons, etc. The syngas can be used directly as fuel, to produce renewable fuels or for the production of hydrogen after a purification process. On the other hand, water electrolysis is a well-established route to produce hydrogen from renewable sources, using electricity to split the water molecule into hydrogen and oxygen using different technologies (alkaline, proton exchange membrane, anion exchange membrane or solid oxide electrolysis). The present study will assess the technical and economic feasibility of integrating both technologies, biomass gasification and water electrolysis, in a hybrid plant for different applications, including the production of a hydrogen-rich synthesis gas for renewable fuel production and the production of pure hydrogen for use in fuel cells. The analysis will consider the appropriate sizing of the gasification and electrolysis plants and purification requirements, as well as the potential use of oxygen from electrolysis in the gasification process and CO2 captured in the purification process in the production of renewable fuels.

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Título	"Mathematical modelling and experimental simulation of an AEM electrolyzer system"
Autores	Alberto Monterroso Muñoz (1), Eduardo López González (1), Miguel Ángel Ridao Carlini (2), Diego Tejada Guzmán (1), Adrián Castro Calero (1) (INTA, US)
Medio	13. European Conference on Renewable Energy Systems (ECRES 2025)) – Perugia (Italia) 26-27 mayo 2025.
Abstract	Anion Exchange Membrane (AEM) electrolysis is a relatively recent technology that is gaining popularity due to its technical advantages over traditional alkaline electrolysis and its closer similarities to Proton Exchange Membrane (PEM) electrolysers. Both AEM and PEM technologies hold significant potential to address future integration challenges in renewable energy systems for green hydrogen production. However, research on AEM is still very limited. In this work, an Anion Exchange Membrane water electrolyser (AEMWE) model has been implemented to simulate the electrochemical properties under both steady-state and transient scenarios. The proposed AEMWE electrochemical model integrates the stack voltage, hydrogen production and efficiency simulations based on a classical parametric approach on the MATLAB-Simulink software. This implementation is supported by the existing advancements on electrochemical models from Proton Exchange Membrane (PEM) electrolysers, which serves as a starting point for developing a novel AEMWE simulation tool leveraging fundamental principles common to both technologies. Furthermore, this model has been validated with up to 65 hours of experimental data based on a 2,4 kW commercial AEM electrolyser. Finally, the proposed model has the potential to effectively simulate and control green hydrogen production based on AEM electrolysis under real-word conditions for improved performance and interpretability.

Título	"Renewable Hydrogen Production through the Purification of Syngas into Metal Hydrides in an Integrated Electrolysis and Biomass Gasification Plant"
Autores	E. López, A. Castro and D. Tejada (INTA)
Medio	23rd International Conference on Renewable Energies and Power Quality (ICREPQ'25) - Tenerife (Spain), 25 -27 junio 2025.
Abstract	Hydrogen produced from renewable sources will play a pivotal role in the transition to a decarbonized economy, in particular in the transportation and industrial sector. However, this pathway faces several challenges in terms of cost, efficiency, lifetime, etc. Several technologies can be used to produce renewable hydrogen. Among them, water electrolysis and biomass gasification offer a high level of maturity, and their integration can improve the availability of hydrogen from renewable sources, reducing the impact of fluctuating sources, such as solar or wind, while offering the possibility of supplying not only hydrogen, but also other valuable products for biofuel production. This integration requires the implementation of suitable purification methods to extract the hydrogen from the syngas produced in the gasification process. This work presents an experimental purification facility for syngas using metal hydrides based on a FeTi alloy. The evaluation of this facility will analyse, after successive loading and unloading cycles, the purity of the gas obtained, the CO2 and CO absorption capacity of the hydrides, the lifetime of this system in terms of number of cycles, the regeneration capacity, the total energy efficiency of the process, etc. Preliminary results of this evaluation will be presented at the congress.

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Título	"Experimental Analysis and Modelling of an AEM Electrolyzer"
Autores	A. Monterroso-Muñoz (1), E. López-González (1), M. Ridao (2), D. Tejada (1) and A. Castro (1) (INTA, US)
Medio	23rd International Conference on Renewable Energies and Power Quality (ICREPQ'25) - Tenerife (Spain), 25 -27 junio 2025.
Abstract	Anion Exchange Membrane (AEM) electrolysis is a relatively recent technology that is gaining popularity due to its technical advantages over traditional alkaline electrolysis and its closer similarities to Proton Exchange Membrane (PEM) electrolysers. Both AEM and PEM technologies hold significant potential to address future integration challenges in renewable energy systems for green hydrogen production. However, research on AEM is still very limited. To address this issue, a comprehensive experimental analysis based on a variety of test scenarios has been conducted on a 2,4 kW commercial AEM electrolyser. The proposed test benches cover a range of conditions, from steady-state operation at various power levels to demanding dynamic and transient scenarios, including photovoltaic energy tests. Furthermore, an experimentally validated Anion Exchange Membrane water electrolyser (AEMWE) model has been implemented to simulate the electrochemical properties under these test conditions. The proposed AEMWE electrochemical model integrates the stack voltage, hydrogen production and efficiency simulations based on a classical parametric approach on the MATLAB-Simulink software. Consequently, the proposed experimental analysis and model validation has the potential to successfully simulate and control green hydrogen production based on AEMWE technology under real-word conditions, thus providing greater clarity in this field.

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Título	"Optimization of operating strategies in PEM and AEM Multi-Stack Electrolyzers for renewable hydrogen production"
Autores	E. López González (1), A. Monterroso Muñoz (1), M.A. Ridao (2), D. Tejada Guzmán (1), J. Renau, F. Isorna Llerena (1), C. Bordons (2), V. García Peñas (INTA, US)
Medio	17th International Green Energy Conference (IGEC-XVII) & 6th International Conference on Energy and AI. (IGEC2025) Reikiavik (Islandia) 12-15 octubre 2025.
Abstract	The intermittent nature of main renewable energy sources has a significant influence on the operating conditions of electrolyzers for renewable hydrogen production, in particular when they are directly coupled with these variable sources. Relevant Key Performance Indicators (KPIs) of water electrolysis-based renewable hydrogen production systems, such as the amount of produced hydrogen, efficiency, durability and cost are directly related to these operating conditions. A typical approach in electrolyzers is to use a modular and flexible architecture based on several stacks, to improve the overall system energy efficiency and extend their lifetime. Water electrolysis requires direct current (DC) electricity to split water molecules into hydrogen and oxygen. Commercial electrolyzers are usually connected to alternating current (AC) grids, so AC/DC converters, or rectifiers, are required to supply power to the stacks. Depending on the number of stacks, they can be connected in series to a single rectifier, which manages the operating conditions of all the stacks in the chain. Moreover, these chains can be connected in parallel, to increase the flexibility of the operation and their adaptation to variable power supply conditions, at the cost of increasing the complexity of the control system needed to manage the entire operation. Different control strategies can be applied to the individual stacks and the AC/DC converters to optimize the global performance of the system. These strategies mainly consider the allocation of the available power among stacks and chains, as well as the on-off switching of individual stacks and chains. Power allocation will be evenly shared among the operating stacks in a chain, but the power allocated to each chain could be different, set by the rectifier. Among the available water electrolysis technologies, Proton and Anion Exchange Membrane (PEM and AEM) electrolysis offer a suitable dynamic response and transient times regarding their integration with renewable energy sources. This work addresses the simulation and experimental validation of different operating strategies for three multi-stack systems based on different technologies and number of stacks: • Four PEM stacks with one (four stacks in series) and four AC/DC converters (one per stack).

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	• Two AEM stacks (each with its own AC/DC converter) • A hybrid configuration based on two PEM stacks (one AC/DC converter) and one AEM electrolyzer (with its own rectifier). All these configurations are based on commercially available PEM stacks and AEM electrolyzers, with total nominal power in the range of 4.8 – 5.6 kW. The proposed strategies dynamically distribute power demand among the stacks, according to different criteria: maximum hydrogen production, maximum operating efficiency and minimum degradation. Electrochemical properties such as current demand, stack voltage stability, and faradaic efficiency have been addressed in appropriate PEM and AEM models to assess the system response to fluctuating renewable energy inputs. The performance evaluation of each multi-stack system is conducted through multiple test scenarios, including representative real-word solar profiles, showing a stable operation even under highly dynamic weather conditions. The simulation results will facilitate the identification of the most promising operating strategies, which will be validated experimentally.

Título	"Integration of biomass gasification and water electrolysis plants for renewable fuels production"
Autores	E. López (1), D. Tejada (1), A. Castro (1), B. Rijo (2), C. Mateos-Pedrero (2), P. Brito (2), M. A. Ridao (3), F. J. Pino (3) and J. I. Domínguez (4) (INTA, IPP, US, CIDAUT)
Medio	European Hydrogen Energy Conference. (EHEC 2026) – Sevilla 11-13 marzo 2026
Abstract	Water electrolysis is a well-established route to produce hydrogen from renewable sources, using electricity to split the water molecule into hydrogen and oxygen using different technologies (alkaline, proton exchange membrane, anion ex-change membrane or solid oxide electrolysis). On the other hand, biomass gasification is a mature technology that produces renewable hydrogen and other products in a controlled process using heat and a gasification medium, typically air, steam or oxygen. The main product of biomass gasification is a mixture of gases, called synthesis gas or syngas, whose composition and calorific value depend on, among other factors, the feedstock and the gasifying agent. Typical components of such syngas are carbon monoxide, hydrogen, methane, nitrogen (especially when air is used as the gasification agent), carbon dioxide, other lighter hydrocarbons and traces of heavier hydrocarbons, etc. The syngas can be used directly as fuel, to produce renewable fuels, or hydrogen gas after a purification process. The present study will assess the technical and economic feasibility of integrating both technologies, biomass gasification and water electrolysis, in a hybrid plant for different applications, including the production of a hydrogen-rich synthesis gas for renewable fuel production and the production of pure hydrogen for use in fuel cells. The analysis will include a simple modelling of the integrated plant, evaluating the appropriate sizing of the gasification and electrolysis systems and purification requirements, as well as the potential use of oxygen and heat from electrolysis in the gasification process.

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Título	"Simulation and experimental validation of operating strategies for renewable hydrogen production in PEM and AEM multi-stack electrolyzers "
Autores	E. López (1), A. Monterroso (1), M.A. Ridao (2), D. Tejada (1), J. Renau, F. Isorna (1), C. Bordons (2) and V. García (INTA, US)
Medio	European Hydrogen Energy Conference. (EHEC 2026) – Sevilla 11-13 marzo 2026
Abstract	The intermittency of renewable energy sources strongly affects the operating conditions of directly coupled electrolyzers for hydrogen production. Relevant Key Performance Indicators (KPIs) of water electrolysis-based renewable hydrogen production systems, such as the amount of produced hydrogen, efficiency, durability and cost are directly related to these operating conditions. Electrolyzers benefit from modular and flexible architectures that enhance energy efficiency and extend operational lifetimes. Commercially available electrolyzers require AC/DC converters to supply power to the individual stacks or assembly of them. Depending on the number of stacks, they can be connected in series to a single rectifier, which manages the operating conditions of all the stacks in the chain. These chains are usually connected in parallel to increase the flexibility of the operation with variable power supply conditions, increasing on the other hand the complexity of the control system. Several strategies can be applied to the management of individual stacks and the AC/DC converters to optimize the whole performance of the system. These strategies mainly consider the allocation of the available power among stacks and chains, as well as the on-off switching of individual stacks and chains. Among the available water electrolysis technologies, Proton and Anion Exchange Membrane (PEM and AEM) electrolysis offer a suitable dynamic response and transient times regarding their integration with renewable energy sources. This work addresses the simulation and experimental validation of suitable operating strategies for three multi-stack systems based on different technologies and number of stacks.

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Título	"Experimental validation of operational strategies and decision support tools for renewable hydrogen production in PEM and AEM multi-stack electrolyzers"
Autores	E. López (1), A. Monterroso (1), M.A. Ridao (2) and D. Tejada (1) (INTA, US)
Medio	Hyceltec 2026 - X Symposium on Hydrogen, Fuel Cells and Advanced Batteries- Alicante 8-11 junio 2026
Abstract	The intermittency of renewable energy sources strongly affects the operating conditions of electrolyzers for hydrogen production, when they are directly coupled to renewable energy generation plants. Relevant Key Performance Indicators (KPIs) of water electrolysis-based renewable hydrogen production systems, such as produced hydrogen, efficiency, durability and cost are directly related to these operating conditions [1]. Single electrolyzers and large hydrogen production plants can benefit from modular and flexible architectures that enhance energy efficiency and extend operational lifetimes, considering, for example, multi-stacks configurations [2]. Commercially available electrolyzers require AC/DC converters to supply power to the individual stacks or assembly of them. Depending on the number of stacks, they can be connected in series to a single power converter, which manages the operating conditions of all the stacks in the chain. These chains are usually connected in parallel to increase the flexibility of the operation with variable power supply conditions, increasing on the other hand the complexity of the control system [3]. Different operating strategies can be applied to the management of individual stacks and the AC/DC converters to optimize the whole performance of the system, but they could also be extrapolated to the management of large plants based on several electrolyzers, deciding the number of them into operation and the load. This work addresses the simulation and experimental validation of suitable operating strategies for three multi-stack systems based on PEM and AEM technologies, with different configurations and number of stacks, in order to analyze how the most suitable strategies could be implemented by an IA based tool to support the decision of the control system of the electrolyzer, depending on the operating criteria defined by the end-user. The work will also analyze how this tool could be applied to large hydrogen plants.

Título	"Preliminary assessment of hydrogen production via solar-driven biomass gasification"
Autores	(UEVORA)
Medio	Hyceltec- Alicante 8-11 junio 2026
Abstract	Solar-driven biomass gasification enables the production of energetically upgraded syngas by supplying the endothermic heat demand through concentrated solar power (CSP). Building upon a previously established techno-economic assessment of solar-driven syngas production, this work quantifies the hydrogen fraction contained in the syngas and estimates the corresponding levelized cost of hydrogen (LCOH) using identical methodological assumptions. Typical syngas compositions from the literature are used to determine hydrogen yields as a fraction of total syngas output, while the economic analysis preserves the same CAPEX, OPEX, project lifetime and financial parameters as the reference syngas study. The results indicate that hydrogen production costs derived from solar-driven syngas generally remain above the European target under the considered baseline assumptions. Nevertheless, the analysis highlights a clear potential for cost reduction if higher hydrogen fractions are achieved, for instance through the use of alternative gasification agents such as steam or oxygen-enriched media. These findings suggest that solar-driven gasification could evolve into a competitive complementary hydrogen pathway, particularly when coupled with biomass residue valorization and process optimization strategies aimed at increasing hydrogen yield.

Título	"Advanced Zeolitic Catalysis for Sustainable Hydrogen Production"
Autores	Amri, I., Nouira, A., Hamdi, N., & Canavarro, D. (UEVORA)
Medio	Advanced Materials and Chemical Engineering (pp. 29-68). IGI Global Scientific Publishing. DOI: 10.4018/979-8-3373-4402-7.ch002
Abstract	Zeolites have proven to be highly effective catalysts in various reactions, including acid, base, and redox catalysis. This chapter discusses the use of zeolitic materials as an affordable and efficient approach to producing green hydrogen. It focuses on three main goals: first, providing a general overview of zeolites and their diverse applications across multiple fields; second, examining the role of zeolitic materials as catalysts in hydrogen production processes; and finally, presenting case studies that highlight the mechanisms behind catalytic reactions during hydrogen generation with zeolites.

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Título	"Techno-Economic Assessment of Biomass Gasification for Hydrogen Production and natural gas grid applications"
Autores	José R. Copa Rey, Bruna Rijo, Paulo Brito (IPP)
Medio	34th European Biomass Conference and Exhibition (EUBCE). Haia 19 a 22 Maio 2026
Abstract	This study investigates the conversion of residual biomass into hydrogen-rich syngas through thermochemical gasification, assessing its potential for injection into the natural gas grid in alignment with the EU Green Deal and Fit-for-55 goals. Two gasification configurations were evaluated using olive and forestry residues: Configuration A, employing air as the gasifying agent, and Configuration B, using a mixture of steam and oxygen. Both systems integrated gas cleaning and purification units, with additional PSA separation when required. A comprehensive techno-economic model was developed to estimate CAPEX, OPEX, levelized cost of energy (LCOE), and financial indicators (NPV, IRR, and PBP), enabling comparison of hydrogen and syngas injection pathways. Configuration B achieved a higher hydrogen yield (1.3 kg/h) and syngas LHV (13.5 MJ/Nm3), more than double the hydrogen concentration of Configuration A. These findings highlight the technical feasibility and economic potential of biomass-derived hydrogen and syngas for decentralized grid integration, emphasizing the importance of carbon valorization and green financing mechanisms. Configuration B proved the most cost-effective pathway, with IRR values above 10% and PBP below 12.8 years, demonstrating investment attractiveness under supportive financial frameworks.

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Título	"CO2 VALORIZATION AS A KEY DRIVER FOR THE TECHNO-ECONOMIC FEASIBILITY OF SYNGAS INJECTION INTO NATURAL GAS GRIDS"
Autores	Bruna Rijo, José R. Copa Rey, Paulo Brito (IPP)
Medio	34th European Biomass Conference and Exhibition (EUBCE). Haia 19 a 22 Maio 2026
Abstract	This study, developed within the framework of the Interreg AIHRE project (Analysis and Promotion of Renewable H2 in the POCTEP region), investigates the thermochemical gasification of residual biomass (olive and forestry residues) to produce a hydrogen-rich syngas suitable for renewable gas grid injection. The research integrates hydrogen purification and CO2 valorization into a unified techno-economic assessment to enhance both environmental sustainability and financial performance. A detailed economic model was developed to estimate capital (CAPEX) and operational (OPEX) costs, levelized cost of energy (LCOE), and financial indicators (NPV, IRR, PBP) under multiple financing scenarios. Special attention was given to CO2 valorization, considering its capture and sale for industrial applications at €1.20/kg. Results show that incorporating CO2 valorization significantly improves economic outcomes: the NPV becomes positive, the IRR increases to 10.03% (exceeding the 8.3% discount rate), and the PBP shortens to 18.55 years, well below the plant's 25-year lifespan. These findings demonstrate that CO_2 utilization can substantially enhance the techno-economic viability of biomass gasification systems while supporting EU decarbonization goals. The integration of CO2 valorization emerges as a key strategy for achieving a circular carbon economy and advancing sustainable hydrogen and syngas production for renewable gas grid applications.

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Título	"Techno-economic analysis of the integration of biomass-based processes and water electrolysis for hydrogen and renewable fuels production"
Autores	Eduardo López (1), Diego Tejada (1), Adrián Castro (1), Bruna Rijo (2), Cecilia Mateos-Pedrero (2), Paulo Brito (2), Jose I. Domínguez (3), Ángel Álvarez (4), Jimena Incer, Fausto Posso (INTA, IPP, US, CIDAUT, ITG)
Medio	Hyceltec 2026 - X Symposium on Hydrogen, Fuel Cells and Advanced Batteries - Alicante 8-11 junio 2026
Abstract	Biofuels and hydrogen will play an essential role in clean energy transition. They complement direct electrification and energy efficiency measures to reduce emissions in hard-to-abate sector, while providing security and development opportunities. Renewable hydrogen can be produced from biomass conversion, but it is also a key asset to improve biomass processes when supplied from other sources, such as water electrolysis using renewable electricity. Smart integration of hydrogen and biomass-based processes offers opportunities to optimize resources, reduce costs and improve overall system flexibility. In this context, the AIHRE project (Analysis and Promotion of Renewable Hydrogen in the Spain-Portugal Cross-Border Region) addresses the hybridization of these technologies, from a technical and economic point of view, to optimize the generation of different products. The present work assesses the technical and economic feasibility of integrating biomass conversion processes and water electrolysis, in hybrid plants to produce e-biomethanol and pure hydrogen for other uses (e.g. mobility). The work compares different configurations, scales and level of integration, considering biomass commercially available in Spain, Portugal, Costa Rica and Colombia, as well as different sources of supply of renewable electricity for hydrogen production in these countries (solar local generation, renewable power purchase agreement and direct connection to grids with high renewable energy penetration), in order to increase the utilization factor, optimize the size of all the elements of the integrated plant, optimize overall energy efficiency, reduce energy operating costs and minimize the levelized cost of the final products.

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3.2. Investigación en MEAS (pilas de combustible PEMFC).

Título	"Methodology for MEA characterization"
Autores	Martín Dalmas Joël (1), Martín Pintos Adrián (1), Castrillo Cuevas Marcos (1), Dominguez Carrero Jose Ignacio (1) (CIDAUT)
Medio	Hyceltec- Alicante 8-11 junio 2026
Abstract	MEAs are one of the most important components in PEM fuel cells, and characterizing their performance is essential for the subsequent design of the complete PEM stack. Although there is extensive literature on characterization techniques in threeelectrode cells, the application of some of these techniques to in-situ MEAs is not as widespread, whereas these characterization methodologies can provide significant added value for the study and monitoring of degradation processes in these electrochemical systems. Three commercial PEM membrane electrode assemblies (MEAs) from different suppliers were benchmarked under an identical activation and testing protocol to establish quantitative correlations between cell performance, impedance response and electrochemically active surface area (ECSA). Following a controlled conditioning procedure, polarization curves were recorded with air and O_2 at the cathode to differentiate kinetic and mass transport contributions. Electrochemical impedance spectroscopy (EIS) was performed under the same operating conditions to extract ohmic and charge transfer resistances. Cyclic voltammetry (CV) was conducted in two potential windows: 0.05–0.60 V for ECSA determination via hydrogen underpotential depostion (Hupd), and 0.05–1.30 V to evaluate oxide formation and surface electrochemical features. A consistent performance ranking (N1 > N2 > N3) was observed across all techniques. Higher current densities were directly associated with lower charge transfer resistance and larger cathodic ECSA values. The integrated Hupd charge revealed significantly higher electrochemically active surface area at the cathode than at the anode in all MEAs, in agreement with manufacturer catalyst loadings. The results demonstrate that a combined IV–EIS–CV methodology enables robust discrimination of commercial MEAs and provides a consistent link between intrinsic catalytic surface area and full-cell performance.

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3.3. Investigación en purificación de corrientes gaseosas.

Título	"Biochar as a Sustainable Adsorbent for Syngas Purification in Biomass Gasification Processes"
Autores	Roberta Panizio, José R. Copa Rey, Cecilia Mateos-Pedrero, Paulo Brito, Bruna Rijo (IPP)
Medio	34th European Biomass Conference and Exhibition (EUBCE). Haia 19 a 22 Maio 2026
Abstract	The present work proposes the integration of biochar, derived from pyrolysis or gasification, into the syngas cleaning system as a sustainable, low-cost, and circular adsorbent. Biochar's high specific surface area, developed microporosity, and tunable surface functional groups confer strong adsorption capabilities for contaminants such as CO2, tars, H2S, and NH3. The use of biochar valorizes a byproduct of thermochemical conversion within the same process chain, thereby reducing dependence on fossil-derived adsorbents, lowering operational costs, and enhancing environmental sustainability. The expected outcomes include improved purification efficiency, reduced greenhouse gas emissions, and the generation of cleaner syngas with higher calorific value. Utilizing biochar produced from the same or similar biomass feedstocks fosters a closed-loop system, minimizing waste generation and promoting circular resource utilization. The implementation of biochar-based syngas cleaning systems represents a scientifically robust and environmentally aligned approach that enhances the efficiency, sustainability, and economic feasibility of thermochemical conversion technologies. This innovation contributes directly to the realization of European climate and energy goals, supporting the development of low-carbon, circular bioenergy systems and strengthening regional bioeconomic resilience in line with EU sustainability directives

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Título	"Biomass Gasification with Air: Integration of Gas Cleaning and CO_2 Valorization for Enhanced Process Performance"
Autores	Paulo Brito, Bruna Rijo, Roberta Panizio, Jose Copa Rey (IPP)
Medio	Hyceltec- Alicante 8-11 junio 2026
Abstract	This study, developed within the framework of the Interreg AIHRE project, focuses on the thermochemical gasification of residual biomass (olive and forestry residues) using air as the gasifying agent (Configuration A), aiming at the production of syngas and its subsequent valorization through gas cleaning and CO_2 utilization. A downdraft gasifier was coupled with a dedicated gas cleaning system, including cyclone separation, water scrubber, and zeolites and activated carbon adsorption. The gas cleaning system proved effective in removing contaminants, particularly tears, as confirmed by the observed color change (orange) in the washing water, indicating the transfer of condensable compounds from the gas phase to the liquid phase. This highlights the importance of integrating scrubbing stages to improve syngas quality and ensure process reliability. Additionally, CO2 capture and valorization were assessed as a key strategy to enhance process sustainability and economic performance. CO2 capture using CaO at 700 °C was successfully demonstrated, with efficiencies up to 42%, and quantified through thermogravimetric analysis based on normalized mass loss. The potential sale of captured CO_2 (assumed at €1.20/kg) was incorporated into the techno-economic model. Results show that CO2 valorization significantly improves financial performance, enabling positive net present value (NPV) and internal rate of return (IRR) values above 10%, while reducing the payback period. Although Configuration A produces lower hydrogen yields compared to alternative setups, the combination of effective gas cleaning and CO2 utilization enhances its viability. In general, this work demonstrates that integrating gas cleaning and CO2 valorization is essential to improve both the environmental and economic performance of biomass gasification systems.

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Título	"Effect of CaO Loading on In-Situ CO2 Capture during Pruning Biomass Gasification"
Autores	Bruna Rijo, José Rey, Paulo Brito, Roberta Panizio (IPP)
Medio	25th International Symposium on Analytical and Applied Pyrolysis (PYRO 2026) - Pisa 7 a 11 junio 2026
Abstract	This study, developed within the framework of the Interreg AIHRE project (Analysis and Promotion of Renewable H_2 in the POCTEP region), investigates the integration of in-situ CO2 capture using CaO during biomass gasification is a promising route to reduce carbon emissions while maintaining process efficiency. However, the influence of CaO loading on sorbent utilisation efficiency remains insufficiently understood. In this study, the effect of CaO addition on gas composition and CO2 capture performance during pruning biomass gasification was investigated, with particular attention to oxygen (O2) and carbon dioxide (CO2) concentration profiles. Experiments were conducted using pruning alone and pruning mixed with 10 wt% and 20 wt% CaO. Gas concentrations were continuously monitored, and CO2 capture was quantified by mass balance, while char conversion was independently evaluated. Results show that char conversion was essentially identical for all cases, indicating that CaO addition did not affect the overall extent of char oxidation. However, significant differences were observed in the gas-phase composition. In the absence of CaO, CO2 concentration increased rapidly after ignition and reached peak values close to 10%, reflecting the full release of CO2 from biomass oxidation into the gas phase. Correspondingly, the O2 concentration exhibited the largest decrease, attributable to both oxygen consumption and dilution by accumulated CO2. When CaO was added, CO2 concentrations were markedly reduced throughout the reaction. The maximum CO2 concentration decreased to approximately 4–5% for both CaO loadings, confirming effective in-situ CO2 capture via carbonation. Quantitative analysis showed that the addition of 10 wt% CaO resulted in the highest CO2 capture, corresponding to 42% of the total CO2 produced on a mass basis, while 20 wt% CaO captured 39%. Despite the higher sorbent loading, the increase in CaO content did not lead to a proportional enhancement in CO2 capture.

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Título	"Recent Advances in Renewable Hydrogen Purification Technologies: A General Review"
Autores	José Copa Rey, Catarina Nobre, Bruna Rijo, Andrei Longo, Paulo Brito, Cecilia Mateos-Pedrero (IPP)
Medio	Clean Technol. 2026, 8(2), 35; https://doi.org/10.3390/cleantechnol8020035
Abstract	Renewable hydrogen purification is a critical yet often underemphasised step in enabling its use as a clean energy carrier. Hydrogen produced from biomass-based thermochemical and biological routes typically contains CO_2, CO, CH_4, H_2S, and other impurities that must be removed to meet stringent requirements for fuel cell, industrial, and grid-injection applications. This review provides a critical and up-to-date assessment of renewable hydrogen purification technologies, focusing on their suitability for variable and impurity-rich renewable hydrogen streams. Established benchmark technologies, including pressure swing adsorption and cryogenic separation, are described, with emphasis on their operating principles, material innovations, and process integration strategies. Recent advancements in inorganic, polymeric, and mixed-matrix membranes are highlighted, with particular focus on how advanced porous materials enhance selectivity, permeability, and flexibility. Additionally, a comparative techno-economic assessment is presented, evaluating each purification method based on technology readiness level, capital and maintenance costs, energy efficiency, and operational lifespan. By incorporating recent research trends, this approach facilitates the selection and design of purification systems that are not only efficient and scalable but also cost-effective, tailored to both decentralised and centralised renewable hydrogen production.

3.4. Investigación en almacenamiento de hidrógeno en boruros.

Título	"Scale-up of a clean hydrogen production system through the hydrolysis of sodium borohydride for off-grid applications"
Autores	Diogo Silva, Hélder Nunes, Cármen Rangel, Alexandra Rodrigues Pinto (UPORTO)
Medio	International Journal of Hydrogen Energy, 144, 3 July 2025, Pages 1207-1212
Abstract	Hydrogen is considered a promising energy vector with the potential to replace fossil fuels, and sodium borohydride serves as an effective energy carrier capable of releasing hydrogen (H2) for off-grid applications. However, the hydrolysis of sodium borohydride has only matured at laboratory-scale. Therefore, the scale-up of a laboratory reactor was designed and manufactured to study the effect of larger H2 production. For that, the effect of inhibitor NaOH concentration and water quality were studied. Experiments using 3 wt% NaOH showed overall better performance than those using 1 wt%. Additionally, experiments using tap water — scarcely reported in the literature — demonstrated performance equal to or better than that achieved with distilled water. These results are indicative of a possible significant reduction in the H2 production cost through this method.

Título	Method to obtain a carbon-supported NiRu catalyst
Autores	Liliana Carneiro, Josefina Ferreira, Diogo Silva, Alexandra Rodrigues Pinto (UPORTO)
Medio	European Patent Office, application number EP25218620.0
Abstract	The present application relates to a method to obtain a NiRu catalyst supported on Carbon Black. The method comprises three main steps of producing nickel metal nanoparticles, producing NiRu nanoparticles, and then producing the carbon-supported NiRu catalyst. The methodology here described are optimized to be simple and easy to implement, yielding a NiRu catalyst with improved catalytic properties and economic feasibility

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Título	Off-Grid Hydrogen Production to Decarbonize Remote Coastal and Maritime Operations
Autores	Diogo Silva, Liliana Carneiro, Josefina Ferreira, Diogo Santos, Rui Ferreira, Daniela Falcão, Alexandra Rodrigues Pinto (UPORTO)
Medio	Canadian Hydrogen Convention, 21-23 April 2026
Abstract	Remote and maritime operations still rely heavily on diesel where grid access and hydrogen infrastructure are absent. This limits the deployment of clean power for small vessels, coastal communities, and remote industrial sites. The objective is to develop and validate a modular, on-demand hydrogen generation system operating below 50 bar—significantly safer than typical 350–700 bar hydrogen storage—and directly coupled to a PEM fuel cell. The concept targets intermittent, mission-driven loads and supports energy autonomy and decarbonization in off-grid environments, especially where logistics and safety constraints hinder compressed hydrogen.

Título	Hydrogen Innovation: A Workshop Series – Invited Lecture
Autores	Diogo Silva (UPORTO)
Medio	Concordia University of Edmonton, 23-24 April 2026.
Abstract	"From Research to Innovation: Advancing Hydrogen Production Technologies": This session introduces the speaker's research journey while setting the stage for understanding hydrogen's growing role in the global energy transition. It explores innovative approaches to hydrogen production, with a focus on cutting-edge methods such as the hydrolysis of sodium borohydride, highlighting both scientific principles and practical applications; "Hydrogen Safety and Systems: Production, Storage, and Risk Management": This session focuses on hydrogen safety—an essential aspect of its adoption. Participants will gain insight into hydrogen generation processes such as water electrolysis, explore various storage strategies and operating conditions, and examine key risks alongside current regulations and best practices for safe handling and deployment; "Hydrogen in Action: Portugal's Strategy, Projects, and Future Pathways": This session broadens the perspective by examining hydrogen development in Portugal. It highlights national strategies, the integration of renewable energy, notable projects and research initiatives, and concludes with a forward-looking discussion on challenges and future opportunities in the hydrogen sector.

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RESUMEN AIHRE

Título

AIHRE: Análisis e Impulso del H2 REnovable en la región POCTEP

Fecha de inicio - Fecha de fin del proyecto

01/07/2023 - 30/06/2026 (36 months)

Tipo de Proyecto

Análisis e Impulso de H2 Renovable

Programa

INTERREG POCTEP – tercera convocatoria

Financiación

1,5M€ - Cofinanciado al 75 %

Coordinador

Fundación CIDAUT

Visión general del proyecto

El proyecto AIHRE pretende impulsar la implementación del hidrógeno en la zona POCTEP, desarrollando la tecnología necesaria para su valorización y analizando las diferentes etapas de la cadena de valor del hidrógeno renovable en dicha zona.

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