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Boletim de Vigilância Tecnológica

Secções

Número 9 **Setembro 2025**

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Produção de Hidrogénio

1 Greenzo Energy Secures Prestigious Project From Jindal Stainless To Deliver Green Hydrogen Electrolyser Plant In Odisha

02/09/2025 | Hydrogen Central| **Link**

Greenzo Energy has won an order from Jindal Stainless to set up a green hydrogen electrolyser plant at its Kalinga Nagar complex in Odisha. The plant will produce 472,000 kg of hydrogen annually, with scalability up to 1.5 KTPA, supporting processes like the Bright Annealing Line and Bell Furnace to cut emissions. Using Greenzo's indigenous alkaline bipolar electrolyser, it will deliver ultra-pure hydrogen at 30 bar with high efficiency. The project also includes training and operational support for JSL's team. For Jindal Stainless, it is a major decarbonization step, while for Greenzo it strengthens its role in India's clean energy transition

2 Transition Industries Awards Techint E&C and Siemens Energy a FEED Contract for a 210 MW Electrolyzer Facility for the Pacifico Mexinol Project

02/09/2025 | Hydrogen Central| **Link**

Transition Industries has awarded Siemens Energy and Techint E&C a FEED contract for a 210 MW electrolyzer facility, part of its Pacifico Mexinol project in Sinaloa, Mexico. The plant will use Siemens' Elyzer P-300 technology to produce about 4,000 kg of green hydrogen per hour, supporting what is set to become the world's largest standalone ultra-low carbon methanol facility when it begins operations in 2029. The FEED study will define the design and cost framework ahead of EPC execution, ensuring high standards of efficiency, safety, and scalability. Once complete, Pacifico Mexinol will produce 350,000 MT of green methanol and 1.8 million MT of blue methanol annually, positioning it among the largest global producers of sustainable fuels.

3 Utility Global Selects Rockwell Automation To Automate Its Economic Clean Hydrogen Production Systems

02/09/2025 | Hydrogen Central| **Link**

Utility Global has partnered with Rockwell Automation to provide control and automation for its H2Gen® systems, producing hydrogen from water without electricity. These modular systems integrate into existing infrastructure and supply clean hydrogen to industries like steel, mobility, and chemicals, reducing emissions and costs. Rockwell's PlantPAx® system and FactoryTalk® software enable scalable commercial deployment, starting with a Houston unit and expanding to biogas applications in 2026. Utility emphasizes that automation speeds deployment and supports its goal of delivering economic clean hydrogen to hard-to-abate sectors. Rockwell highlights the platform's reliability, security, and flexibility for industrial use. Together, they aim to advance decarbonization and enable a scalable, low-carbon hydrogen transition worldwide.

4 Breakthrough in hydrogen dissociation offers new hope for carbon emission reduction

05/09/2025 | Hydrogen Central| **Link**

Researchers from China's Dalian Institute of Chemical Physics and Italy's University of Trieste have achieved a breakthrough in photocatalytic hydrogen dissociation. The study, published in Science, shows that hydrogen molecules can now be split at room temperature using light, avoiding the high temperatures and pressures previously required. This advance enables more efficient hydrogenation reactions, central to nearly a quarter of industrial chemical processes. The method could lower energy use, reduce by-products, and cut carbon emissions. Applications include producing valuable chemicals like ethane and ethylene from hydrogen and CO_2. Scientists aim to scale the process for industrial use, potentially decarbonizing coal-based chemical production.

5 NETL Researchers Gasify Plastic Waste With Coal and Biomass for Improved Hydrogen Rich Gas Production

05/09/2025 | Hydrogen Central| **Link**

Researchers at the U.S. Department of Energy's NETL are developing a method to gasify plastic waste with coal and biomass to produce hydrogen-rich syngas. This approach tackles the global plastic waste crisis, which has left billions of tons in landfills and ecosystems. Conventional gasification of plastics faces issues like agglomeration, high energy demands, and tar formation. Using coal refuse as a co-feedstock adds catalytic properties that enhance efficiency and reduce these barriers. The process also allows flexible adjustments of feedstock ratios and temperatures to optimize syngas quality. NETL's findings point to a cleaner, more economical path for converting waste plastics into valuable energy.

6 New drilling campaign starting in Moselle – On the path to low-carbon methane and natural hydrogen production

26/08/2025 | Hydrogen Central| **Link**

La Française de l'Énergie (FDE) will launch a €15 million drilling campaign in Lorraine this autumn to produce low-carbon methane and assess natural hydrogen reserves. The 12-month project includes enhancing an existing well, drilling a new one, and a 4,000-meter exploration well. Certified reserves exceed 2.1 billion m^3 of gas, with production methods avoiding fracking and meeting strict environmental standards. Local output aims to cut reliance on imports and deliver a carbon footprint ten times lower. Uses considered include gas supply, hydrogen conversion, and power generation with CO_2 capture, while creating jobs and boosting regional development.

7 IIT Madras develops 'cost-effective' seawater electrolysis system

28/08/2025 | Hydrogen Central| **Link**

IIT Madras has unveiled a seawater-based green hydrogen electrolysis system that is cheaper to build and operate, potentially boosting adoption. By using seawater instead of freshwater, the technology eases resource pressure and enables coastal hydrogen hubs linked to wind or solar power. The breakthrough aligns with India's National Green Hydrogen Mission to become a top producer and exporter. If scaled, it could cut costs and enhance India's competitiveness in the hydrogen market. Similar efforts are underway globally, with projects in China, the US, and the UK also advancing seawater electrolysis.

8 Key transition point in catalyst kinetics could boost green hydrogen production

04/09/2025 | Hydrogen Central| **Link**

Researchers at the Fritz Haber Institute of the Max Planck Society have identified a key transition point in catalyst kinetics that could boost green hydrogen production. Published in Nature Chemistry, the study shows how interfacial solvation and structural changes on catalyst surfaces govern the oxygen evolution reaction (OER), a major bottleneck in water electrolysis. Using operando spectroscopy and temperature-dependent electrochemistry, the team found activity shifts once excess charge builds up and interacts with solvated ions. Crucially, this effect is independent of catalyst loading or surface area, pointing to intrinsic properties. The findings stress the need to study catalysts and electrolytes as a single interphase. The breakthrough could enhance energy conversion technologies critical for scaling clean hydrogen.

NOTÍCIAS

Produção de Hidrogénio

9 'Five times the hydrogen' | Imperial College spin-off claims its electrode mat can reduce green H2 costs by up to 30%

22/08/2025 | Hydrogen Insight| **Link**

London-based start-up M-Spin, a spin-off from Imperial College, has developed metallic electrode mats with 1,000 times the surface area of current alternatives. Designed for both alkaline and PEM electrolysers, the mats can boost green hydrogen output up to fivefold while cutting costs by as much as 30%. Head of product development Ian Johnson said the breakthrough drives major gains in current density and efficiency when used as electrodes and porous transport layers. The company has just opened a new lab in London to advance the technology. If scaled, it could significantly improve the economics of green hydrogen production.

NOTÍCIAS

Células de Combustível

1 ZeroAvia Certification-Intent Fuel Cell System Successfully Replicates Full Flight Profile in Ground Test

02/09/2025 | Hydrogen Central | **Link**

ZeroAvia has successfully completed a full ground test of its ZA600 hydrogen fuel cell system, simulating a 250-nautical-mile flight on a Cessna Caravan. The 200kW modules demonstrated stable power output for takeoff, climb, and cruise, with four modules together powering the company's 600kW electric motor while ensuring fault tolerance. A key innovation is the use of a Venturi device for hydrogen recirculation, which improves efficiency, reduces weight, and simplifies certification compared to traditional blowers. As the first fuel cell system designed to meet CS-E and CS-23 requirements, the ZA600 is moving rapidly toward certification and commercialization.

2 Idaho researchers make fuel cell / electrolysis cell more efficient and stable

04/09/2025 | Hydrogen Central | **Link**

Researchers at Idaho National Laboratory (INL) have developed a more efficient and stable protonic ceramic fuel cell/electrolysis cell (PCFC/PCEC). These devices can switch between producing hydrogen from steam and electricity or generating power from stored hydrogen, offering flexibility for utilities. The team improved durability under high-steam conditions by redesigning the multilayer ceramic structure with perovskite-based materials. This innovation boosts conductivity, reduces degradation, and increases hydrogen production efficiency. Scaled up to 25 cm^2, the cells mark progress toward industrial deployment. INL researchers see PCEC technology as a potential game-changer for clean hydrogen and future energy systems.

3 Horizon Fuel Cell signs Exclusive Hydrogen Train Partnership with Indian Engineering Giant Bharat Heavy Electrical

08/09/2025 | Hydrogen Central | **Link**

Horizon Fuel Cell has entered a 10-year exclusive partnership with Bharat Heavy Electricals (BHEL) to develop and commercialize hydrogen-powered locomotives in India. This agreement aligns with India's "Green Hydrogen Mission," which seeks to replace diesel trains with clean, zero-emission alternatives. BHEL, a leading engineering enterprise, will contribute its national-scale manufacturing expertise, while Horizon provides its proven heavy-duty fuel cell systems already deployed worldwide. The collaboration reflects the rapid rise of hydrogen as a solution for decarbonized transport, industry, and export opportunities such as ammonia. Horizon's next-generation VLS-IV Series 400kW fuel cell stack promises improved efficiency, with up to 20% lower hydrogen consumption and longer system lifetime. Together, the two companies aim to accelerate India's transition toward sustainable rail and industrial operations.

4 New Flyer introduces extended-range option to its Xcelsior CHARGE FC™ fuel cell bus, designed for rural and long-distance transit

08/09/2025 | Hydrogen Central | **Link**

New Flyer has introduced an extended-range option for its Xcelsior CHARGE FC™ fuel cell bus, powered by Ballard, adding a four-tank hydrogen module that boosts onboard capacity by 17.5kg. First deployed by Humboldt Transit Authority (HTA) in California, the system has exceeded expectations in range, reliability, and performance under steep and challenging duty cycles. By utilizing roof space for extra tanks, fuel capacity rises by 50%, enabling up to 640 miles (1,030 km) of driving range. This enhancement reduces refueling needs, improves efficiency, and offers a strong solution for rural and long-distance transit. HTA testing confirmed dependable operation across highway, elevation, and passenger-loaded routes.

5 Fuel Cell Technology – Advent Tec, hnologies Announces Major Milestone in its Strategic Collaboration with Airbus

10/09/2025 | Hydrogen Central | **Link**

Advent Technologies has reached a key milestone in its collaboration with Airbus, advancing its Ion Pair™ MEA for high-temperature PEM fuel cells. The breakthrough reconfigures the membrane electrode assembly and hardware to boost power density and system efficiency, validating the platform for aviation use. Advent says the innovation could also benefit defense, heavy-duty mobility, and off-grid power. CTO Emory De Castro highlighted the role of HT-PEM tech in enabling lighter, more efficient hydrogen propulsion systems. CEO Gary Herman added that the versatile fuel cell solution has potential across multiple industries. The project now moves toward more ambitious performance goals.

6 Purem by Eberspaecher offers comprehensive portfolio for fuel cell systems

11/09/2025 | Hydrogen Central | **Link**

Purem by Eberspaecher will showcase its full range of fuel cell components at the Hydrogen Technology World Expo in Hamburg this October. The company's portfolio includes a Hydrogen Recirculation Blower (HRB) that improves hydrogen utilization by recirculating unused gas, with pilot tests set for 2025 and production planned in 2027. It is also offering modular exhaust air systems with water separators and silencers to manage steam and noise emissions in fuel cell vehicles. Additional balance-of-plant components include gas control and cathode isolation valves for efficiency and durability. Purem will also present its first module for direct air capture of CO_2. Together, the technologies aim to optimize fuel cell performance for mobility and stationary uses.

NOTÍCIAS

Tecnologia de Armazenamento de Hidrogénio

1 Styrofoam-based hydrogen storage: New process offers safe, reusable solution

04/09/2025 | Hidrogen Central | **Link**

A research team at UNIST, together with KIST and POSTECH, has developed a breakthrough method to convert waste Styrofoam into a safe hydrogen storage medium. Published in ACS Catalysis, the study introduces a closed-loop system that transforms polystyrene into liquid organic hydrogen carriers (LOHCs). These liquids store hydrogen at room temperature and pressure, making transport and reuse safer and more practical. The process uses ruthenium catalysts for hydrogen absorption and platinum catalysts for release, with optimized supports improving efficiency. Distillation and waste heat recovery further enhance durability and energy savings. The technology addresses both plastic recycling and hydrogen storage, offering strong industrial potential.

2 Engineered Supramolecular Crystals for High-Capacity Hydrogen Storage

04/06/2025 | Hidrogen Central | **Link**

A new study highlights engineered supramolecular crystals as a promising solution for high-capacity hydrogen storage. Reported in Nature Chemistry, the crystals use multivalent hydrogen bonding to form precise hydrogen-bonded organic frameworks, achieving strong volumetric (53.7 g/L) and gravimetric (9.3 wt%) performance under dynamic conditions. Tests confirmed enhanced stability and efficiency, addressing a key hurdle in balancing storage density and weight. Researchers say the materials could boost hydrogen-powered vehicles and other clean technologies by improving storage reliability. The work, supported by Chinese research foundations, points toward industrial applications. Further refinements are planned to advance large-scale deployment.

3 Liquefied Hydrogen – DNV awards AiP to SHI for 80K LH_2 carrier design

15/06/2025 | Hidrogen Central | **Link**

DNV has awarded Samsung Heavy Industries (SHI) an Approval in Principle (AiP) for their 80,000 m³ liquefied hydrogen (LH_2) carrier design, revealed at Gastech 2025. The vessel features a vacuum-insulated Type C tank within a robust hull, using glass fiber-reinforced plastic (GFRP) supports to reduce heat ingress and minimize boil-off gas. The spherical tank shape is optimized for lower weight and size without compromising safety under extreme cryogenic conditions. SHI says this design reinforces its role in enabling a global hydrogen supply chain. DNV noted that the AiP confirms the design's feasibility and that no major technical barriers impede its implementation

4 Uniper to explore potential UK hydrogen storage development, in partnership with British Salt

01/08/2025 | Hidrogen Central | **Link**

Uniper, in partnership with British Salt, is exploring the Salinae Hydrogen Storage project in Cheshire, which could store up to 400GWh of hydrogen in 13 salt caverns. Displaced brine would supply British Salt's Middlewich plant, while Uniper holds exclusive rights to assess the site's potential. The plan includes designing two wells for storage development, pending planning approval and a supportive government business model. If advanced, the project could enhance UK energy flexibility and help decarbonize hard-to-electrify sectors like steel, cement, and transport.

5 Así funciona el sistema de baterías de sodio-azufre que ha probado CIUDEN para almacenar energía renovable

19/08/2025 | Hidrogénio Verde | **Link**

Un sistema de almacenamiento de energía con baterías de sodio-azufre (NaS) ha sido probado a 305 °C, incluyendo ensayos en frío y en caliente para verificar el funcionamiento individual y conjunto de los equipos. La potencia nominal máxima es de 1.000 kW en carga y 750 kW en descarga, con una energía mínima almacenada de 5.800 kWh, cumpliendo los límites operativos exigidos. Se utilizará junto a una planta solar fotovoltaica de 2,1 MWp para alimentar dos electrolizadores —uno PEM y otro SOEC— destinados a producir hidrógeno verde. Esto permitirá experimentar con autoconsumo, optimizar la gestión energética y mejorar eficiencia y seguridad. Las baterías NaS operan mediante reacciones electroquímicas entre sodio fundido y azufre fundido, separados por cerámica beta-alúmina, con ventajas como alta densidad energética, larga vida útil, resistencia a altas temperaturas y bajo coste de materiales.

6 Turquoise hydrogen produced by plasma torches injected into gas-fired peaker plant

15/09/2025 | Hidrogen insight | **Link**

Turquoise hydrogen produced via “thermal plasma electrolysis” was successfully injected at Centrica’s 100 MW Brigg Power Station in Lincolnshire, marking the UK’s first H2 trial in a gas-fired peaker plant. The hydrogen, used at 3 % concentration in an internal combustion engine for one hour, was generated on-site by UK start-up Hiiroc—5 % owned by Centrica—using a CO_2-free process that converts fossil gas or biomethane into hydrogen and solid carbon.

NOTÍCIAS

Distribuição de Hidrogénio

1 Clean hydrogen pipeline shrinks, but production set to grow fivefold by 2030: IEA

12/09/2025 | H2 View | **Link**

The IEA's Global Hydrogen Review 2025 shows announced clean hydrogen projects have fallen from 49 to 37 mtpa due to cancellations and delays, yet production is still set to rise fivefold by 2030. Projects at final investment decision (FID) should deliver 4.2 mtpa, raising clean hydrogen's share from 1% to 4% of global supply. The agency says growth could mirror solar PV if policies boost demand and secure offtake. Since 2020, over 200 projects have reached FID, despite economic headwinds. Global hydrogen demand hit nearly 100 million tonnes in 2024, still dominated by fossil fuels. The IEA urges policymakers to back shovel-ready projects in established sectors over uncertain mega-projects.

2 Dutch pilot shows oil and gas well tech can safely store hydrogen underground: whitepaper

12/09/2025 | H2 View | **Link**

Halliburton says existing oil and gas completion technology can be safely applied to underground hydrogen storage, potentially reducing costs for early projects. A Dutch pilot tested hydrogen in a 1,290-metre gas well and leached salt cavern over two phases: integrity testing with nitrogen and hydrogen, followed by months of storage trials. The programme confirmed that standard components used in oil, gas, and methane storage functioned effectively in pure hydrogen conditions. Halliburton's whitepaper, published on h2-view.com, suggests the findings could simplify early hydrogen storage development and accelerate commercial adoption.

3 H2 MOBILITY expands service portfolio: GHG quota service for hydrogen filling station operators

11/09/2025 | Hydrogen Central | **Link**

H2 MOBILITY has launched a new GHG quota service to help hydrogen filling station operators access the complex greenhouse gas trading market. The service bundles emission savings from multiple operators, ensures legal compliance, and strategically times sales to improve returns. This approach enables smaller operators, previously excluded by regulatory hurdles or low volumes, to participate in quota trading. The package includes secure intra-year marketing, timely documentation, and regular price updates. By easing market entry and maximizing revenue potential, H2 MOBILITY strengthens its role as Europe's largest hydrogen refueling network. The initiative also supports expansion of hydrogen mobility while advancing EU decarbonization goals through quota trading.

4 Eiffage Énergie Systèmes builds a hydrogen vehicle station demonstrator in Vitrolles

06/08/2025 | Hydrogen Central | **Link**

Eiffage Énergie Systèmes has completed construction of a hydrogen production and distribution station demonstrator in Vitrolles, France. The facility will soon be equipped with a new-generation AEM electrolyzer from GEN-HY, designed without rare earths and offering higher efficiency than conventional systems. Powered by photovoltaic shades, the electrolyzer will produce around 50 kg of green hydrogen per day—enough to supply about ten light vehicles—with refueling times of just five minutes. The station will initially support Eiffage's own hydrogen utility vehicles while serving as a showroom to showcase expertise and train staff. Positioned as a prototype and regional first, the project highlights hydrogen's potential for zero-emission mobility.

5 Hydrogen stations in pipeline for M4 'corridor'

08/08/2025 | Hydrogen Central | **Link**

Fuel Cell Systems Limited (FCSL) has been named hydrogen refuelling infrastructure partner for HyHAUL, the UK's flagship hydrogen-powered HGV project. New stations will be installed in key M4 corridor locations, including Reading and Avonmouth, with on-site storage, compression, and dispensing tailored to heavy-duty logistics. The initiative will create the UK's first hydrogen freight corridor, supporting 30 fuel cell trucks by 2026 and up to 300 by 2030. Backed by the UK Government's £200 million ZEHID programme, the HyFleet refuelling systems are UK-built to meet the scale and reliability demands of zero-emission freight.

6 Element 2, HRS deepen partnership with new hydrogen station in Scotland

05/08/2025 | Hydrogen Central | **Link**

HRS, the French hydrogen refueling station manufacturer, has signed a letter of intent with UK-based Element 2 to deliver a mobile HRS14 station in Glasgow. With a 14kg/hour capacity, the unit can be dismantled, transported, and operational within ten days, offering flexibility to Scotland's growing hydrogen mobility market. The deal follows last year's order for a station at Teesside Airport, marking the fourth HRS station in the UK. Element 2, aiming to deploy 50 stations in five years, is leading a nationwide rollout for commercial fleets. The project supports Scotland's 2045 net zero target while reinforcing HRS's international expansion strategy.

NOTÍCIAS

Mobilidade Terrestre com Hidrogénio

1 Walmart Chile launches country's first green hydrogen truck

02/09/2025 | Hydrogen Central | **Link**

Walmart Chile has introduced the country's first green hydrogen long-haul truck, developed with Grupo Marval, as part of its push for low-emission logistics. Powered by renewable hydrogen, the truck emits no CO_2, operates almost silently, and offers a 750 km range with a 49-tonne load capacity—matching diesel performance while cutting emissions. It follows Walmart Chile's 2023 launch of a hydrogen plant with ENGIE, which produces 240 kg of hydrogen daily. The initiative supports the company's target of 10% low-emission transport journeys by 2024 and 40% by 2029, aligning with Chile's ambition to become a global green hydrogen hub.

2 Hydrogen – CaetanoBus delivers the first H2City Gold buses toFinland and showcases them during WRC week

01/09/2025 | Hydrogen Central | **Link**

CaetanoBus has delivered its first hydrogen-powered H2.City Gold buses to Finland, strengthening its European presence. The five units were introduced during WRC Finland week in Jyväskylä, operating on selected routes to test performance in real conditions. The project, led by the Central Finland Mobility Foundation, aims to integrate the buses into public transport through Koiviston Auto Jyväskylä. With over 215 hydrogen buses sold in Europe, CaetanoBus reinforces its role in zero-emission mobility. The demonstrations highlighted comfort, quality, and system reliability. Sales Director Tiago Sá stressed hydrogen's importance in decarbonizing fleets and meeting EU climate targets.

3 Hyundai Motor Group Presents Hydrogen Vision for Energy Transition at CEM16

29/08/2025 | Hydrogen Central | **Link**

Hyundai Motor Group showcased its hydrogen leadership at the 16th Clean Energy Ministerial (CEM16) in Busan, underlining hydrogen's role in decarbonization and energy resilience. The Group shared its hydrogen business strategy, calling for stronger public-private collaboration to accelerate the transition. Ken Ramirez, Head of Energy & Hydrogen, emphasized industrial applications, efficiency, and hydrogen's importance in the global energy mix. Hyundai also participated in high-level dialogues on industry decarbonization and future fuels, stressing certification, infrastructure, and international cooperation. To support the event, 32 all-new NEXO FCEVs were provided as official vehicles for ministers. The initiative reinforced Hyundai's nearly three decades of expertise in hydrogen innovation.

4 Toyota Joins TOKYO H2 Project Aiming to Make Tokyo a Global Leader in Hydrogen

04/09/2025 | Hydrogen Central | **Link**

Toyota has joined the TOKYO H2 project, a public-private initiative led by the Tokyo Metropolitan Government to make Tokyo a global leader in hydrogen. As part of the project, Toyota has introduced the fuel cell Crown into the city's taxi fleet, aiming for 200 units by fiscal year 2025. The renovated TOYOTA MIRAI Showroom now serves as a hub for collaboration and public education on hydrogen and fuel cell vehicles. TOKYO H2 focuses on expanding hydrogen use in commercial mobility, including taxis and trucks, while raising awareness throughout the city. Toyota aims to make hydrogen more familiar in daily life and stimulate demand across the supply chain. The company continues to support hydrogen production, storage, transportation, and utilization to advance a hydrogen society.

NOTÍCIAS

Mobilidade Terrestre com Hidrogénio

5 Five and a Half Times Around the World: Daimler Truck Fuel Cell Trucks Successfully Complete More Than 225,000 Kilometers in Real-World Customer Operations

04/09/2025 | Hydrogen Central | **Link**

Daimler Truck's five Mercedes-Benz GenH2 fuel cell trucks completed over 225,000 km in real-world trials across Germany with customers including Amazon and Holcim. The trucks showed diesel-comparable practicality, long ranges over 1,000 km, fast refueling with liquid hydrogen, and average consumption of 5.6–8 kg/100 km. Customers praised performance, comfort, and reliable integration into logistics operations. Daimler provided full technical and after-sales support, using the trials to refine the trucks for upcoming small-series production

6 Hydrogen high tech at the BMW Group: start of series production in 2028 is getting closer.

04/09/2025 | Hydrogen Central | **Link**

BMW Group is preparing for series production of its third-generation fuel cell systems at Plant Steyr starting in 2028. Prototypes are already being developed at BMW's hydrogen competence centres in Munich and Steyr, with components supplied from the Landshut technology hub. The new fuel cell system is 25% more compact, more powerful, and more efficient than previous generations, with improved integration for future vehicle architectures. BMW collaborates with Toyota on the core fuel cell technology, leveraging synergies for passenger and commercial vehicles. Prototype production focuses on assembly, testing, and validation to ensure scalability and quality. This marks a key step in BMW's technology-open approach and expansion of zero-emission drive systems.

NOTÍCIAS

Corredores de Hidrogénio: Aspetos Normativos e de Promoção

1 Agendas do PRR reforçadas em 319 milhões de euros

27/08/2025 | Governo de Portugal| **Link**

A reprogramação das Agendas Mobilizadoras e das Agendas Verdes do Plano de Recuperação e Resiliência (PRR) está finalizada.
O resultado alcançado foi um aumento global de apoios em 319 milhões de euros, aumentando assim a dotação global das Agendas para 3 mil milhões de euros.
Este processo, conduzido pelo IAPMEI – Agência para a Competitividade e Inovação em articulação com a Estrutura de Missão Recuperar Portugal (EMRP), representa um investimento estratégico transversal a praticamente todos os setores críticos para a competitividade, inovação e soberania tecnológica nacional.
As áreas setoriais com acréscimos mais expressivos, em linha com as prioridades europeias e nacionais, são a aeronáutica e espaço; as tecnologias de informação e comunicação; e os transportes, mobilidade e logística.

2 Rethinking green hydrogen certification: Why Australia's debate matters globally

04/09/2025 | Hydrogen Insight| **Link**

A new Australian study highlights the global challenge of defining what makes hydrogen truly "green." Using a life cycle assessment, it evaluated certification principles such as time-matching and geographic correlation, which can cut emissions but raise costs and limit flexibility. The research also flagged a gap: embodied emissions in infrastructure are not yet considered in certification schemes. This creates trade-offs between environmental rigor and practical feasibility. With diverging standards across regions, exporters risk losing access to key markets. Australia, with its vast renewable potential, has a unique opportunity to shape credible global hydrogen norms

3 First 3D real-time imaging of hydrogen's effect on stainless steel defects opens the way to a safer hydrogen economy

11/09/2025 | Hydrogen Central| **Link**

Researchers from the University of Oxford and Brookhaven National Laboratory have, for the first time, captured 3D real-time images of how hydrogen atoms alter stainless steel at the atomic scale. Using advanced X-ray diffraction at the US Advanced Photon Source, they tracked defects called dislocations and found hydrogen makes them unexpectedly mobile, triggers unusual "climb" motions, and reduces strain fields through a process known as elastic shielding. These changes explain how hydrogen weakens metals, raising risks of cracking in pipelines, storage tanks, and energy systems. The breakthrough, published in Advanced Materials, offers vital insights to design next-generation alloys resistant to embrittlement, improving safety for hydrogen-powered aircraft, fusion reactors, and heavy infrastructure.

4 Fukui and ClassNK sign MOU for joint consideration of ultra-high pressure safety relief valves for hydrogen dual-fuel engines

11/09/2025 | Hydrogen Central| **Link**

Fukui Seisakusho and ClassNK have signed a new MOU at Gastech 2025 in Milan to jointly advance ultra-high-pressure safety relief valves for hydrogen dual-fuel engines. The agreement builds on their 2023 collaboration, which led to type approval of a low-pressure valve for liquefied hydrogen carriers earlier this year. Under the new deal, Fukui will develop high-pressure RPS-type valves while ClassNK will review them for type approval. The initiative targets key technical challenges such as hydrogen embrittlement resistance and sealing performance, aiming to accelerate the safe adoption of hydrogen propulsion systems.

5 Commission launches new initiatives with industry to boost Europe's Automotive leadership

12/09/2025 | European Commission | **Link**

Today, President Ursula von der Leyen chaired the third Strategic Dialogue on the Future of the European Automotive Industry, bringing together the European automotive industry, social partners, and other stakeholders in Brussels. The meeting reaffirmed the need to act fast to implement the Automotive Action Plan. As technology transforms mobility and geopolitics reshapes global competition, there can be no business as usual.
Led by President von der Leyen, key discussions focused, amongst others, on securing Europe's leadership in electric vehicles, accelerating innovation in autonomous and connected vehicles, and strengthening European battery manufacturing industry. The Commission is safeguarding European companies against unfair competition, improving access to critical raw materials, and supporting workers through reskilling.

6 Austria launches new hydrogen strategy focused on green H2 subsidies, imports, storage and pipelines

16/09/2025 | Hydrogen Insight| **Link**

Austria has launched a national hydrogen initiative designed to establish the country as a European hub for green hydrogen. The program centers on subsidies for electrolysis plants, an H2 import strategy to secure long-term supply, and new rules and financing for storage and pipeline infrastructure. A key focus is the planned 3,400km Southern Hydrogen Corridor linking North Africa to Europe. Economy minister Wolfgang Hattmannsdorfer said the initiative aims to convert renewable power into hydrogen and synthetic gas, strengthening Austria's energy independence, competitiveness, and resilience.

7 Governments cannot expect industry to take on all the risk for hydrogen projects — and vice versa

05/09/2025 | Hydrogen Insight| **Link**

At the Investing in Hydrogen conference in London, critics once again highlighted the high levels of subsidy requested by developers, portraying the sector as overly dependent on public money and suggesting it may never become profitable without constant government backing. However, industry insiders pushed back, arguing that while state support is indeed crucial, it should be carefully designed and time-limited — used only to launch projects and prove their viability, not to keep them permanently alive. Hans Olav Raen, CEO of Yara Clean Ammonia, emphasized that subsidies must act as "a starting fuel at the beginning, not a long-term solution," underlining that targeted early-stage support is the right path to building a sustainable hydrogen economy.

8 'UK first' | Gas company repurposes 30km pipeline for hydrogen to demonstrate safe engineering works

04/09/2025 | Hydrogen Insight| **Link**

British gas supplier SGN has achieved a UK first by safely carrying out operations and maintenance work on a 30km hydrogen pipeline, part of a £29.9m government-backed demonstration project. The initiative focused on repurposing a section of the country's 11,600km high-pressure Local Transmission System (LTS), which delivers energy to towns, cities, and industrial clusters. A representative stretch between Granton and Grangemouth was converted to carry hydrogen, allowing engineers to replicate real-world conditions. The team successfully performed hot works, including welding and drilling into a live pipeline to create new connections, alongside flow-stopping tasks to control hydrogen within the pipe. These operations proved that existing gas infrastructure can be safely adapted, marking a key milestone in the UK's hydrogen transition.

9 Portugal 2030: Mais de 3,6 mil M€ vão ser lançados a concurso nos próximos 12 meses

19/09/2025 | AD&C | **Link**

A Comissão Interministerial do Portugal 2030 aprovou a atualização do Plano Anual de Avisos.
O Plano Anual de Avisos do Portugal 2030 e do Fundo para o Asilo, a Migração e a Integração (FAMI) permite conhecer quais os próximos avisos que serão lançados, sendo, assim, possível planear atividades e investimentos, reforçando a previsibilidade para as diferentes operações e projetos.
De acordo com a mais recente atualização, está prevista a publicação de 239 Avisos de concurso, incluindo multi regiões, com uma dotação de Fundo associada de 3.613.523.405€, distribuídos pelas várias regiões do país e pelos diversos objetivos de política do Portugal 2030, nas áreas sociais, da economia, do ambiente, do mar e do território.

10 CEF Energy: EUR 76.3 million to support works and studies for cross-border renewable energy projects

23/09/2025 | CINEA| **Link**

On 22 September 2025, following the 2024 call for works and studies for cross-border renewable energy (CB RES) projects under CEF Energy, the European Commission adopted an award decision selecting three projects to receive a total of EUR 76.3 million in EU funding.
These projects will foster cross-border cooperation in renewable energy, increase the deployment of clean energy solutions, and contribute to achieving the EU's energy and climate objectives.

11 CEF Energy: Five new projects obtain status and join the CB RES list

1/09/2025 | CINEA| **Link**

The European Commission has approved the addition of five new cross-border renewable energy (CB RES) projects to the official CB RES list. With this latest round, a total of 13 projects now hold the CB RES status, granting them eligibility to apply for financial support under the CB RES window of the CEF Energy programme.

- Comprehensive Offshore Renewable Energy Studies (CORES): the project paves the way for groundwork for future cross-border deployment of floating offshore wind energy in Portugal in a cooperation with Luxembourg. It will assess offshore wind zones, grid reinforcements, and auction models, helping to unlock up to 10 GW of offshore wind capacity in Portugal. The project also fosters collaboration around green hydrogen, port infrastructure, and energy system planning.

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Produção de Hidrogénio

1 Harnessing biomass: High-entropy phosphide nanosheets-carbon hybrid electrocatalysts for efficient hydrogen production

Wei Ning et al. Journal of Materials Science and Technology, vol. 254. pp.156 - 167, August 2025 **Link**

Abstract The economically viable water electrolysis technology offers great potential for the rapid development of sustainable and clean hydrogen fuel. The multiple proton-coupled electron transfer processes lead to the sluggish kinetics of the oxygen evolution reaction at the anode, which becomes the key rate-controlling step in hydrogen production by water electrolysis. Development of electrocatalysts with superior performance for biomass electrocatalytic conversion-coupled H2 generation has emerged as an attractive strategy to mitigate the OER hurdle. Herein, high-entropy phosphide nanosheets (NiFeCoWMoP) are grown on low-curvature hierarchically porous carbonized wood (CW) (NiFeCoWMoP/CW) via solvothermal and phosphide topological methods. The produced NiFeCoWMoP/CW is used as an integrated carbon electrode and presents a remarkable bifunctional properties towards both the hydrogen evolution reaction (HER) and glucose electrocatalytic conversion (GCR), delivering a high current density of 100 mA cm−2 at potentials of only −0.151 V and +1.343 V in 1 M KOH, respectively. Furthermore, the NiFeCoWMoP/CW-based electrolysis system can achieve a reaction current of 100 mA cm−2 at a low voltage of only 1.534 V for GCR coupled with H2 production. Results from this study underscore the significance of high-entropy phosphide nanosheets as multifunctional electrocatalysts for biomass electrocatalytic conversion and hydrogen production.

2 Two-dimensional lamellar TiO2 surface-loaded RuCo nanoclusters for pH-universal electrocatalytic hydrogen evolution

Enhao Liu et al. Journal of Materials Science and Technology, vol. 254. pp.71 - 80, August 2025 **Link**

Abstract The development of cost-effective, efficient, and corrosion-resistant electrocatalysts is crucial for industrial hydrogen production under universal pH conditions. In this study, RuCo nanoclusters were deposited onto Ti3C2Tx MXene using an impregnation method and subsequently annealed in a mildly oxidative atmosphere, leading to the formation of anatase TiO2 with retained 2D morphology. This transformation significantly improved the material's oxidation and corrosion resistance. Furthermore, the spatial confinement effect of MXene ensured the uniform dispersion of RuCo nanoparticles on the catalyst surface after annealing, thereby exposing abundant active sites. The catalyst delivers low hydrogen evolution overpotentials of 44 mV in 1 M KOH and 50 mV in 0.5 M H2SO4 at a current density of 10 mA cm−2. Characterization and theoretical calculations indicate that Co doping donates additional electrons to Ru, stabilizing its low-valence state and thus improving the overall structural stability. This localized charge transfer further tunes the D-band center of Ru sites, promoting optimal interactions with reaction intermediates. As a result, it lowers the energy barrier and enhances the catalytic activity.

3 Investigating the charge transfer mechanism of 1D/2D ZnO/$SnIn_4S_8$ S-scheme heterojunction for efficient photocatalytic hydrogen evolution

Tengyuan Gao et al. Journal of Materials Science and Technology, vol. 254. pp.241 - 251, August 2025 **Link**

Abstract The rapid recombination of photogenerated electron-hole pairs persistently hinders the advancements of single-component photocatalysts in hydrogen production. To address this fundamental challenge, this work constructed a 1D/2D ZnO nanofiber/SnIn4S8 nanosheet S-scheme heterojunction via an electrospinning and solvothermal synthesis strategy. The resultant ZnO/SnIn4S8 heterojunction exhibits a well-coupled nanofiber structure with SnIn4S8 nanosheet loading on the surface. The optimized ZSIS-0.03 composite achieves a record hydrogen evolution rate of 1374.41 μmol g−1 h−1, surpassing pristine ZnO and SnIn4S8 by 2.89 and 8.69-fold, respectively. Mechanistic investigations combining femtosecond transient absorption (fs-TA), in-situ XPS, electron paramagnetic resonance (EPR) spectroscopy, and DFT calculations elucidate the S-scheme charge transfer dynamics: the photoinduced holes in SnIn4S8 recombine with electrons in ZnO at the heterointerface through a built-in electric field, while high-potential electrons in SnIn4S8 and holes in ZnO are preserved to participate in the interfacial redox reactions.

Furthermore, theoretical simulations coupled with Crystal Orbital Hamilton Population (COHP) analysis revealed that Sn sites exhibit enhanced water adsorption energy (−0.55 eV) through optimal adsorptive Sn–O coordination bonds (–ICOHP = 0.31), significantly promoting electron transfer to the adsorbed H2O. Consequently, the unique 1D/2D structure significantly enhances light harvesting, provides abundant active sites (surface area 41.22 m2 g−1), and establishes directional charge transport pathways. This work not only deciphers the atomic-level charge transfer mechanisms in S-scheme systems but also provides a universal strategy for designing high-efficiency heterojunction photocatalysts.

4 Building hollow multi-shell structured Zn2MnO4/CdS S-scheme heterojunction for boosted photocatalytic H2 production

Liu Fangxuan et al. Journal of Materials Science and Technology, vol. 250. pp.233 - 242, July 2025 **Link**

Abstract Building an S-scheme heterojunction photocatalyst with a hollow multi-shell structure is regarded as of great significance to realize efficient H2 production. Herein, a hollow multi-shell structured Zn2MnO4/CdS S-scheme heterojunction photocatalyst was successfully constructed via a coordination polymer self-assembly strategy combined with non-uniform shrinkage effect and subsequent hydrothermal treatment. In the unique heterojunction system, the hollow multi-shell structure bestows significant merits upon the design of photocatalysts for boosted photocatalytic H2 production, including enhanced light capture ability, shortened photo-induced charge transfer distance, and provides abundant reactive sites. Simultaneously, the S-scheme mechanism not only promotes the separation and migration of photo-induced charge, but also additionally maintains the strong redox ability. As a result, Zn2MnO4/CdS heterojunction displays an unparalleled photocatalytic H2 production rate of 22.42 mmol g−1 h−1, almost 10.99 and 35.03 times that of pure Zn2MnO4 and CdS, respectively. Simultaneously, the heterojunction also demonstrates outstanding cycling stability, with no significant decline in photocatalytic H2 production activity after 10 cycles. Furthermore, the in-situ irradiated X-ray photoelectron spectroscopy and electron paramagnetic resonance spectroscopy further verify the S-scheme charge transfer pathway in Zn2MnO4/CdS heterojunction. Our study proposes an innovative viewpoint of hollow multi-shell structured S-scheme heterojunction photocatalyst for solar-driven H2 production.

5 Bimetallic cocatalysts driving electron extraction in COFs for photocatalytic hydrogen production

Ge Yan et al. Applied Catalysis B: Environment and Energy , vol. 382. September 2025 **Link**

Abstract Building an S-scheme heterojunction photocatalyst with a hollow multi-shell structure is regarded as of great significance to realize efficient H2 production. Herein, a hollow multi-shell structured Zn2MnO4/CdS S-scheme heterojunction photocatalyst was successfully constructed via a coordination polymer self-assembly strategy combined with non-uniform shrinkage effect and subsequent hydrothermal treatment. In the unique heterojunction system, the hollow multi-shell structure bestows significant merits upon the design of photocatalysts for boosted photocatalytic H2 production, including enhanced light capture ability, shortened photo-induced charge transfer distance, and provides abundant reactive sites. Simultaneously, the S-scheme mechanism not only promotes the separation and migration of photo-induced charge, but also additionally maintains the strong redox ability. As a result, Zn2MnO4/CdS heterojunction displays an unparalleled photocatalytic H2 production rate of 22.42 mmol g−1 h−1, almost 10.99 and 35.03 times that of pure Zn2MnO4 and CdS, respectively. Simultaneously, the heterojunction also demonstrates outstanding cycling stability, with no significant decline in photocatalytic H2 production activity after 10 cycles. Furthermore, the in-situ irradiated X-ray photoelectron spectroscopy and electron paramagnetic resonance spectroscopy further verify the S-scheme charge transfer pathway in Zn2MnO4/CdS heterojunction. Our study proposes an innovative viewpoint of hollow multi-shell structured S-scheme heterojunction photocatalyst for solar-driven H2 production.

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Células de Combustível

1 Stable and active nanofiber electrodes tuned via a negative thermal expansion strategy for designing high-performance solid oxide fuel cells

Piotr Winiarz et al., Applied Catalysis B: Environmental, September 2025 **Link**

Abstract Thermal mismatch between the electrode and electrolyte is a key limitation hindering the commercial application of solid oxide fuel cells. This issue can be solved by state-of-the-art negative thermal expansion materials (NTEs), enabling the fabrication of thermally stable electrodes. Herein, for the first time, we report successful fabrication of in situ-assembled heterostructured nanofiber electrode incorporating an NTE material, using the electrospinning technique. The thermomechanical properties of $SmBa_{0.5}Sr_{0.5}CoCuO_{5+\delta}$ were tuned to match the electrolyte by incorporating a chemically-compatible NTE material: $Sm_{0.85}Zn_{0.15}MnO_{3-\delta}$ (SZM15). The polarization resistance at 800°C of the electrode with 10 wt% addition SZM15 decreased by 55 % compared to the pristine cathode, resulting in a good peak power density of 850 mW·cm−2, approximately 40 % higher than in the pristine cell. These results present a novel strategy for designing stable and active nanofiber electrodes by tuning thermomechanical properties through the incorporation of NTE materials, thereby enhancing cell performance and ensuring durability.

2 Integrated probing of cycling-induced degradation of multi-component electrode in hydrogen fuel cells via machine learning-empowered spectroscopic imaging

Daehee Yang et al., Applied Catalysis B: Environmental and Energy, September 2025 **Link**

Abstract To improve the performance of proton-exchange membrane fuel cells (PEMFCs), the control of the spatial distribution of ionomer–Pt alloy catalysts on porous carbon supports is crucial because changes in their morphological and geometrical distributions are relevant to the performance degradation of PEMFCs upon operation. However, their changes remain poorly understood due to the absence of characterization tools with sufficient chemical sensitivity and spatial resolution. Here, an efficient machine learning-assisted electron energy loss spectroscopy is introduced to interpret cycling-induced morphological changes of the cathode at the nanoscale. This approach allows the reliable visualization of the three distinctive components of Pt alloy catalysts, ionomers, and carbon in the electrode. Furthermore, based on large data interpretation, changes in the ionomer–Pt alloy distribution and ionomer coverage on the carbon support can be statistically assessed in relation to the degree of structural degradation of the components upon cycling.

3 Cooperative dual-atomic-site catalysis enables highly efficient oxygen reduction reaction and long-life Zn-air battery

Kunpeng Gao et al., Applied Catalysis B: Environmental and Energy, Vol.382 , September 2025 **Link**

Abstract Rational design and synthesis of electrocatalysts that efficiently catalyze oxygen reduction reaction (ORR) is critical to the development of fuel cells and Zn-air battery (ZAB). However, it remains the most significant obstacle due to the potential-dependent energy barrier for oxygen intermediates (OOH*, O* and OH*) adsorption/desorption on single atom active sites. Here we report a novel deprotonated 2-aminoterephthalic acid (H2BDC-NH2) coordinated compound precursor-mediated method for synthesizing dual-atomic-site electrocatalyst (FeNi-DSAs/NSs) that facilitate ORR kinetics. The experimental and theoretical calculation results verify that the Fe and Ni cooperative effect induces a distinct negative shift of the d-band center for Fe, thereby reducing the adsorption strength of oxygen intermediates on Fe sites. Additionally, the introduced Ni species decrease the energy barrier of the rate-determining step (RDS), thus accelerating catalytic ORR process. Consequently, FeNi-DSAs/NSs exhibits excellent ORR performance in 0.1 M KOH solution with a very large half-wave potential (E1/2) of 0.92 V and a remarkable lifespan, maintaining stability for over 90 h. In aqueous Zn-air battery (A-ZAB), this electrocatalyst enables a high-power density (254 mW cm−2), and can maintain stable charge/discharge for more than 1600 h with negligible potential gap fluctuation. Notably, for quasi-solid-state Zn-air battery (QSS-ZAB) with FeNi-DSAs/NSs, it shows excellent cycle life for over 110 h and high energy conversion efficiency at 0.5, 1.0, and 2.0 mA cm−2, respectively. This work not only provides a novel design strategy for excellent catalysts, but also highlights the potential application of non-precious metal electrocatalysts in renewable energy conversion and storage apparatuses.

4 High hydroxide conductive and alkaline stable poly(vinyl benzyl chloride) cross-linked poly(aryl piperidinium) anion exchange membrane for fuel cell applications

A Jeevitha et al., Energy, Vol.336 , September 2025 **Link**

Abstract Fuel cells are a promising alternative for clean energy conversion, with anion exchange membrane fuel cells standing out due to their ability to employ less expensive non-platinum group metal catalysts. Although, they can outperform proton exchange membrane fuel cells, their chemical instability and poor hydroxide conductivity hinder the commercialization. Therefore, the development of anion exchange membranes with excellent hydroxide conductivity and physicochemical stability is essential. In this study, anion exchange membranes based on poly(meta/para terphenylene methyl piperidinium) cross-linked with poly(vinyl benzyl chloride) were prepared by a solution casting method. The effect of cross-linking on membrane stability and electrochemical performance was systematically investigated. Notably, the cross-linked membrane containing 20 wt% poly(vinyl benzyl chloride) exhibited the highest hydroxide ion conductivity of 152.2 mS cm−1 at 90 °C, more than double that of the uncross-linked membrane. Furthermore, a hydrogen-oxygen fuel cell using this membrane achieved a peak power density of 388.9 mW cm−2 at 60 °C. The membrane also retained 85.5 % of its conductivity after 500 h of alkaline treatment at 60 °C. These results highlight the strong potential of the cross-linked membrane for use in next-generation anion exchange membrane fuel cells.

5 Hybrid reinforcement learning for performance prediction and degradation analysis of proton exchange membrane fuel cells under real vehicle operating conditions

Yan Gao et al., Energy Conversion and Management, Vol.345 , August 2025 **Link**

Abstract Accurately predicting the lifetime of proton exchange membrane fuel cells and identifying the underlying degradation mechanism is crucial for fuel cell vehicles' prognostic and health management. However, most studies rely on laboratory test data with limited relevance to real-world driving conditions. This study presents a hybrid degradation prediction method that combines a semi-mechanism voltage model with an Actor-Critic reinforcement learning algorithm. To enhance prediction accuracy and capture condition-specific degradation information, operating conditions are incorporated as labeled features in the model training process. The proposed method achieves superior voltage prediction accuracy, with mean absolute percentage errors of 1.86% and 1.35% on two real-world vehicle datasets, representing 27.6% and 36.9% improvements over unlabeled approaches, respectively. Furthermore, this study quantitatively analyzes parameter degradation in startup/shutdown, idling, and dynamic loading operation processes. This research offers valuable insights for future engine design and condition-based maintenance of fuel cell vehicles.

6 An optimal power management strategy for enhancing fuel economy in fuel cell-battery hybrid electric vehicles

Shelma George, Rajeev T, Electric Power Systems Research, Vol.251 , September 2025 **Link**

Abstract Fuel Cell-Battery Hybrid Electric Vehicles (FCBHEVs) are emerging as a promising solution for sustainable transportation, offering high efficiency and zero tailpipe emissions. Optimizing power distribution between energy sources is essential for improving fuel economy. This paper introduces a hybrid approach that combines optimization techniques with machine learning (ML). It uses LSTM networks for real-time estimation of key battery states, such as State of Charge (SoC), enabling informed decision-making. Additionally, an advanced optimisation layer utilises a weighted multi-objective cost function to minimise system costs and weights while maintaining power balance and operational constraints. To further guide energy sharing between the battery and fuel cell, a Hybrid Storage Participation Index (HSPI) is introduced, quantifying the relative contribution of each energy source over a drive cycle. The HSPI approach aims to improve fuel economy and reduce fuel consumption per 100 km, and also dynamically allocates power demand between the fuel cell and the battery according to real-time operating conditions. The results across various drive cycles demonstrate significant improvements in fuel economy, with reductions of up to 70–73 % compared to conventional rule-based strategies. Furthermore, the proposed strategy enhances vehicle fuel efficiency—measured in litres per 100 km—ensuring better energy utilization and extended system longevity.

PUBLICAÇÕES

Tecnologia de Armazenamento de Hidrogénio

1 Advanced materials for solid-state hydrogen storage: A review on high-surface-area innovations

Rama Chandra Muduli et al., International Journal of Hydrogen Energy vol.170, September 2025 **Link**

Abstract Hydrogen is a potential energy source with a high calorific value of approximately 142 MJ kg-1 and energy density, suitable for various applications such as transportation, power generation, and space exploration. Storage is a major challenge in adopting hydrogen energy due to safety issues and low technological readiness. Solid-state hydrogen storage in porous materials offers a promising solution to the challenges of hydrogen storage and transportation, which are critical for the widespread adoption of hydrogen as a clean energy carrier. Herein, the review examines recent advancements in the design, synthesis, and characterization of various porous materials for hydrogen storage (the past two decades are covered), emphasizing optimizing storage capacity, kinetics, and thermodynamic properties. Porous materials, including carbon nanostructures, silicon and its derivatives, metal-organic frameworks, covalent organic frameworks, porous organic polymers, zeolites, and selected 1D porous materials (specifically SiC, Pt, and Pd-based), are analyzed for hydrogen storage due to their high surface areas, adjustable pore structures, and ability to adsorb/desorb hydrogen at relatively low pressures and moderate temperatures than primarily used metal hydrides and complex hydrides. The challenges of achieving high storage capacity potential for integrating porous materials into practical storage systems are examined. The review focuses on nanoscale engineering in porous materials, which boosts the hydrogen storage properties through specific storage mechanisms, including the nano-pump effect, nano-sizing effect, hydrogen spillover, metal decoration, and nano-catalytic effect. Developing next-generation porous materials with improved hydrogen storage capabilities offers significant potential for fostering a sustainable hydrogen economy, decreasing dependence on fossil fuels, and reducing greenhouse gas emissions.

2 Unraveling the catalytic mechanism of Nb_2C MXene for enhanced hydrogen storage in MgH_2

Zhixin Yang et al., International Journal of Hydrogen Energy vol.175, September 2025 **Link**

Abstract Two dimensional layered Nb_2C MXene was synthesized by chemical exfoliation method, and it exhibited excellent catalytic activity on the hydrogen storage of MgH_2 in this work. The introduction of 5 wt.% Nb_2C MXene enables MgH_2 to start releasing hydrogen at 175 °C, achieving a total dehydrogenation capacity of 7.15 wt.%. 6.37 wt.% H_2 is desorbed within 10 min at 230 °C from MgH_2-5 wt.% Nb_2C, and 6.52 wt.% H_2 is rapidly taken up within 1.2 min at 125 °C, demonstrating excellent kinetic performance. This composite can also rapidly release 7.00 wt.% H_2, and absorb 6.98 wt.% H_2 in 6 min at 260 °C. The addition of Nb_2C MXene lowers the activation energy for the dehydrogenation of MgH_2 to 68.09 kJ mol^{-1}, which is below that of numerously reported Nb-based catalysts. Mechanistic studies reveal that the uniformly distributed and stably existing Nb-based species (Nb^{4+}, Nb^{5+}, and Nb^0) formed in ball milling act as active species, which not only improve the hydrogen re/dehydrogenation kinetics but also boost cycling stability of MgH_2. This study establishes a foundation for probing the kinetic promotion mechanism for Nb_2C MXene in regulating MgH_2's hydrogen-storing behavior, offering valuable insights for advancing high-performance hydrogen storage materials.

3 Cost-effective novel MIL-101(Cr) hydrogen adsorbents: From adsorption potential theory to vacuum maintenance in liquid hydrogen storage tanks

Xinyi Li et al., International Journal of Hydrogen Energy vol.176, September 2025 **Link**

Abstract The worldwide pursuit of carbon neutrality has intensified the demand for clean energy solutions. Hydrogen has emerged as a promising carbon-neutral energy carrier. Low-temperature liquid hydrogen storage is one of the most effective ways to store and transport hydrogen. To investigate vacuum retention challenges in liquid hydrogen storage systems, this study adopts a cost-efficient MIL-101(Cr) adsorbent and evaluates its hydrogen storage capabilities through multiscale characterization. A predictive model for hydrogen adsorption was established based on adsorption potential theory. At 1 × 10−5 Pa and 20 K, the theoretical hydrogen storage

capacity is estimated to be 1000–2000 cm_3(STP)/g, which significantly exceeds that of conventional hydrogen storage systems. In practical application, we constructed an analytical model for 40-foot industrial cryogenic tanks, in which conventional adsorbents were replaced with 8 g of MIL-101(Cr). This configuration decreases the interlayer pressure rise rate by 44.6 %, maintains the residual hydrogen partial pressure after 10.4 % cooling. Compared with cryogenic adsorbents alone, it extends the time to reach the critical interlayer pressure of 1 × 10_{-2} Pa by 28 %, reaching 1974 h. The multiscale validation approach bridges nanoscale adsorption mechanisms with macroscale system performance, establishing MIL-101(Cr) as a viable solution for vacuum maintenance in liquid hydrogen storage tanks. This work provides a solid foundation for the development of advanced adsorbents and the progress of hydrogen storage and transportation technologies.

4 Non-thermal external field-driven synthesis and performance modulation of high-density hydrogen storage materials

Panpan Zhou et al., Energy Storage Materials, vol.82, August 2025 **Link**

Abstract Solid-state hydrogen storage materials (HSM) have attracted significant attention due to their high volumetric hydrogen density and enhanced safety. However, de/hydrogenation reactions processes of HSM are primarily governed by thermal energy, where heat exchange serves as the fundamental driving force for the reversible hydrogen storage. While conventional thermal driving methods are effective for certain metal hydrides, they demonstrate limited driving efficiency when applied to lightweight high-density HSMs with strong chemical bonds and high stability, such as Mg-based HSMs, complex HSMs and lightweight metal hydride. In contrast, emerging non-thermal energy input strategies like external field-driven techniques (e.g., plasma, ultrasonic, microwave, light, and electric fields) have demonstrated innovative potential beyond traditional thermal activation for HSMs. These advanced techniques not only facilitate material synthesis but also significantly reduce operating temperatures for de-/hydrogenation while enhancing reaction kinetics, thereby allowing precise control over hydrogen storage behaviors. This review systematically summarizes recent advances in non-thermal input external field-driven material synthesis and de-/hydrogenation behavior modulation of high-density HSMs, provides in-depth discussions on the underlying enhancement mechanisms, respective advantages/limitations, material/functional applicability, and near-term feasibility as well as long-term implications of these non-thermal external fields, and outlines future optimization strategies and potential scalable applications for next-generation HSMs.

5 Holding the invisible: Advanced materials for hydrogen storage

Aimen Laalam et al., International Journal of Hydrogen Energy, vol.169, September 2025 **Link**

Abstract Hydrogen storage remains the main barrier to the broader use of hydrogen as an energy carrier, despite hydrogen's high energy density and clean combustion. This study presents a comparative evaluation of conventional and emerging storage methods, integrating thermodynamic, kinetic, economic, and environmental metrics to assess capacity, efficiency, cost, and reversibility. Physisorption analysis reveals that metal organic frameworks can achieve storage capacities up to 14.0 mmol/g. Chemical storage systems are evaluated, including nanostructured MgH_2 (7.6 wt%), catalyzed reversible complex hydrides, liquid organic hydrogen carriers, and clathrate hydrates. Techno-economic analysis shows storage costs from \$500–700/kg H_2 to \$30–50/kg H_2, with energy efficiencies of 50%–90%. Life cycle assessment identifies manufacturing as the primary source of emissions, with carbon footprints varying from 150 to 2057 kg CO_2-eq/kg H_2. Cryo-compressed storage emerges as the most practical transportation option, while metal hydrides are more suitable for stationary use. This study provides a quantitative foundation to guide material selection and system design for next-generation hydrogen storage technologies.

PUBLICAÇÕES

Distribuição de Hidrogénio

1 Optimization of hydrogen distribution networks in petroleum refineries using a genetic algorithm: A novel approach to enhance efficiency and reduce consumption

Kiyanoosh Razzaghi et al.,International Journal of Hydrogen Energy, vol.178, September 2025 **Link**

Abstract Hydrogen management in petroleum refineries is crucial due to the rising demand for hydroprocessing and stringent environmental regulations. This study presents an advanced genetic algorithm framework for optimizing hydrogen distribution networks. The framework features a novel mutation strategy that enhances search efficiency and solution feasibility. It employs a dynamic mapping mechanism between phenotype and genotype spaces, which ensures design variables remain within feasible regions. The superstructure model allows exploration of all potential source-sink connections. An adaptive penalty function handles constraints without manual parameter tuning. Analysis of the results shows that adjustments to the pipeline network lead to a 2.5 % decrease in hydrogen usage. Integrating a pressure-swing adsorption unit reduces utility consumption by 12 %. The unique design of the mutation operator accelerates convergence and avoids premature stagnation. This approach provides a scalable solution for optimizing refinery hydrogen, striking a balance between operational efficiency, economic benefits, and environmental considerations.

2 Hydrogen microprinting revealing role of strain-induced defects on hydrogen distribution near austenite crack tip

Weijie Wu et al., Journal Corrosion Science , vol.257, September 2025 **Link**

Abstract In this study, we combined hydrogen micro-printing test with finite-element (FE) analysis to investigate the microscale origins of crack-tip hydrogen enrichment in 2101 duplex stainless steel during in situ hydrogen-charging slow strain rate tensile loading. Results show that hydrogen concentrates mainly on either side of austenitic hydrogen-induced cracks and within the very narrow region immediately ahead of the tip, with no direct correlation to strain-induced martensite or dislocation density. FE models incorporating hydrogen-lowered vacancy-formation energy demonstrate that hydrogen-promoted vacancy generation via dislocation jog drag produces high local vacancy densities that trap hydrogen, accounting for the observed enrichment. These findings can help to gain a deeper understanding of the interactions and respective roles of various hydrogen embrittlement mechanisms.

3 Optimization strategy for PV-hydrogen coordination in PV high-penetration distribution networks considering transformer lifetime consumption

Lucheng Hong et al., International Journal of Hydrogen Energy, vol.165, September 2025 **Link**

Abstract The high penetration of PV in distribution networks leads to serious issues such as voltage violations and reverse power flow, which significantly affect the operational reliability of transformers and the further integration of renewable energy. To address these challenges, this paper proposes an optimization strategy for PV-hydrogen coordination in high-penetration distribution networks considering transformer operational reliability. First, a state perception method for high-penetration PV distribution networks is developed based on the PSO-XGBoost model, providing accurate network state information to support subsequent optimization. Second, a PV-hydrogen coordination optimization model based on a PSO-XGBoost-enabled distribution network state perception model, aiming to mitigate voltage violations and reverse power flow issues, indirectly reducing transformer lifetime loss. In view of the high dimensionality and significant computational burden associated with the PV-hydrogen coordination optimization model, the twin delayed deep deterministic policy gradient (TD3) algorithm is employed to improve the solution efficiency. Finally, the proposed strategy's effectiveness is validated using a typical case study of the IEEE 33-bus distribution network. Simulation results show that PV-hydrogen coordination optimization adjusts the voltage range from [0.92, 1.10] to [0.95, 1.05], reduces the maximum reverse power flow from 4.094 MW to 0.899 MW, decreases network losses from 3.773 to 3.304, and lowers the annual transformer lifetime loss from 0.207 to 0.008.

4 Coupled internal/external flow-induced vibration and pipe-seabed impact for hydrogen-mixed submarine pipe span

Hongjun Zhu et al., Ocean Engineering, vol.341, August 2025 **Link**

Abstract This paper reports the experimental results of the coupled internal/external flow-induced vibration as well as the pipe-seabed impact for a submarine pipe conveying hydrogen-mixed slug flow. The vibration displacement and pipe-wall impact process of a near-wall flexible pipe with an initial gap ratio of G/D = 0.25 were captured using the non-intrusive optical measurement in the reduced velocity range of Ur = 7.82–23.92, taking the wall-free pipe as the baseline case. The results indicate that the existence of bottom wall leads to a reduction of vibration order, and suppresses the pipe responses in both in-line and cross-flow directions. The onset Ur of higher-order vibration varies with the internal flow, exhibiting a higher value when the pipe transports hydrogen-mixed slug flow as compared to water-filled pipe. Although the slug flow frequency is observed in the pipe vibration, the hydrogen-mixed flow is not the primary contributor to the coupling response. Four pipe-wall impact patterns are identified for the pipe conveying gas-liquid slug flow, depending on the response amplitude and dominant vibration mode. The transported gas-liquid slug flow and inclined arrangement of pipe span contribute to the asymmetrical distribution of impact position about the mid-span. The spatial transfer of impact position is attributed to the mode competition in transition cases.

5 Hydrogen production, delivery pathways, and distribution for transportation

Rofice Dickson et al.,Hydrogen and e-Mobility, Version 2026, Ch.10, pp. 155-180 **Link**

Abstract Hydrogen is emerging as a promising cleaner fuel for the transportation sector, but its effective distribution to demand centers poses significant challenges. Due to its low volumetric density and high flammability, transporting hydrogen in its gaseous form on a large scale is impractical. This necessitates the use of liquid hydrogen carriers, which are crucial for the safe, efficient, and cost-effective storage and transport of hydrogen. This chapter explores various hydrogen carriers, including ammonia, formic acid, methanol, dibenzyltoluene, dimethylether, oxymethylene ether, and liquid hydrogen, with a focus on their economic and environmental feasibility. The analysis provides a comprehensive review of the production methods, transportation logistics, and hydrogen retrieval processes associated with these carriers. Among them, ammonia stands out as the most economically viable option for low (1.82 kt/y) and medium (10 kt/y) market penetration scenarios, with levelised costs of hydrogen (LCOH) calculated at $11.39/kg and $7.88/kg, respectively. For scenarios involving high market penetration, liquid hydrogen offers the lowest LCOH at $6.07/kg. Additionally, formic acid is notable for its minimal global warming potential of 0.61 kg CO2eq/kg H2, making it the most environmentally friendly hydrogen carrier. To further understand hydrogen distribution dynamics, a hydrogen delivery model is utilized to calculate costs associated with delivering hydrogen to various refueling stations using tube trailers. The findings indicate that storage costs represent the largest portion of overall distribution expenses. Key factors influencing these costs include hydrogen vehicle market penetration, population density, and the distance from production facilities to distribution centers. By addressing both economic and environmental considerations in the development of hydrogen infrastructure, stakeholders can facilitate a more effective transition to cleaner mobility solutions.

PUBLICAÇÕES

Mobilidade Terrestre com Hidrogénio

1 Transient sealing performance of rubber seals during high-pressure hydrogen filling process

Yi Ma et al., International Journal of Hydrogen Energy, vol.136, May 2025 **Link**

Abstract Considering the dynamic changes in hydrogen pressure and temperature during the filling process, a transient thermal-mechanical coupling model of rubber seals for the hydrogen filling was developed considering hydrogen swelling and temperature effect, and the time-varying sealing performance of rubber seals was investigated during the filling process by the CFD-FEM co-simulation. Based on the dynamic pressure-temperature correlations in hydrogen storage vessels, the effects of ambient and pre-cooling temperatures, hydrogen flow rates, and filling modes on the contact and thermodynamic properties, morphological evolution, and sealing stability of rubber seals were analyzed. Under the effects of dynamic pressure, thermal expansion, and hydrogen swelling, the contact width and maximum contact pressure of the rubber O-ring increase by more than 50 % and 6 times, respectively, from the initial to end filling time. The two-stage slow-fast filling and three-stage filling modes are more conducive to controlling temperature rise and maintaining rubber sealing stability.

2 Exploring the potential of high-performance hydrogen storage using metal hydrides with triply periodic minimal surface structures for mobility applications

Kenta Abe et al., International Journal of Hydrogen Energy, vol.166, September 2025 **Link**

Abstract Metal hydrides (MHs) are a promising solution for hydrogen storage due to their safety and high volumetric hydrogen density. However, their slow absorption/desorption rates and low gravimetric storage capacity limit their application, particularly in the mobility sector. To address these challenges, this study explores the integration of a metal hydride reactor (MHR) into a vehicle body utilizing triply periodic minimal surface (TPMS) structures as heat exchangers. These structures offer a lightweight design, high mechanical strength, and excellent heat transfer properties. Four TPMS structures—Diamond, Gyroid, Schwarz-P, and Lidinoid—were analyzed for their mechanical strength, hydrogen absorption/desorption rates, and storage capacity. A numerical evaluation was conducted on these types of TPMS-based MHR (60, 120, and 300 mm per side). The results show that these structures can withstand bending loads of up to 8000 N. Among them, Lidinoid exhibited the highest hydrogen absorption and desorption efficiencies due to its large heat transfer area and complex geometry, which facilitated uniform MH distribution. It absorbed approximately 1.3 wt% of hydrogen in 600 s and released it in 650 s. Additionally, integrating the MHR into a battery housing (2230, 1406, and 124 mm per side) enabled a hydrogen storage capacity of up to 7.65 kg, underscoring the potential of TPMS-based MHRs to enhance MH-based hydrogen storage for mobility applications.

3 Comparative analysis of thermodynamic performance and economic viability of compressed and liquid hydrogen refueling stations

Jinyeong Jeong et al., International Journal of Hydrogen Energy, vol.180, September 2025 **Link**

Abstract Compressed gaseous hydrogen refueling station (CHRS) and liquid hydrogen refueling station (LHRS) represent two principal pathways to enable large-scale hydrogen mobility; yet rigorous comparative evaluations remain scarce. This study systematically assesses thermodynamic and economic characteristics under unified design conditions at capacities of 800, 1,000, and 2000 kg/day. Results show that the LHRS achieves 47 % lower energy than the CHRS (111.6 kW reduction), owing to pump-based pressurization and reduced cooling requirements. Economic analysis indicates pronounced economies of scale; as the capacity increases, the levelized cost of hydrogen (LCOH) decreases by 41.9 % (2.42 USD/kg) for the CHRS and 51.3 % (2.82 USD/kg) for the LHRS. At 2000 kg/day, both systems achieve an LCOH below 2.1 USD/kg. The LCOH comprises hydrogen procurement, capital expenditure, and operating expenditure. The CHRS is more sensitive to electricity price, while the LHRS is affected more by the discount rate. These findings provide insights for rational hydrogen infrastructure planning.

4 Hydrogen mobility and operation of transportation network

JÖzkan Köse et al., Hydrogen and e-Mobility, 2026, pp.207-222, September 2025 **Link**

Abstract Hydrogen mobility presents a transformative opportunity for the transportation sector by reducing dependence on fossil fuels and mitigating environmental impacts. Advances in hydrogen technology and the development of refueling infrastructure are vital to realizing hydrogen's potential as a sustainable energy solution. Hydrogen production and supply chain are key elements in the global transition to sustainable energy systems. Hydrogen can play an important role in decarbonizing various sectors by leveraging various production methods and optimizing logistics. Hydrogen transportation is critical to this transition, and pipelines are the most cost-effective method for long-distance transportation. While existing natural gas infrastructure can be adapted for hydrogen use, challenges need to be addressed to ensure the integrity and safety of pipelines. Integration of hydrogen into existing gas infrastructure provides a viable pathway for its gradual adoption, but requires careful consideration of safety standards. Furthermore, environmental impact assessments, including life cycle assessments, are crucial to ensure that hydrogen contributes to sustainability goals. The development of advanced materials to counter hydrogen embrittlement and optimized transport networks will play a vital role in scaling hydrogen use. Strategic investments in hydrogen infrastructure and continuous innovation are essential to unlock the full potential of hydrogen as a clean energy carrier and ensure its widespread adoption. Despite ongoing technical, economic, and infrastructural challenges, hydrogen remains a promising solution to decarbonize and contribute to a sustainable energy future.

5 Spatiotemporal analysis of hydrogen leakage dynamics under fuel cell vehicle chassis utilizing distributed hydrogen sensors

Zirong Yang et al., International Journal of Hydrogen Energy, vol.176, September 2025 **Link**

Abstract Ensuring the rapid and efficient monitoring of hydrogen leakage phenomena for fuel cell vehicles (FCV) is of vital importance. In the study, a comprehensive hydrogen sensing network comprising 25 concentration sensor is developed, and hydrogen leakage experiments beneath the vehicle chassis are conducted under the conditions of six leakage positions and four leakage flow rates. The dynamic and maximum hydrogen concentration, analysis of leakage monitoring effectiveness as well as the heatmap of concentration distribution are presented. Based on the test data from 10 NLPM to 1000 NLPM leakage flow rates, there is a possibility for leaked hydrogen to enter the passenger compartment while the highest concentration is below 3000 PPM among all leakage positions. For the FCV original sensor placement, a total number of 23 hydrogen leakage cases can be detected among all 24 experimental cases. Besides, the sensor S22 exhibits greater capacities to detect leakage phenomena compared with the sensor S3. It is inferred that the rear and front suspension areas serve as impediments to the further propagation of leaked hydrogen, preventing it from diffusing extensively throughout the whole chassis. In addition, hydrogen leakage phenomena occurring between the front and rear suspension area is more easily to be monitored since more sensors detect 25 % lower explosion limit (LEL) hydrogen concentration for the leakage positions L2 L5. The averaged median value of required time to reach 25 % LEL under L1 L6 leakage positions is 24.7 s, 6.8 s, 6.7 s, and 5.9 s for the leakage flow rate of 10, 100, 200, and 1000 NLPM. More attention should be paid to the detection of hydrogen leakage at relatively small leakage flow rates since it is more challenging to be effectively monitored.

PUBLICAÇÕES

Corredores de Hidrogénio: Aspetos Normativos e de Promoção

1 From scrap tyres to jet fuel: Hydrogen integration and economic feasibility within a circular economy framework

Ali Gunerhan et al., International Journal of Hydrogen Energy, vol.179, September 2025 **Link**

Abstract This study presents an innovative approach to producing sustainable aviation fuel from scrap tyres within the framework of the circular economy. The pyrolysis process decomposes scrap tyres into char, oil, and gas products. The pyrolysis oil is then refined into jet fuel through catalytic cracking, alkylation, and hydrotreating processes. Meanwhile, the pyrolysis syngas is used as feedstock for hydrogen production via the steam reforming process. As a result, it was calculated that approximately 93,074.4 tonnes/year of sustainable aviation fuel could be produced from 202,200 tonnes of scrap tyres per year. Additionally, 3796.26 tonnes of hydrogen could be produced annually from pyrolysis syngas. Finally, the estimated minimum selling prices of jet fuel and hydrogen were $0.86/L and $2.79/kg, respectively. Previous research has shown that the hydrogen used to refine pyrolysis oil comes from external sources. However, this study shows that all the hydrogen needed for the refining processes can be obtained from the pyrolysis syngas itself. To the best of our knowledge, this approach has not been adopted before in the literature. The proposed model not only enables low-cost production of sustainable aviation fuel but also contributes to sustainable waste management practices.

2 Hydrogen fuel cell electric vehicles (FCEV) in Indonesia: Policy for clean transport, net-zero emissions, and energy security of hydrogen fuel cell electric vehicles

Ibham Veza et al., Energy 360, vol.4, September 2025 **Link**

Abstract Hydrogen fuel cell electric vehicles (FCEVs), emitting only water at the tailpipe, offer a strategic complement to battery electric vehicles (BEVs) in decarbonizing transport, especially for long-range and heavy-duty applications where rapid refueling is critical. This policy paper assesses Indonesia's emerging hydrogen mobility strategy as a driver for clean transport, energy security, and achievement of the national net-zero target by 2060. The National Hydrogen Strategy, launched in December 2023, sets ambitious goals to cut fossil fuel reliance, expand domestic green hydrogen production, and establish Indonesia as a regional exporter. A notable step is the mandate for 50 percent hydrogen-powered transport in the new capital Nusantara by 2035, reflecting recognition of FCEVs as a key technology. The paper reviews the policy and regulatory framework, evaluates infrastructure readiness, and compares the performance of FCEVs against BEVs and internal combustion engine vehicles (ICEVs). Barriers include high green hydrogen costs, limited refueling stations, regulatory gaps, and lack of targeted incentives. International experiences from Japan, South Korea, and Germany show that fiscal support, certification schemes, and infrastructure investment can accelerate adoption. A phased roadmap is proposed for Indonesia, prioritizing FCEVs in heavy-duty and long-range transport. The roadmap highlights leveraging geothermal and solar resources to produce certified green hydrogen, ensuring genuine emissions reductions. Policy recommendations include carbon pricing aligned with renewables, green hydrogen certification, hydrogen refueling corridors, and integration of hydrogen into broader transport decarbonization strategies. Addressing these challenges systematically will strengthen energy security, enable industrial development, and position hydrogen mobility as a viable pillar of Indonesia's low-carbon future.

3 Integrating Hydrogen Fuel Cell Trucks into Freight Transport: Scenarios for Costs, Emissions, and Policy in China

Na Chen et al., Energy, Pre-proof ref.EGY 138609, September 2025 **Link**

Abstract The freight transport industry in China is a significant source of carbon emissions. In 2024, it used 439 million tons of standard coal and released around a billion tons of CO_2 annually, with trucks accounting for more than 70% of this total. China's dual-carbon goals are at odds with this dependence on fossil fuels, raising concerns about energy security and air quality. Hydrogen fuel cell trucks are a viable low-carbon option, especially for long-haul and heavy-duty jobs. This is because they have a lot of energy density, can be refueled quickly, and can carry huge loads. This research used an agent-based simulation model, calibrated using cost, efficiency, and infrastructure data, to analyze the adoption trajectories of Hydrogen fuel cell trucks from 2024 to 2050 across five

policy and technology scenarios. The framework encapsulates the interactions among vehicle purchasers, manufacturers, fuel providers, and policymakers, while assessing adoption patterns within the energy–environment–economy (3E) paradigm. The results show that the cost of hydrogen fuel is the most crucial element. When costs drop from 35 CNY/kg to 20 CNY/kg, the number of trucks expected to be on the road by 2035 goes from less than 0.6 million to more than 1.2 million. Fossil-based hydrogen with carbon capture makes it possible to reach short-term deployment goals, and renewable hydrogen pathways cut total well-to-wheel CO_2 emissions by around 40% compared to business as usual. Other benefits include a 70–85% drop in nitrogen oxides and almost no particulate matter emissions. The results show that China's 2030 peak and 2060 neutrality goals may be met with a phased policy framework that includes early subsidies and corridor-based infrastructure development, along with long-term renewable hydrogen expansion and carbon pricing.

4 Considering hydrogen policies with a focus on incentive compatibility towards electricity grids

Daniel Gessner, International Journal of Hydrogen Energy, vol.178, September 2025 **Link**

Abstract A lot of countries have recently published updated hydrogen strategies with many of them increasing and renewing their commitment. In parallel, corresponding policy mechanisms are increasingly coming into focus with the first ones already having awarded funding contracts to projects and construction being underway. However, these policies are usually translated from renewable energy policy without considering the specific risks and uncertainties, spillovers, and positive externality of operating grid-conducive electrolyzers in electricity grids which are increasingly subjected to electricity supply volatility from renewables. This article details how different aspects of a dedicated hydrogen policy can address the technology's specific issues from an economic perspective, namely funding provision, market and technology risk mitigation, and the complex relationship with further actors in electricity markets. Results show that, compared to renewable energy policy, mechanisms need to emphasize the input side more strongly as price risks and intermittency from electricity markets are more prominent than from hydrogen markets. Also, it proposes a targeted mechanism to capture the positive externality of mitigating excess electricity in the grid while keeping investment security high. Economic policy should consider such approaches before scaling support and avoiding the design shortcomings experienced with early RE policy.

5 Optimising hydrogen carrier pathways for industrial decarbonisation: A techno-policy framework for readiness in infrastructure and governance

Somtochukwu Godfrey Nnabuife et. al., International Journal of Hydrogen Energy, vol.178, September 2025 **Link**

Abstract Industrial decarbonisation is a major route to net-zero emissions, and hydrogen is emerging as a key energy carrier for hard-to-abate sectors. This work applies a techno-policy readiness framework which encompasses infrastructure compatibility, regulatory institutional alignment, technological readiness, and market readiness, to improve hydrogen carrier pathways for industrial purposes. The framework uses comparative assessments of production routes, transport and storage pathways, and policy instruments to assess the techno-economic performance and governance readiness to support each hydrogen carrier pathway. The findings indicate that ammonia and liquid organic hydrogen carriers (LOHCs) have the highest readiness for long distance transportation, while compressed hydrogen and liquid hydrogen can still be used for shorter distances or niche markets. The analysis also indicated that successful hydrogen rollout will depend as much upon governance and infrastructure alignment, and not only on technical readiness. Overall, this research provides realistic pathways for policymakers and industry actors to expedite their hydrogen uptake into industrial systems, and ultimately enable a quicker transition to global decarbonisation goals.

EVENTOS

7-8 OCT

Hy-fcell 2025 – International Exhibition and Conference for Hydrogen and Fuel Cells

The hy-fcell is one of the world's leading international trade fairs and conferences for hydrogen and fuel cell technology. Combining a high-level exhibition and conference, it brings together experts from industry, research, and policy to drive innovation and explore new business opportunities.
Focal topics 2025:

- Production technology – manufacturing fuel cells and electrolysers
- Hydrogen mobility – applications from lorries to aviation
- European Single Market – Strategies for Europe as a business location
- International networking – cooperation and knowledge transfer

Link

12-13 NOV

Wood Mackenzie Hydrogen Conference

With the low-carbon hydrogen economy struggling to move at pace, a boost is needed in the market to reconcile the supply and demand challenges. As the market looks to break the pattern of announcing capacity whilst demand remains relatively small-scale, questions remain around government policy and support, funding and costs, project delivery and end market requirements.
There is also a need to understand market dynamics, conditions and project specific drivers taking projects to FID while stalling others. All these challenges and more, need to be addressed to scale-up the low-carbon hydrogen sector allowing it to play a critical role in delivering as part of the energy transition.

Link

20-21 NOV

ASIA-PACIFIC HYDROGEN 2025 SUMMIT & EXHIBITION

Sydney, Australia

Asia-Pacific Hydrogen 2025 Summit&Exhibition

The Asia-Pacific Hydrogen Summit & Exhibition 2025 returns to Sydney's ICC on 20–21 November for its largest edition to date. Organized by the Sustainable Energy Council and RX Global, in partnership with the Australian Hydrogen Council and supported by national and state bodies, it is the leading hydrogen event in the region. The summit is a hub for major announcements, partnerships, and innovation in the hydrogen economy. Over 2,500 experts from APAC and beyond will gather to share insights, form alliances, and drive forward hydrogen projects into the 2030s

Link

8-9 DEC

HYDROGEN ARABIA 2025 SUMMIT & EXHIBITION

Riyadh, Saudi Arabia

Hydrogen Arabia 2025 Summit&Exhibition

Join us in Riyadh for the first Hydrogen Arabia conference, showcasing Saudi Arabia's role as a global hydrogen leader and Circular Carbon Economy pioneer. Valued at $1.6 billion, the hydrogen market benefits from Saudi Arabia's resources, strategic location, and strong government backing. Aligned with Vision 2030 and Net Zero 2060 goals, the kingdom is investing heavily in clean energy, including the world's largest green hydrogen plant.

Link

EVENTOS

25-26 MAR 2026

EnergyON summit
ŚRODKOWOEUROPEJSKIE FORUM TECHNOLOGII WODOROWYCH

EnergyON 2026 Summit

The EnergyON Summit is one of the largest and most influential events in Central and Eastern Europe focused on energy transition and industrial decarbonization. Gathering over 150 speakers and more than 150 exhibitors from 11 countries, the 2025 edition featured 90+ panels, keynotes, and workshops across six stages. The program highlighted crucial topics such as modernizing and digitizing energy networks, advancing nuclear and renewable energy integration, energy storage, and low-emission heating solutions. It also explored strategies for achieving Net Zero through CCS/CCU, sustainable use of raw materials, and the role of AI and cybersecurity in protecting infrastructure. The summit serves as a platform for dialogue among industry, government, and academia, fostering innovation and collaboration. More than just a conference, it is a hub where tangible solutions for the future of energy and industry emerge.

Link

12-13 MAY 2026

Reuters Events
Industrial Decarbonisation Europe 2026
12-13 May | Amsterdam | #IDEU26

Industrial Decarbonisation Europe 2026

Industrial Decarbonisation Europe 2026 is a Reuters Events conference scheduled for May 12-13, 2026, in Amsterdam, bringing together over 250 senior leaders and decision-makers from hard-to-abate industries like metals, mining, transportation, and chemicals to discuss strategies for achieving net-zero emissions. The event focuses on carbon capture, hydrogen, energy efficiency, policy impact (EU ETS and CBAM), and developing resilient, low-carbon business models.

Link

19-21 MAY 2026

WORLD HYDROGEN 2025
SUMMIT & EXHIBITION

Rotterdam Ahoy, Netherlands

World Hydrogen 2025 Summit&Exhibition

The World Hydrogen Summit & Exhibition returns to Rotterdam for its largest edition yet. Organized by the Sustainable Energy Council and RX Global with Dutch government partners, it is the key global meeting for hydrogen industry leaders. Recognized as the place where major hydrogen deals are made, the event fosters strategic partnerships. With 15,000 experts expected, it offers a platform to assess progress, align with decarbonisation goals, and drive new hydrogen project developments into the 2030s.

Link

PROJETOS FINANCIADOS

GH2M - Accelerating the deployment of green hydrogen mobility in EU regions

Link

Deadline date: 30/06/2028

The transport sector accounts for around 25% of CO_2 emissions in the EU-27, requiring urgent decarbonisation measures. Green hydrogen (H_2) is a promising solution for hard-to-electrify transport segments. However, regional disparities in adoption and policy support persist. GH2M aims to accelerate the integration of green H_2 into sustainable mobility planning across EU regions. The project brings together 9 partners from 8 regions at different stages of H_2 deployment. It focuses on zero-carbon synergies between urban, heavy-duty, and rail mobility. GH2M also addresses policy gaps and fosters regional cohesion. The ultimate goal is to support the EU's 2050 climate neutrality target.

PRHyUS
Promoting Renewable Hydrogen Utilization for a Sustainable and Greener Europe

Link

Deadline date: 31/07/2029

Many European regions are developing hydrogen strategies, but local industries face barriers to adoption. These regions often rely heavily on fossil fuels, with high-emission industrial sectors. Despite investments in renewable hydrogen, scaling its use remains challenging. PRHyUS addresses this by improving regional policies to boost hydrogen demand, cross-sector adoption, and deployment. The project aims to break supply chain barriers and support sustainable hydrogen integration. It contributes to EU climate goals by promoting knowledge and reducing GHG emissions. The consortium includes partners from Italy, Poland, Belgium, Bosnia and Herzegovina, France, Serbia, and Romania. Together, they aim to improve seven policy instruments and create favourable conditions for hydrogen use.

UNIFHY
Unifying policies to support the uptake of green hydrogen to decarbonize Europe.

Link

Deadline date: 30/06/2028

Greenhouse gas emissions in the EU are not falling fast enough to meet 2033 targets. Reducing fossil fuel use while maintaining energy security and jobs remains a major regional challenge. The UNIFHY project explores how green hydrogen can support this transition. It helps public authorities improve energy policies by learning from regional good practices. The project begins with analysing existing hydrogen policies and stakeholder needs. Then, regions match their challenges with tested solutions from partners. UNIFHY will propose policy improvements to support green hydrogen and biogas adoption. If successful, it could drive a Europe-wide shift toward emission-free industry and transport

PROJETOS FINANCIADOS

HYDEA
Boosting the hydrogen transition in the Atlantic Area ports

Link

Deadline date: 30/09/2026

HYDEA is a project aimed at integrating green hydrogen technologies into ports across the Atlantic Area to improve energy efficiency and reduce carbon emissions. By combining hydrogen with other renewable energies, it seeks to transform how ports operate sustainably. The initiative focuses on raising awareness and knowledge about hydrogen, testing innovative technologies through real-life pilot projects, and exploring business models to make its use practical and profitable. It also develops strategies and guidelines to support ports and policymakers in adopting hydrogen solutions. Ultimately, HYDEA's mission is to turn ports into cleaner, more efficient energy hubs. More than a project, it is a step toward a sustainable maritime future.

SAtComm
Sustainable Atlantic Communities

Link

Deadline date: 30/11/2026

The SAtComm project focuses on empowering Energy Communities to take control of their energy use and play an active role in the clean energy transition. With new EU regulations placing energy users at the center, the project addresses the challenge of differing national approaches across the Atlantic Area. Its goal is to analyze these rules, develop adaptable and sustainable technologies, and enable practices like peer-to-peer energy trading, smart consumption management, flexible electricity use, and battery storage. Pilot projects in rural and coastal areas will test these solutions, ensuring their practicality and scalability. By sharing results, SAtComm aims to guide other communities in adopting similar smart energy strategies. More than research, it is a pathway to stronger, more sustainable Energy Communities.

ANEMEL
From waste water to sustainable power

Link

Deadline date: 2026

ANEMEL is a pioneering project redefining green hydrogen by producing it from low-grade water sources such as seawater and wastewater, while replacing rare and costly metals with abundant alternatives like nickel and iron. Backed by the European Innovation Council with €3.31 million in Pathfinder funding, it has developed high-performance electrolysers capable of running over 2,000 hours and achieving breakthrough efficiency. This approach makes hydrogen production cleaner, cheaper, and more scalable, addressing the limitations of traditional methods that rely on ultra-pure water and scarce resources. Coordinated by the University of Galway, ANEMEL benefits from strong collaborations within the EIC network, boosting visibility and partnerships. Moving from lab to market, the project is now testing larger systems for deployment in coastal, industrial, and water-scarce regions. More than a scientific advance, ANEMEL marks a step toward accessible and sustainable hydrogen at the core of the energy transition.