تحت الرعاية السامية لصاحب الجلالة الملك محمد السادس
UNDER THE HIGH PATRONAGE OF HIS MAJESTY KING MOHAMMED VI

Under the aegis of

KINGDOM OF MOROCCO
Ministry of Energy Transition and Sustainable Development

Organized by

IRESEN Institut de Recherche en Energie Solaire et en Energies Nouvelles
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THE WORLD POWER-TO-X SUMMIT 2025

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MARRAKECH

TOGETHER, POWERING THE GLOBAL ENERGY TRANSITION

MOROCCO NOW
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EDITO

Dear Readers,

Welcome to the fifth edition of the World Power to X Summit, held this year on October 1st and 2nd in the vibrant city of Marrakesh. We are pleased to gather once again with global leaders, innovators, and experts to advance the conversation around green hydrogen and its transformative potential.

Samir Rachdi, CEO IRESEN

In conjunction with this milestone event, we are proud to present the latest edition of Green Hydrogen Magazine. As the sector continues to mature and attract international attention, this publication offers timely insights into the key trends, challenges, and opportunities shaping the future of green hydrogen as we head into 2025.

We dive into the ongoing offtakers challenge, examining how securing long-term contracts remains crucial for the growth of green hydrogen. We also explore the shifting landscape of global investment, with a focus on how international players are adapting to new economic and regulatory realities. A key highlight this year is the Gartner Hype Curve, which shows that the current perceived slowdown in green hydrogen is simply part of its natural maturation process.

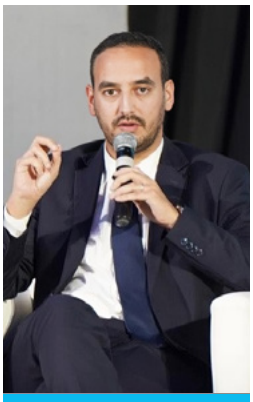
In Morocco, the expanding green hydrogen investments in the Sahara are spotlighted, supported by evolving regulatory frameworks and technological innovation. We also address the important issue of water use in desalination, which will be critical for the sustainability of these projects. As Morocco strengthens its position in the green hydrogen market, the World Power to X Summit will further advance international collaboration and investment opportunities.

Green hydrogen represents a dual opportunity for Morocco—not only as an exporter but also as a hub for innovation and technical expertise. This issue showcases how Morocco is poised to lead in both economic and environmental progress as part of the global energy transition.

Thank you

for your continued support of Green Hydrogen Magazine. Together, we can power a greener, more sustainable future.

SOMMAIRE



FINANCING AND DE-RISKING HYDROGEN PROJECTS: THE 10 GW LIGHTHOUSE INITIATIVE

Renewable hydrogen represents a zero-emission solution for decarbonizing hard-to-abate sectors such as steelmaking, fertilizers, shipping, and aviation. For emerging markets and developing countries (EMDCs), it offers not only a pathway to reduce industrial emissions but also a unique opportunity to attract foreign investment, strengthen energy security, and create new sources of growth and employment.

Dolf Gielen

Senior Energy Economist and Hydrogen Lead - World Bank

Despite the surge of interest—more than 500 renewable hydrogen projects have been announced across EMDCs (excluding China)—few have reached Final Investment Decision (FID). This reflects a set of structural barriers: high capital intensity, regulatory uncertainty, limited offtake commitments, and restricted access to concessional finance. Together, these factors have widened the gap between ambition and implementation, slowing sectoral progress.Financing and rFinancing and risk mitigation are decisive in determining whether projects can achieve bankability. A World Bank "rule of thumb" indicates that producing 1 Mt of renewable hydrogen annually requires approximately 10 GW of electrolyzer capacity, 20 GW of renewable power, and USD 30 billion in total investment. While the recent emergence of ultra-low-cost renewable electricity (1–3 US cents/kWh) has opened the door for competitive production, cost of capital remains a defining challenge. Modeling demonstrates that reducing the weighted average cost of capital (WACC) from 10% to 5% can lower the levelized cost of hydrogen (LCOH) by half.

Globally, 3.8 GW of electrolyzer capacity is operational, serving less than 0.5% of annual hydrogen demand (~100 Mt). Landmark facilities such as Envision's 500 MW green ammonia project in China (exporting to Japan), the 700 MW Stegra green steel plant in Sweden, and Saudi Arabia's 2 GW NEOM project demonstrate early progress. Yet, these remain exceptions; in EMDCs most activity is concentrated in smaller 20–100 MW projects, intended as stepping stones toward scale.

Recent developments show the cost gap is narrowing. For instance, India's SECI renewable ammonia auctions delivered winning bids between INR 50–64/kg ($568–740/t), implying renewable hydrogen costs below USD 3/kg. This compares favorably to grey ammonia, which remains in the $400–500/t range.

Successful projects to date share common traits: access to concessional or blended finance, low EPC costs, competitively priced electrolyzers, and integration with low-cost renewable generation. In Latin America, projects often leverage existing hydropower, while in Morocco, Mauritania, and Saudi Arabia, hybrid solar-wind designs dominate. Falling battery storage costs (below USD 65/kWh) now also enable solar-only configurations, opening vast new production areas in sun-rich regions such as Namibia or Morocco.

The 10 GW Lighthouse Initiative

Launched by the World Bank Group and Launched by the World Bank Group and ESMAP with the backing of the Breakthrough Agenda at COP29 (Baku), the 10 GW Lighthouse Initiative is a coordinated effort by 15 leading development finance institutions (DFIs) to bring 10 GW of renewable hydrogen electrolysis capacity to FID by 2030. The initiative targets projects in the 50 MW to 1 GW range, with the dual purpose of proving commercial viability and reducing costs through technology learning, demonstration effects, and innovative financing models.

10 GW Lighthouse Initiative

68
Projects have been mapped

10 countries
Brazil, Chile, Colombia, Egypt, India, Mauritania, Morocco, Namibia, South Africa and Tunisia

From **500** projects
In EMDCs

Main criteria considered
i. Project stage
ii. Size
iii. 10 GW existing support
iv. Availability of information
v. Sectorial representation

Support measures deployed under the Lighthouse Initiative include:

- Blended finance solutions
- Risk mitigation mechanisms
- Policy advisory
- Investor matchmaking

KEY INSIGHT
Ammonia, methanol and **direct reduced iron** are the 3 mains industries advancing in EMDCs.

Participating DFIs include the African Development Bank, Agence Française de Développement, Asian Infrastructure Investment Bank, CAF, CDP, EBRD, H2Global, Invest International, Inter-American Development Bank, JBIC, KfW, and the World Bank Group (IBRD, IFC, and MIGA).

Country Prioritization and Pipeline Development

Ten countries have been identified as priorities based on renewable resource potential, policy readiness, and strategic alignment: Brazil, Chile, Colombia, Egypt, India, Mauritania, Morocco, Namibia, South Africa, and Tunisia. More than 60 projects in these geographies have undergone initial screening, with a subset advancing to detailed feasibility and technical due diligence. Several are expected to reach FID by 2026–2027.

Support measures deployed under the Lighthouse Initiative include:

Blended finance solutions combining concessional and commercial capital.

Risk mitigation mechanisms such as offtake guarantees, liquidity reserve accounts, and debt service reserve accounts.

Policy advisory to align regulatory frameworks with international market requirements.

Investor matchmaking to connect host governments, developers, and global offtakers.

For example:

In **India**, the World Bank supported SECI in designing reverse auctions with mechanisms for covering the cost differential between renewable and grey hydrogen.

In **Brazil**, investment in shared port and utility corridors in Ceará lowers costs for ammonia and methanol exports.

In **Chile**, the Green Hydrogen Facility pioneered reserve accounts to mitigate debt service and liquidity risks for early-stage projects.

In **Colombia**, Lighthouse partners provided grant support for feasibility studies and financing structures for ammonia projects.

Looking Ahead

The Lighthouse Initiative demonstrates that hydrogen can be viable, scalable, and transformative in EMDCs. By 2030, the target is to bring at least 10 GW of projects to FID, catalyzing tens of billions of dollars in investment while supporting industrial decarbonization, new value chains, and climate objectives.

MOROCCO:
GREEN HYDROGEN/AMMONIA, A STRATEGIC CHOICE AT THE HEART OF THE ENERGY AND INDUSTRIAL TRANSITION

Badr IKKEN

Executive President of Gi3 / Managing Partner of Gi2 / President of the Morocco-Germany Business Council – CGEM

Morocco, a Global Pioneer with Eight Projects Underway, Focused on Green Ammonia

Morocco is among the first countries in the world to establish a clear framework for green hydrogen and its derivatives. The country stands in a select group—alongside Saudi Arabia, India, Australia, Germany, and a few others—not merely piloting small initiatives but launching large-scale, fully fledged projects.

What sets Morocco apart is its focus on a key derivative: green ammonia. This choice is highly relevant given that the country is already a global industrial leader in the fertilizer sector through OCP Group. Instead of targeting costly substitutes such as synthetic kerosene or diesel, Morocco has chosen to prioritize ammonia—a product already closer to price parity with grey ammonia and therefore more competitive in the short to medium term.

The Kingdom has laid out a clear framework and mobilized top-tier private actors to build this new sector. No fewer than eight projects are currently under development, driven by consortia bringing together Moroccan and international players: OCP, TEH2, CIP and AP Moller Capital, ENGIE, Ortus, Acciona, Nordex, Cepsa, Taqa, Nareva, Acwa Power, UEG, and China Three Gorges. Among these, the two most advanced are those led by OCP Group and the TEH2, CIP, and AP Moller Capital consortium, underscoring the dynamism of Morocco's ecosystem. By 2030–2032, these projects could represent over 30 gigawatts of installed capacity and investments exceeding 100 billion.

Why Green Ammonia is Morocco's Most Relevant Choice

Morocco's approach stands out for its pragmatism. While other regions are banking on synthetic fuels like kerosene or green diesel—which remain three to four times more expensive than their fossil equivalents—Morocco is focusing on ammonia, whose projected cost is already close to parity with grey ammonia.

Today, grey ammonia costs around $500 per ton. Forecasts for green ammonia hover near $600 per ton (as seen in the latest project approved in India), making substitution economically realistic by the end of the decade. By contrast, synthetic kerosene currently exceeds $2,000 per ton, compared to $700 per ton for fossil kerosene.

Reducing national dependency: By gradually replacing imports of grey ammonia with local low-carbon production, Morocco strengthens both its energy and industrial sovereignty.

Seizing export opportunities: With Europe, Asia, and Africa as natural markets, Morocco is positioning itself as a future leading supplier of green ammonia.

A Distinctive Moroccan Model

Unlike the European Union, which is primarily focused on quickly replacing fossil imports, Morocco has opted for a hybrid model:

The State provides an enabling environment: regulatory framework, land allocation (over 300,000 hectares already mobilized),

Private investors take on the risk: selected consortia commit only if projects are economically viable,

Infrastructure is coordinated and shared,

Industrial integration is promoted through the national investment charter,

Scaling is progressive: targeting competitive segments first (ammonia), and diversifying into derivatives such as methanol or synthetic kerosene in the medium term.

This strategy has already attracted a critical mass of interest: nearly 50 projects submitted for review, far exceeding initial expectations.

A Colossal Industrial and Employment Potential

Recent studies in Morocco show that each gigawatt of green hydrogen or ammonia capacity translates into $2–2.5 billion in investment and 35,000–40,000 direct, indirect, and induced jobs. With projections reaching 200 gigawatts by 2040, Morocco could generate more than 4 million jobs, with wide-ranging industrial impacts across the entire value chain: desalination, electrolysis, chemical synthesis, transport, storage, and port logistics.

This momentum will also foster local industries for the manufacturing of electrical components (transformers, inverters), mechanical parts (pumps, exchangers), and structural elements (turbine towers, wind blades). Achieving a 30% industrial integration rate would mean retaining nearly $60 billion directly within the national economy.

Universities and research centers such as UM6P, IRESEN, UIR, Euromed Fès, and Mohammed V University—alongside platforms like the Green Energy Park and the soon-to-be Green H2A—are already preparing a new generation of specialized engineers and technicians.

The parallel with the automotive and aerospace industries is clear: in just over a decade, Morocco has succeeded in building integrated value chains, capable of exporting and generating hundreds of thousands of jobs.

.

A Historic Opportunity for Morocco

Beyond decarbonizing its economy, Morocco now has the opportunity to become a regional energy and industrial hub. Thanks to its abundant sunshine, strong winds, Atlantic and Mediterranean coastlines, and a strategic vision embodied in the "Morocco Offer," the country can capture a significant share of the global value in a sector expected to weigh hundreds of billions of euros.

By betting on green ammonia and industrial integration, the Kingdom positions itself not only as an energy producer, but also as a generator of wealth, jobs, and technology.

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MOROCCO AND EUROPE:
BUILDING A GREEN HYDROGEN CORRIDOR FOR SHARED PROSPERITY

Green hydrogen has become central to the global energy transition. For Europe, it is both a strategic solution to decarbonise hard-to-abate industries and a lever to reinforce energy security. The European Union (EU) has set an ambitious target: by 2030, to produce 10 million tonnes of renewable hydrogen domestically and import another 10 million tonnes annually. Meeting this ambition requires strong and reliable partners.

Adrien de Bassompierre
Head of the European Investment Bank (EIB) Representation in Morocco

Morocco: a strategic partner for Europe

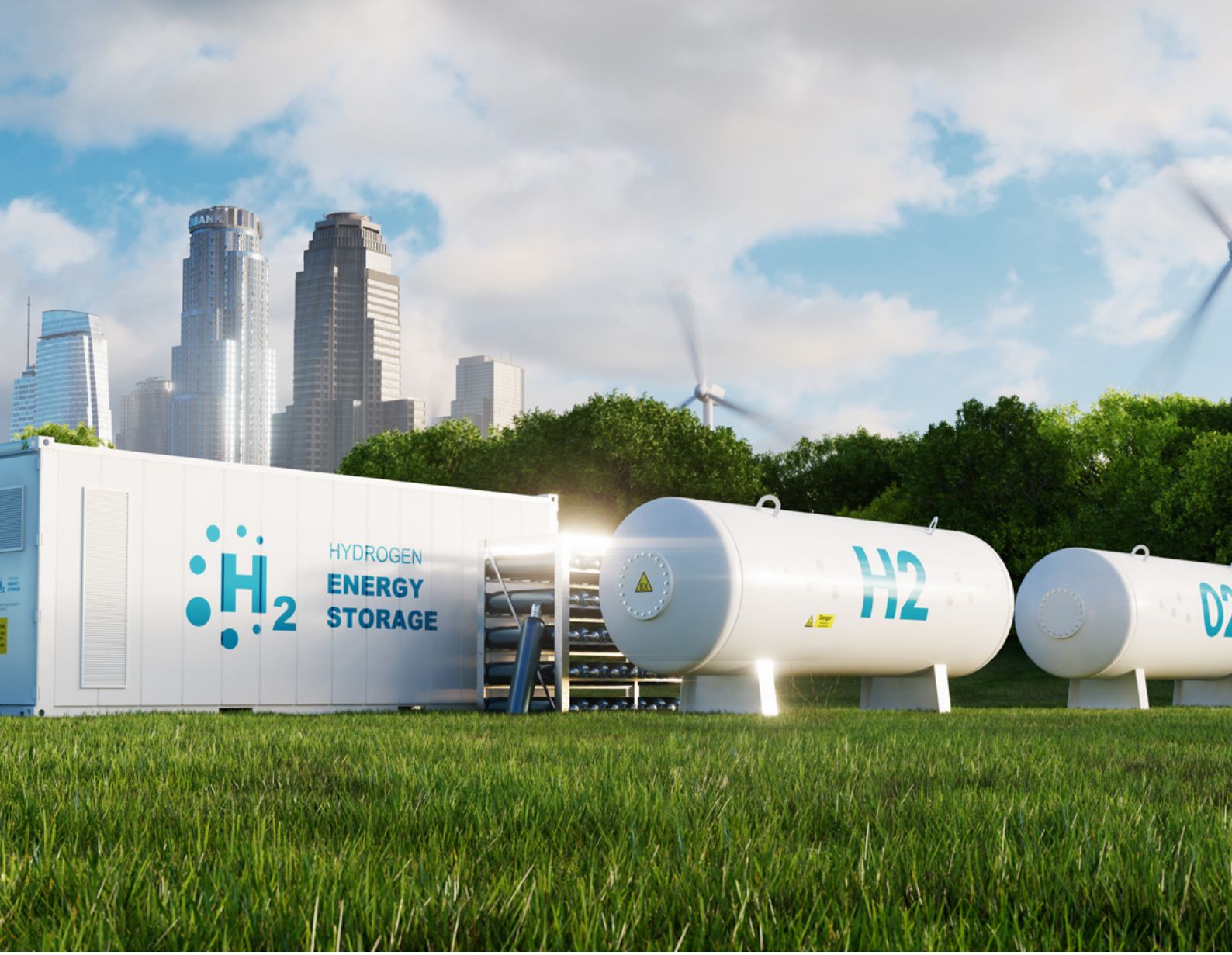
With world-class solar and wind resources, Morocco is exceptionally well positioned to play this role. Its geographical proximity and proven track record in renewable energy make it one of Europe's most natural partners. Over the past two decades, the European Investment Bank (EIB) has co-financed nearly all of Morocco's landmark renewable projects, helping to build the foundation for this new chapter in cooperation.

Today, the EU has put in place a comprehensive regulatory framework for renewable and low-carbon hydrogen. The Low-Carbon Hydrogen Delegated Act, adopted in July 2025, provides clarity for investors by requiring at least a 70% reduction in greenhouse gas emissions compared to conventional hydrogen. To better connect supply and demand, the EU has also launched the Hydrogen Mechanism, an IT platform open to international producers, including those in Morocco. Together, these measures are creating the conditions for a real hydrogen market to emerge.

Unlocking value chains and green industrialisation

For Morocco, green hydrogen is not just an export opportunity. It can also drive domestic decarbonisation —in sectors such as fertilisers, chemical and steel industries— while anchoring skills, technology transfers, and new green jobs. By fostering hydrogen clusters and industrial ecosystems, Morocco can accelerate its green industrialisation and strengthen its role as a regional leader.

This vision aligns with the EU–Morocco Green Partnership, under which Moroccan projects have already undergone pre-certification against EU standards and benefited from training, capacity building and study visits in Europe. These initiatives show that Morocco is well placed to meet the stringent requirements of international hydrogen markets from the very start.



Financing the next stage: reference projects and partnerships

Globally, low carbon hydrogen projects continue to face challenges related to cost and bankability. Production costs remain high compared to conventional hydrogen, and many large-scale projects struggle to close. The key to unlocking this market lies in reference projects: bankable investments that demonstrate technology at scale, secure offtake agreements, and pave the way for replication.

This is where the EIB can make a difference. As the EU's climate bank, we provide a broad range of financial instruments and advisory services to support both public infrastructure and private consortia. We are also working with EU initiatives and Member States to channel concessional financing and targeted subsidies that can help de-risk investments and make projects viable. Public–private partnerships will be essential to share risks and ensure the development of common infrastructure.

Our recent approvals — from large-scale clean energy storage in Spain to one of Latin America's largest green hydrogen fertiliser projects in Paraguay (110 MW of electrolysis) — illustrate the scale of what is now achievable. We hope to replicate this momentum in Morocco, with projects that demonstrate bankability and create long-term value for both Europe and Morocco.

A shared roadmap

The global hydrogen market is still nascent. Out of nearly 100 million tonnes of hydrogen consumed each year, only about 1% is currently green. The direction is clear: Europe and Morocco stand to benefit equally from closer cooperation, turning ambition into a true win-win partnership.

Looking ahead, the focus will be on a few critical priorities:

Deepen certification and carbon accounting to ensure transparency.

Develop coherent infrastructure, from industrial clusters to ports and interconnections.

Support reference projects with smart financing and long-term contracts.

Invest in skills and training to capture maximum local value.

Green hydrogen is more than a new energy source:

it is a bridge between Europe and Morocco, offering climate benefits, energy security and industrial opportunities. The EIB will remain at the heart of this partnership, financing innovation, infrastructure and cooperation to turn the hydrogen economy into reality.

HYDROGEN'S HYPE CURVE:
THE TECHNOLOGY IS SLIDING THROUGH GARTNER'S "TROUGH OF DISILLUSIONMENT"— BUT IT WILL CLIMB OUT

Jeffrey Beyer

Founder and Managing Director, Zest Associates

Technologies rarely rise in straight lines. They lurch through cycles of enthusiasm and despair. The Gartner hype curve captures this rhythm neatly: a promising "technology trigger" sparks wild claims; a "peak of inflated expectations" follows; then comes the crash into the "trough of disillusionment," before the survivors crawl up the "slope of enlightenment" toward a "plateau of productivity." Hydrogen is marching through that cycle in plain sight.

Trigger and peak

The trigger came around 2019–2020. Renewable power was suddenly cheap, electrolysers were scaling up, and net-zero pledges proliferated. Europe launched a hydrogen strategy; Japan revived its dream of a "hydrogen society"; the Gulf announced giga-projects to supply the world. Between 2020 and 2023, enthusiasm peaked. Press releases hailed "hydrogen valleys," mega-factories and global trade routes. Some even imagined hydrogen heating homes and fuelling hatchbacks.

The trough

Now comes the hangover. Costs remain high — green hydrogen at $4–6/kg struggles against grey hydrogen at less than half that. Supply chains for electrolysers are immature; renewable power is not always abundant; shipping hydrogen as ammonia or liquid gas is harder than it looks on a slide deck. Politics adds friction. America's Inflation Reduction Act promised generous tax credits but wrapped them in red tape. Europe set ambitious targets but has stumbled over permitting. Meanwhile, Russia's war in Ukraine jolted governments back to LNG, denting focus on longer-term hydrogen plans.

The result is familiar: projects delayed, pipelines thinning, and fewer reaching final investment decision. Smaller firms are squeezed; capital is consolidating around bigger players. The sector has tumbled into Gartner's trough of disillusionment.

Enlightenment ahead

But troughs are not graves. They are proving grounds. The lesson of every hype cycle — dotcoms, solar panels, even LNG — is that the froth burns off and discipline follows. Hydrogen is already narrowing to the markets where it makes sense. Michael Liebreich's "hydrogen ladder" is instructive: at the bottom are applications doomed to lose against batteries or heat pumps. At the top sit the hard-to-abate industries — steel, cement, shipping,

aviation, seasonal power storage — where hydrogen is not just viable but vital.

Signs of this recalibration are visible. ArcelorMittal is piloting hydrogen-based steelmaking. Shipping giants are ordering ammonia-fuelled vessels. Japan is pressing ahead with hydrogen imports to secure its energy future. The industry is climbing, slowly, onto the slope of enlightenment.

The plateau

Geography will decide who profits when hydrogen reaches its plateau of productivity. The Middle East is best placed. It has the world's cheapest solar and wind power, vast buildable land, and decades of experience delivering mega-projects. Oil and gas have left it with engineers who understand volatile gases, regulators who manage complex supply chains, and ports that link neatly to Europe and Asia. Saudi Arabia's NEOM project, Oman's green hydrogen plans, and the UAE's push to become a trading hub all rest on solid fundamentals, not hype.

The long view

Hydrogen is not dead, merely maturing. The days of frothy claims that it would fuel cars and heat homes are gone — and good riddance. What remains is a chastened, disciplined industry, zeroing in on the sectors where hydrogen is indispensable. Net zero cannot be achieved without it. The hype cycle predicts a slog, but also an eventual plateau. Hydrogen will get there, and the Middle East will likely dominate when it does.

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HydroJeel positions itself at the forefront of hydrogen solutions, with a clear ambition to foster the development of a promising industrial ecosystem.

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FROM SCARCITY TO ABUNDANCE:
A DESALINATION-POWERED GREEN HYDROGEN FUTURE

Dr. Jauad El Kharraz,

Co-Chair, Mediterranean Clean Energy Network (MEDCEN) Coordinator, TERAMED Initiative. CEO & Founder, Water-Energy-Climate Experts Network (WECEN)

In the face of escalating climate change, the Sustainable Development Goals (SDGs) underscore the urgent need for efficient, sustainable management of resources like water and energy. Water-stressed regions, such as the Middle East and North Africa (MENA), where 456 million people (5.6% of the global population) face rapid urbanization (59% urban in 2021) and 3% annual population growth, exemplify this challenge. Here, desalination emerges as a lifeline, converting seawater or brackish water into potable supplies, independent of climate variability, droughts, or geopolitical tensions. Unlike finite freshwater sources, oceans provide an inexhaustible reservoir, bolstering security for agriculture, industry, and households.

Yet, traditional desalination is energy-intensive, consuming up to 3-5 kWh per cubic meter and historically reliant on fossil fuels, contributing to CO2 emissions that have surged from near zero in 1725 to 35 gigatons annually by 2025.

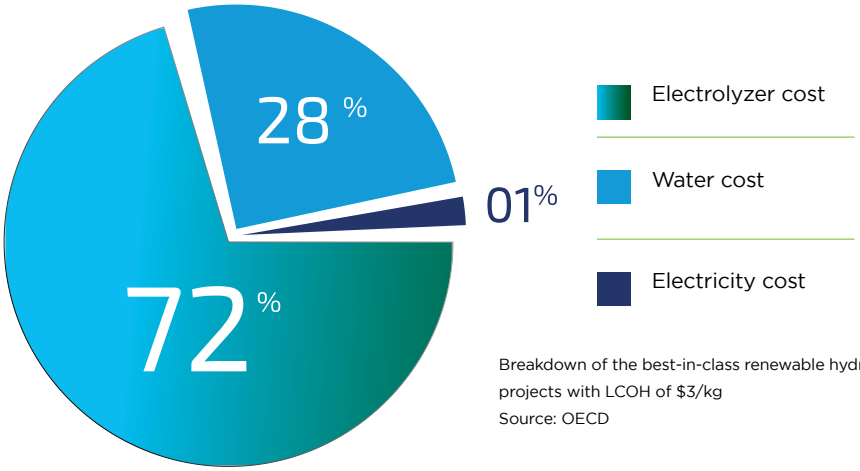
Environmental concerns, including brine disposal (1.5-2 times the volume of produced water) and emissions, have prompted a shift toward renewables. Solar photovoltaic (PV) and wind energy, with plummeting costs (solar PV dropping 89% since 2010 per IRENA) offer transformative potential in sun-rich MENA, where solar irradiation exceeds 2,000 kWh/m²/year. Hybrid systems integrating renewables can slash desalination costs by 20-30%, as seen in Morocco's OCP Group plans to produce 1 million tons of green ammonia by 2027 using solar-powered desalination.

The true revolution lies in desalination's synergy with green hydrogen production. Green hydrogen, generated via electrolysis using renewable electricity, requires 9-15 liters (without counting cooling water) of fresh water per kilogram; potentially straining resources in arid zones. Desalination fills this gap, enabling scalable production while optimizing efficiency. Co-located facilities leverage excess renewable power from desalination plants to drive electrolyzers, and waste heat or brine enhances hybrid processes. For instance, in water-scarce MENA, where electricity demand grows 6.3% annually, this integration could meet IRENA's estimate of $50-100 billion needed for green hydrogen infrastructure by 2030, supporting a 1 terawatt renewable target of the TERAMED initiative in the Mediterranean.

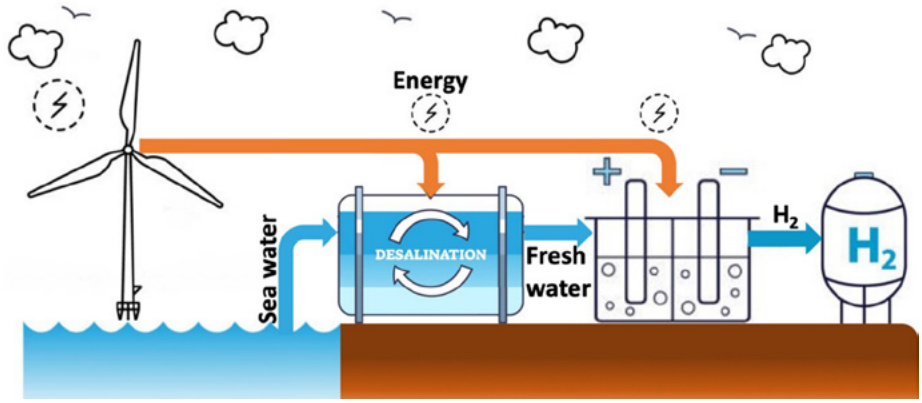
Morocco exemplifies this paradigm. Under its «Morocco Offer,» 1 million hectares of land are allocated for green hydrogen projects, with Phase 1 unlocking 300,000 hectares for 10 GW of renewables by 2030. Six projects approved on September 17, 2025, worth 319 billion MAD ($32 billion), include TAQA-Cepsa's ammonia initiative and Nareva's green steel production, all reliant on renewable desalination to address water needs. Similarly, Egypt's €7 billion EDF Renewables-Zero Waste deal for 1 million tons of green ammonia annually highlights the model's viability, though grid and certification challenges persist.

Economically, green hydrogen's levelized cost (LCOH) has fallen from $3-8/kg in 2020 to potentially $2.40/kg by 2030, per IRENA's 2020 report, driven by electrolyzer scaling (learning rate: 18%) and desalination improvements (15% learning rate). Desalination costs, at $0.50-1.00/m² for large-scale reverse osmosis, represent just 1% of hydrogen production expenses, allowing oversizing plants to supply communal water; turning projects into community benefactors.

To realize this vision, a holistic approach is vital: augmenting supply through tech like ProtiumSource's electrolyzer-ready water solutions, managing demand via efficiency, and fostering collaboration. Regulatory gaps, such as EU-aligned certification under RED II, must be bridged to ensure bankability. Regional case studies, such as those focusing on brine management strategies, highlight sustainability guidelines from UNIDO, with an emphasis on conducting water impact assessments and promoting local value creation.



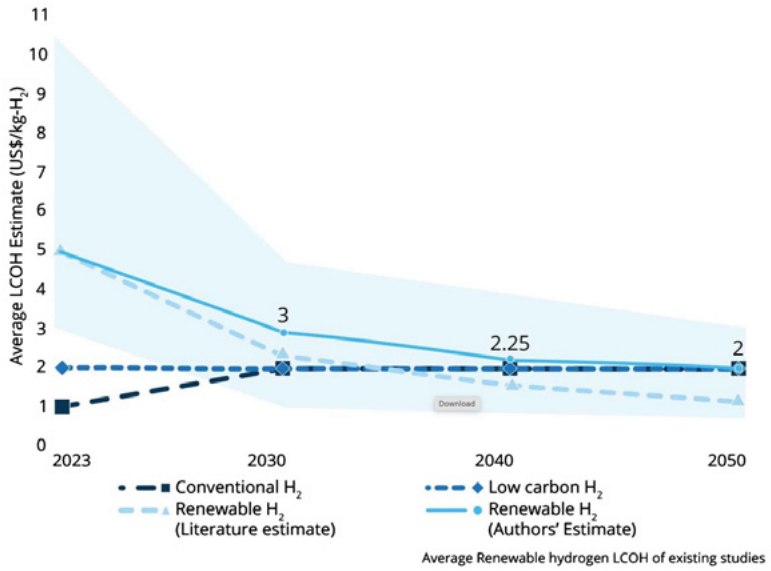
Breakdown of the best-in-class renewable hydrogen projects with LCOH of $3/kg
Source: OECD



From seawater to green hydrogen

Source: Yasemin Balcı, Celal Erbay, Green hydrogen production from offshore wind: A techno-economic analysis for Türkiye, International Journal of Hydrogen Energy, Volume 97,2025, Pages 377-390, ISSN 0360-3199, https://doi.org/10.1016/j.ijhydene.2024.11.431. (https://www.sciencedirect.com/science/article/pii/S0360319924051280)

Levelized Cost of Hydrogen (LCOH)

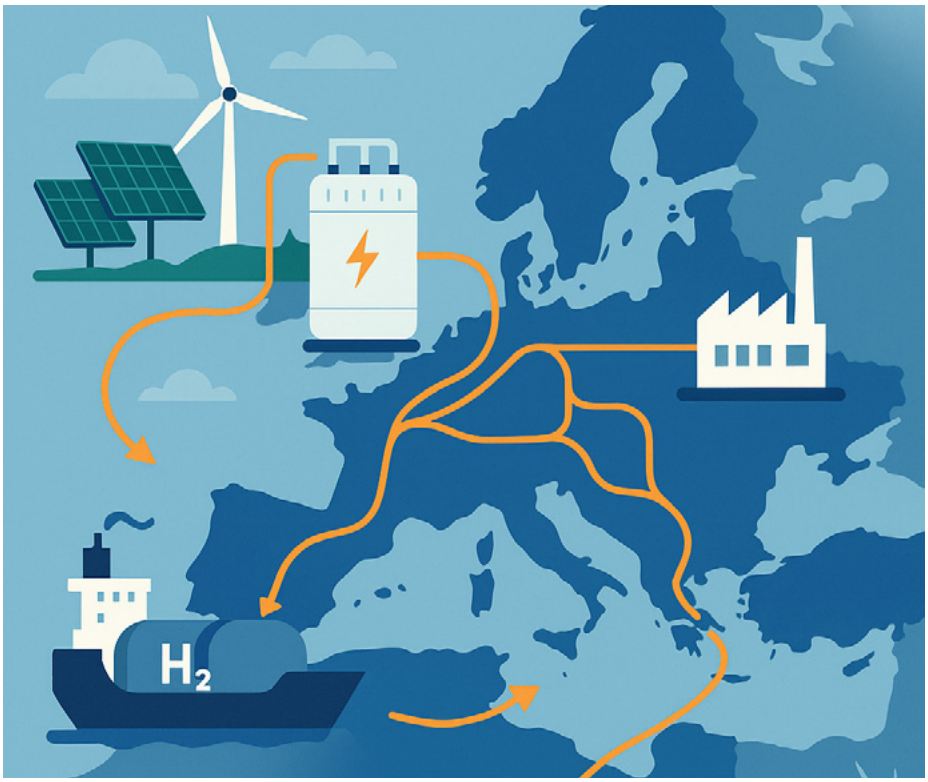


As the World Power-to-X Summit convenes in Marrakesh on October 1-2, 2025, hosted by IRESEN, these dynamics take center stage. By harnessing desalination for green hydrogen, MENA can pivot from scarcity to abundance, fostering a circular economy that decarbonizes energy, creates jobs (up to 10 million by 2050), and secures resources for generations. This transition demands bold policies, investments, and innovation; unleashing a sustainable future where water and energy converge for global resilience.

FROM MOLECULES TO MARGINS, HYDROGEN AS EUROPE'S COMPETITIVE EDGE

Hydrogen isn't just a laboratory topic or a decarbonization footnote. For Europe, it is a major industrial and geoeconomic variable. Since 2022, the upheaval in energy supply has laid bare a simple truth: economies that secure abundant, competitively priced energy gain industry, the others lose it. The United States enjoys a shale rent and a powerful set of incentives (IRA) that reshuffle competitiveness. Asia has consolidated supremacy in refining and transformation that feeds vast value chains. Europe, deprived of cheap Russian gas, pushed toward higher-priced LNG, and facing uncertainty on some raw materials, has seen energy costs rise and parts of heavy industry reconsider their footing. In this context, green hydrogen is not an add-on; it is an instrument of industrial reconquest.

Anas Abdoun
Strategy and energy consultant



What hydrogen changes in Europe's equation

Launched by the World Bank Group and Hydrogen's promise is not only environmental but economic: to substitute, where it makes sense, a decarbonized, scalable energy input for fossil molecules that are volatile and strategically risky while re-anchoring electro-intensive activities. To get there, Europe must align three elements: a competitive production base, "captive" industrial offtakers (steel, chemicals, fertilizers, glass, e-fuels), and above all low-cost, low-loss logistics. That is where transport becomes strategic.

Not all transport options are equal. On continuous flows and continental distances, pipelines are the most economical for large volumes. Levelized costs per 1,000 km undercut maritime chains because the latter stack conversion steps (to ammonia or liquid hydrogen), shipping, storage, and reconversion losses that materially raise the delivered cost. Pipelines, when well utilized, keep technical losses and opex contained and scale predictably as volumes grow. This cost logic matters more as Europe seeks to rebuild an energy base that can support competitive steel, chemicals, and advanced materials within its borders.

Europe is not starting from scratch. The European Hydrogen Backbone (EHB) envisions a continental grid that, by the mid-to-late 2030s, blends new pipes with a repurposing of a large share of existing gas lines. Multiple studies converge on the same order of magnitude: repurposing a gas pipeline for hydrogen costs roughly 10–25% of a newbuild, a decisive advantage for the infrastructure bill and for shortening time-to-market. By 2040, most of the envisaged hydrogen network could consist of such repurposed stretches. This logic is already taking shape with H2Med and its BarMar section (Barcelona–Marseille), designed to push significant volumes of hydrogen from the Iberian Peninsula into France, an emblematic northbound corridor that couples EU backing with TSO execution. In parallel, Germany has locked in a Hydrogen Core Network (around 9,700 km by the late 2030s), financed via a dedicated tariff model and public guarantees, with a majority of assets coming from repurposed gas infrastructure. Aligning regulation and tariffing in this way gives shippers and financiers the long-term visibility needed to commit capital.

Why the southern Mediterranean is Europe's "proximity advantage"

Production geography will shape delivered costs. Low-cost champions frequently cited include Chile, Australia/New Zealand, Namibia and Morocco. Yet they do not compete on the same logistics board. Geographic proximity is a cost advantage whenever a pipeline can replace maritime chains exposed to shipping cycles and conversion losses. Imports from southern Africa, for instance, are often envisaged as ammonia (ship NH_3, then crack back to H_2), a workable but structurally costlier route than direct pipeline delivery from a neighbor. The southern Mediterranean, by contrast, offers a "proximity advantage" that Europe has under-leveraged.

Morocco stands out because it combines three assets: world-class wind and solar resources, advanced physical and regulatory interconnection with Europe, and pipeline-compatible distance to demand centers. The wind/solar pairing reduces the need for gas back-up and smooths intermittency; meanwhile, repurposing existing gas corridors (in the EHB spirit) compresses transport CAPEX. Morocco's long-running institutional depth in renewables strengthens bankability and execution. In short: for Europe, it is not just about finding cheap electrons to split; it is about placing molecules on the doorstep of industry at the lowest delivered cost.

For a German steelmaker or a French chemicals producer, delivered cost governs the choice between importing hydrogen and offshoring production. Stitching together robust European and academic benchmarks yields a practical rule of thumb: every 1,000 km of well-utilized pipeline typically adds only a few tens of euro-cents per kilogram, whereas maritime chains can add €1–2/kg or more once you include liquefaction/synthesis, shipping, storage, and reconversion highly sensitive to capital costs and load factors. Translated into an energy basis, that pipeline advantage represents tens of euros per MWh saved, i.e., margin points restored to European industrial balance sheets. In a post-2022 world, where Europe's gas mix is dominated by Norwegian pipeline gas and LNG (heavily American) and remains vulnerable to seasonal dynamics and global LNG tightness, reducing exposure to spot-driven LNG with a stable, amortizable H_2 pipeline corridor is as much a competitiveness hedge as an energy-security choice.

From theory to execution: what a "H2-competitive" Europe would do

What would a "H_2-competitive" Europe do, concretely? First, lock in demand. Build anchor volumes in steel, low-carbon ammonia, and e-fuels through long-term contracts and Contracts for Difference that stabilize the spread versus fossil alternatives. Without guaranteed offtake, no pipeline reaches final investment decision. Second, secure nearby supply. Develop H_2 platforms in Morocco (with a complementary logic in Mauritania) built around pooled electrolysis, clear land-use regimes, HVDC tie-ins, and front-end engineering for a pipeline corridor aligned with existing gas routes. The EU's regulatory and funding toolbox for hydrogen infrastructure (from PCIs to the EHB) should explicitly anchor a "Maghreb–Europe" corridor, eligible for CEF/EBI windows under the EU–Morocco Green Partnership. Third, align pricing and governance. Follow the German example: define a core network, set a dedicated tariff framework and public risk-sharing to catalyze private capital. On the European side, ensure H2Med meshes into a southern import spine ready to absorb Maghreb molecules; on the Moroccan side, articulate an offer that combines long-term price floors, physical delivery reliability, and co-location of electro-intensive industry to capture part of the value chain locally strengthening both sides' political economy.

Amid discussion of electrolyzers, capacity factors, and catalysts, it is easy to miss the point: green hydrogen is an industrial policy. Europe's success will not be decided by chemistry alone, but by a pragmatic triad—low-cost production sites, pipeline-compatible logistics, and twenty-year industrial contracts. On that score, the Maghreb, above all Morocco, acts as a competitiveness multiplier: it lowers transport CAPEX (repurposing beats newbuild), minimizes energy losses, compresses logistics OPEX, and places molecules within reach of Europe's industrial heartlands. If Europe wants not only to meet climate goals but to re-emerge as a competitive home for heavy industry, it does not have to wait for a miracle. It must finish its H_2 grid, anchor demand, and treat the southern Mediterranean as its strategic energy hinterland. In ten years, success will be measured not by promises, but by pipelines laid, contracts signed, and factories that chose Europe, thanks to hydrogen, over exit.

POST-HYPE REALISM: WHICH ECONOMICALLY SUSTAINABLE ROLES NOW FOR ELECTROLYTIC HYDROGEN AND E-FUELS?

In IEA´s 2019 Future of Hydrogen report, CAPEX assumptions for installed electrolysers were 900 USD/kW for 2019, 700 USD/kW for 2030 and 450 USD/kW for 2050. Inspired in part by the rapid cost declines observed for wind and solar electricity, many companies and governments made very optimistic deployment plans for electrolysers, hydrogen and e-fuels. However, things evolved quite differently. In IEA´s Global Hydrogen Review 2025 published last month, the median CAPEX figure (outside China), was 2400 USD/kW for 2024 and 1300 USD/kW for 2030. Even adjusting by the 6 years's 27% cumulative inflation, this key figure had increased by a solid 2.5 times.

Julien Armijo

Former IEA analyst, co-founder and CEO, The Climate Tech Observator

The hydrogen bubble´s deflation

That underestimation, largely caused by the neglection of costs besides electrolyser´s stacks (balance of plant, engineering, construction) was only one of several overlooked unpleasant hydrogen "realities". Being the lightest of molecules, its transport, storage and handling at any stage are always complex and costly. Powering electrolysers with intermittent renewable electricity adds further hurdles that contributed to reduce efficiencies, increase the costs and deflate the hype.

As a result, many announced projects have been abandoned, and a natural selection of economically relevant markets for clean hydrogen took place. For road transport, battery electric cars have largely won the race, because of their 2.5 times better power-to-wheel efficiency. Direct electrification also dominated residential heating, and hydrogen blending in gas networks has lost most credibility. In general, distributed and small-scale uses of hydrogen have proven largely uncompetitive, due to the need for expensive and missing infrastructures.

Resilient roles for decarbonizing chemicals, steel, shipping, aviation

On the other hand, hydrogen and e-fuels have consolidated their relevance to decarbonize heavy industry and long-range transport, both sectors that can hardly be electrified directly. Oil refineries, today the largest hydrogen consumers, are now an important source of demand for clean hydrogen.

Most importantly, the production of base chemicals (ammonia and methanol) and steel, are the major share of clean hydrogen projects having reached FID (1.6 Mt H2 by 2030). Methanol and ammonia are also being importantly considered as alternative fuels to decarbonize shipping, while aviation is increasingly pulling demand for e-kerosene.

where for methanol and kerosene, similar volumes would be produced from bioenergy. In total, this rough scenario would create demand for 200 Mt of clean hydrogen, a large part of which could be electrolytic.

Table 1 presents a rough illustrative picture of possible future demand for clean hydrogen, with assumptions resembling IEA´s Net Zero scenario:

30% of current refining

100% of ammonia production

30% of shipping switching to ammonia

50% of primary steel (600 Mt) switching to hydrogen-based direct reduction,

100% of methanol production (for chemicals and shipping),

50% 50% of aviation switching to e-kerosene,

	refining	e-NH3	e-NH3 (ship)	steel	e-methanol	e-kerosene
Demand X (EJ)	-	3.4	3	-	2	6
Demand X (Mt)	-	180	160	600	100	140
kg H2/kg X	-	0.18	0.18	0.08	0.19	0.44
Demand H2 (Mt)	12	32	28	48	19	61

Table 1:
Possible long-term global demand for clean H2 from major relevant sectors. Source: author's guess.

Demand creation is the key enabler – and sustainable carbon a major emerging bottleneck

In general, P-to-X products are not expected to be cost-competitive against their fossil counterparts, presenting a substantial "green premium" (often +50% to +500%), even in the presence of carbon pricing. It thus appears increasingly crucial for the climate transition that policy drive (e.g. public procurement, subsidies, quotas of incorporation) and private offtake agreements, especially via "lead markets", having higher ability to pay more, are deployed in synergy.

One example of successful demand consolidation is Swedish Stegra, now building the largest electrolyser in Europe (700 MW), thanks to the voluntary commitments of several car manufacturers to purchase their green steel from 2026. Carbon pricing, and other major regulations, such as the IMO Net Zero Framework expected this October, or the EU's REFuelEU and FuelEU Maritime, are key policy drivers of demand creation.

A major bottleneck, however, is the availability of biomass (especially of second generation, i.e., based on residues and wastes), which is the only affordable source today of sustainable carbon for the production of methanol, e-kerosene, etc., as direct carbon capture is still prohibitively expensive. For example, while 60 methanol-powered large ships are already in the water, and 300 more coming, orders are already slowing down due to insufficient foreseeable low carbon methanol supply. This topic could well deserve closer scrutiny rapidly to allow shaping of viable investments and strategies.

POWER-TO-X SUMMIT 2025: NAVIGATING CHALLENGES AND OPPORTUNITIES IN THE GLOBAL HYDROGEN TRANSITION

IRESEN Editorial team

Fatih Birol, Executive Director of the International Energy Agency (IEA)

More than 2000 attendees and 125 speakers from 40 countries are expected to attend the fifth edition of the Power to X Summit on 1-2 October in Marrakesh. The conference comes amidst a global slowdown in implementing clean hydrogen projects; however, signs of growth persist,as the International Energy Agency (IEA) noted in its final Global Hydrogen Review 2025.

Even though cancellations and delays in the last year lowered the expected global clean hydrogen production by 2030 from 49 to 37 million tonnes annually, the number of projects that received FIDs since October 2024 grew by almost 20%, representing 9% of the projects in the pipeline to 2030; the total number of projects that received FIDs since 2020 has exceeded 200 now. As the IEA report suggested, effective policies to create demand and facilitate offtake contracts are needed now for clean hydrogen to fulfill its potential by 2030.

The main themes of the summit reflect the current situation, as they range from advancing the green hydrogen Morocco Offer, to securing green hydrogen deals, unlocking financial mechanisms, and infrastructure pathways for the global clean hydrogen market, as well as accelerating breakthroughs in science, technology, and innovation.

Responding to these themes, the summit program offers a diversity of panels about policies, finance, infrastructure and technology, as some of the panels will cover ways to harmonize strategies between countries of demand and supply, as well as de-risking and financing mechanisms, while others will discuss building Power-to-X corridors through pipelines and ports, as well as utilizing green molecules to decarbonize hard-to-abate industries.

As the fifth edition of the Power-to-X Summit convenes in Marrakech, there is a chance that the summit will not only serve as a platform to assess the state of the global hydrogen industry but also as a step to advance the Power-to-X plans. Against a backdrop of setbacks and new momentum, the gathering underscores the urgency of aligning policies, financing, and infrastructure to unlock the full potential of clean hydrogen by 2030. With the experiences the different actors have had in the last five years, the summit is set to highlight the challenges and opportunities in building a sustainable global hydrogen economy.

The summit will host national, regional, and global high-level speakers representing governmental entities, multilateral banks, private companies, regional cooperation organizations, and international agencies. In parallel to the summit, the 10th edition of the International Renewable & Sustainable Energy Technology & Science Conference (IRSEC'X) will take place in the same venue, hosting around 500 researchers, Ph.D. candidates, and practitioners presenting research on the most urgent topics in green hydrogen, Power-to-X technologies, carbon capture, energy storage, AI in energy systems, and the water-energy nexus.

The summit comes when Morocco pushes through its green hydrogen plans. On 17 September, the Steering Committee responsible for the Morocco Offer approved moving to the second phase in the preparation of the "Chbika 1" project, owned by a consortium of Danish and French entities - including TotalEnergies - after the completion of the preliminary study phase, moving now to the advanced study phase of the project. The committee also agreed to sign initial contracts to allocate lots of land for six projects owned by five foreign and national consortia and companies, which were announced last March.

GREEN HYDROGEN IN MOROCCO: NAVIGATING POSSIBLE POTENTIAL AND CHALLENGING REALITY

IRESEN Editorial team

It has been almost seven years since Morocco began exploring its potential for producing green hydrogen and its derivatives. In 2018, two preliminary studies were conducted as part of the German-Moroccan Energy Partnership Program. Both studies highlighted Morocco's potential to capture 2–4% of the global Power-to-X market and underscored the possible impact on the national economy through the creation of a dedicated industrial ecosystem around green hydrogen and its derivatives. This potential is rooted in Morocco's geographical proximity to Europe—a key potential consumer—and its abundance of renewable energy resources, with the capacity to generate up to 60,500 terawatt-hours annually from solar and wind. Much has changed locally and globally since then. Green hydrogen has demonstrated both promising potential and challenging realities.

The promise of green hydrogen for Morocco can be summarized in two key points: first, transforming the country from an energy importer into an energy exporter; and second, building an industrial ecosystem that supports broader industrial development. These points were reflected in the Moroccan Green Hydrogen Roadmap published in 2021. The document projected the total demand for Moroccan green hydrogen to reach 13.9 terawatt-hours by 2030 and 153.9 terawatt-hours by 2050. Meeting this demand will require cumulative investments of 90 billion dirhams by 2030 and 762 billion dirhams by 2050. Around 75% of this demand is expected to be for export, with the remainder for domestic use—primarily in the fertilizer industry.

Despite the emphasis on exports, domestic demand remains critical, as it provides a stable foundation for hydrogen production in Morocco. The fertilizer industry, led by OCP—Morocco's largest phosphate and fertilizer producer—is expected to drive this demand. OCP currently imports over 2 million tonnes of ammonia annually. Producing ammonia locally from green hydrogen could reduce fertilizer production costs and ensure compliance with carbon regulations such as the EU's Carbon Border Adjustment Mechanism (CBAM). Other sectors, including transportation, power generation and storage, and chemicals, are also anticipated to contribute to domestic demand in the long term.

However, since the Roadmap's release, the reality of developing a green hydrogen industry has proven more challenging than initially expected. Although the number of announced projects has grown globally, the cost gap between green hydrogen and conventional alternatives remains wide—wider than current government subsidies can bridge. This has led to more project delays and cancellations than final investment decisions. As a result, potential offtakers have been hesitant to commit to long-term contracts at the high prices currently associated with green hydrogen. The slow development of a hydrogen market has also prevented electrolyzer manufacturers from benefiting from economies of scale, keeping their costs high.

Nevertheless, recent policy developments may strengthen the business case for green hydrogen by 2030. These include the EU Renewable Energy Directive (RED III), Japan's Contracts for Difference (CfD) mechanism, South Korea's Clean Hydrogen Portfolio Standard (CHPS), and the U.S. Inflation Reduction Act (IRA), as was suggested in a recent analysis by the Hydrogen Council. Moreover, sectors already using conventional hydrogen—such as ammonia production and petroleum refining—could act as early adopters, driven by regulatory pressure to reduce emissions.

These global challenges have likely contributed to the slow progress of Morocco's hydrogen sector since 2021. However, a major turning point came with the launch of the Morocco Offer in March 2024. The Morocco Offer outlines a framework for developing the hydrogen value chain and is tailored to the needs of both domestic and foreign investors. Under this framework, the government allocated 1 million hectares for green hydrogen projects—300,000 hectares in the first phase. The Moroccan Agency for Sustainable Energy (MASEN) was appointed as the central point of contact for investors, facilitating coordination with other relevant government bodies. A Ministerial Steering Committee was also established to oversee the implementation of the Morocco Offer and to select projects from submitted proposals. The framework details a thorough process for evaluating and approving projects prior to implementation.

The Morocco Offer reflects two key principles. First, the state's role is to enable sector development by providing land, studies, regulations, infrastructure, and political support, while private investment drives actual project implementation. Infrastructure development will be carried out under public-private partnerships involving both national and international players. Second, local industrial integration is a core criterion for project selection. Proposals are assessed based on their contribution to local industrial development, regional economic benefits, and financial returns to the state.

A year after the Morocco Offer's launch, five national and international companies and consortia were selected to develop six projects worth $32.8 billion across the southern regions of Guelmim-Oued Noun, Laayoune-Sakia El Hamra, and Dakhla-Oued Eddahab. These projects will focus on producing green ammonia, synthetic fuels, and green steel. All six are currently in the study phase, pending final investment decisions. Two earlier projects had already been announced: one by TotalEnergies and another through a partnership between Engie and OCP. According to L'Economiste, the steering committee is now reviewing additional project proposals.

The projects' focus on producing green hydrogen derivatives—such as ammonia, synthetic fuels, and green steel—reflects a pragmatic approach for the short and medium term. These commodities are easier to transport than gaseous or liquid hydrogen, which require significant infrastructure and technological advancement. Moreover, they offer higher added value than exporting hydrogen in its pure form. Still, the key to moving these projects forward will be securing offtake agreements, which are essential for reaching final investment decisions and starting implementation.

GREEN HYDROGEN IN MOROCCO: LEGAL FRAMEWORK CHALLENGE

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Morocco does not have a legal and regulatory framework specific to green hydrogen. Year after year, Morocco is laying the foundation to become a green hydrogen powerhouse in Africa and in the world, through its National Hydrogen Strategy launched in 2021 aiming to convert Morocco in a top green exporter by 2030, several private and public initiatives in research and development aiming to develop green hydrogen in Morocco, the establishment of global partnerships with foreign countries like Germany, France and the Netherland and the attraction of private sector companies' investments in large scale hydrogen projects in the south of Morocco.

Last year, the Moroccan government issued the "Moroccan Offer", which covers the entire value chain of the green hydrogen sector and gives incentives to investors wishing to produce hydrogen and its derivatives in Morocco for the domestic market but also for export.

As green hydrogen is produced entirely from renewable resources, Morocco has also strengthened its legal framework relating to renewable energy in 2023 introducing the possibility for plant operators to request certificates of origin that prove to consumers that electricity produced has a renewable energy origin, and reformed its Investment Charter in 2022 to implement the main investment support scheme for renewable energy projects.

However, many experts and researchers indicate that the major obstacle to the rapid deployment of green hydrogen is the uncertainty around the market demand due to high production costs and the fact that the large-scale projects depend on export market, particularly Europe and lack of a clear regulatory framework.

A robust regulatory framework for green hydrogen covering for instance production, storage, transport, infrastructure and a traceability system of the origin of the green hydrogen, will reduce such uncertainty.

Specific regulations provide a stable and predictable environment which will enhance investor's confidence in the Moroccan market, encourage private investments and help export market access by aligning with international standards.

An integrated regulation is fundamental to coordinate production, storage and transport in the green hydrogen sector including the allocation of the land and construction of pipelines and export terminals.

Recognizing this, the Moroccan authorities and specifically the Cluster Green H2 and the National Hydrogen Commission are currently working together on the preparation of a Moroccan legal framework for green hydrogen. The transition to green hydrogen is not only a technological and infrastructural challenge but also a specific regulatory challenge.

DAKHLA PLUGS INTO THE FUTURE: A HYBRID SOLAR-WIND FARM DRIVEN BY NECIM INVEST

Dakhla, Morocco — At a time when the global energy transition is no longer optional but essential, Dakhla is positioning itself as a strategic anchor point for Morocco's renewable energy expansion. The launch of a hybrid solar-wind farm in the region embodies this ambition, combining photovoltaic and wind technologies to deliver stable, flexible, and sustainable power generation.

A Hybrid Farm to Stabilize Energy Supply

The farm will combine high-efficiency solar panels with wind turbines tailored to the Atlantic coast's wind conditions. This hybridization smooths out production: when the wind weakens, solar takes over; when sunlight drops, wind compensates. By blending these complementary sources, the site ensures more consistent output, reduces fluctuations, and strengthens the reliability of the local grid.

Beyond electricity production, the project is aligned with regional development goals: electrifying rural and peri-urban zones, supporting the growth of industrial and logistics infrastructure in Dakhla, and enabling projects such as desalination or greenhouse-based agriculture — all major consumers of clean energy.

Dakhla: Anchoring Green Regional Growth

Dakhla is evolving from a tourist destination and Atlantic gateway into a genuine energy corridor. Its coastal location with steady winds makes it ideal for wind farms, while its high solar irradiation places it among the best candidates for solar installations.

The project will drive territorial development by creating local jobs (construction, maintenance, engineering), training a skilled workforce, and boosting the region's green economy.

Its impact is twofold: strengthening regional energy independence — with fewer transport losses and less reliance on fossil fuels — while positioning Dakhla as a hub for clean innovation capable of attracting research centers, renewable energy startups, and future projects in green hydrogen or Power-to-X.

NECIM Invest: Catalyst, Investor, Facilitator

At the heart of the initiative is NECIM Invest, whose role goes beyond capital injection. Since its creation, NECIM Invest has dedicated itself to identifying, financing, and structuring high-impact environmental and social projects across Morocco and Africa. With expertise in financial structuring, public-private partnerships, and risk management, it acts as a true catalyst of the energy transition.

In Dakhla, NECIM Invest is engaged on several fronts:

Structuring: business planning, financial modeling, consultation with local authorities (region, Wilaya, municipalities), and technical partners.

Financing: mobilizing equity and external co-financing (local banks, green investment funds, international lenders).

Technical supervision and management: equipment selection, team recruitment, and oversight of construction.

Institutional and social support: community dialogue, training programs, social and environmental benefits, compliance with standards and certifications.

Challenges and Prospects

The success of this hybrid farm will be a test of technological and economic maturity. It must prove that production costs (CAPEX + OPEX) are competitive, that stable generation makes the investment viable, and that the social benefits (jobs, local development) give it strong legitimacy.

In the long run, the project could become a springboard for hybrid farms integrated with green hydrogen hubs — particularly if paired with electrolysis. Given its geographic proximity and maritime infrastructure, Dakhla could emerge as a major hydrogen export site to Europe.

The hybrid solar-wind farm in Dakhla is symbolic of Morocco's evolution — from energy consumer to producer of clean, innovative, and exportable power. Thanks to NECIM Invest's strategic commitment, the project has the structure, rigor, and vision needed to transform Dakhla's natural potential into a tangible success — for the region, for Morocco, and for the global cause of the energy transition.

NAREVA

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Pioneering renewables and **water**
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