WORLD ENERGY COUNCIL

EXECUTIVE SUMMARY

WORLD ENERGY INSIGHTS: WORKING PAPER

REGIONAL INSIGHTS INTO LOW-CARBON HYDROGEN SCALE UP

In collaboration with PwC and EPRI

ABOUT

WORLD ENERGY COUNCIL

The World Energy Council has been at the heart of global, regional and national energy debates for nearly a century, developing new thinking and driving effective action around the world to achieve the benefits of sustainable energy for all.

Comprised of over 3,000 member organisations in nearly 90 countries, drawn from governments, private and state corporations, academia and new and wider system shapers stakeholders, the Council is the world's first and only truly global member-based energy network.

The Council works dynamically across the whole energy sector as a global energy transitions platform, pulling together intelligent leadership to catalyse and inform the world's energy policy dialogue, create impact and drive practical action.

The Council does not advocate for any country, company, technology or source of energy. The World Energy Council remains thoroughly committed to the challenge of being both impartial and impactful.

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World Energy Council
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Registered Office
62–64 Cornhill
London EC3V 3NH
United Kingdom

THE WORLD ENERGY INSIGHTS

These World Energy Insights on hydrogen are part of a series of publications by the World Energy Council focused on Innovation. They were developed in collaboration with the Electric Power Research Institute (EPRI) and PwC.

EPRI and Gas Technology Institute (GTI) have created the Low-Carbon Resources Initiative (LCRI) to address the challenges and gaps in achieving deep carbon reductions across the energy economy. LCRI is focused on the value chain of alternative energy carriers and low-carbon fuels—such as hydrogen, ammonia, biofuels (including renewable natural gas), and synthetic fuels—and research, development, and demonstration to enable their production, storage, delivery, and use across the energy economy. These energy carriers/fuels are needed to enable affordable pathways to economy-wide decarbonization by mid-century. This five-year, global collaborative will identify and accelerate fundamental development of promising technologies; demonstrate and assess the performance of key technologies and processes, identifying pathways to possible improvements; and inform key stakeholders and the public about technology options and potential pathways to a low-carbon future.

PwC is a network of firms in 155 countries with over 284,000 people committed to delivering quality in assurance, advisory and tax services, including more than 20,000 professionals engaged in the energy, utilities and resources sectors. With its global strategy, The New Equation, PwC is responding to the challenges shaping the world today, with a focus on building trust and delivering sustained outcomes that create value for organisations, their stakeholders and broader society. Climate change is one of the world's most pressing problems, and PwC has committed to reach net zero greenhouse gas emissions by 2030 and is working with organisations to accelerate their own climate-based transformation. PwC and the World Energy Council have a common goal of promoting energy transition and sustainability by engaging with policymakers and leading industry players. Our shared view is that energy transition and sustainability are achieved through the interaction of robust policy frameworks and a strong, competitive energy industry. Learn more about PwC

In a fast-paced era of disruptive changes, these insights aim to facilitate strategic sharing of knowledge between the Council's members and the other energy stakeholders and policy shapers and contribute to a global dialogue on hydrogen's role in energy transitions. These insights build upon earlier work by the Council, notably the release of the "Hydrogen on the Horizon" series in July and September 2021, and involved regional in-depth conversations with 180+ high-level experts from 67 countries, reflecting 82% of the global Total Primary Energy Supply – TPES (2019 data, U.S. EIA) and 89% of global GDP (2020 data, WB).

The analysis and forecasts available in this publication and any associated references do not reflect the military conflict occurring in Ukraine. Although we acknowledge that the situation in Ukraine and the resulting disruptions in energy markets will greatly affect the future of low-carbon hydrogen, this release is based on analysis prior to the February 2022 events.

EXECUTIVE SUMMARY

TAKEAWAYS

- Low-carbon hydrogen can play a significant role by 2040 across the world, to support countries' efforts to achieve the Paris Agreement goals whilst contributing to the diversity and security of their energy portfolios. This would require significant global trade flows of hydrogen and hydrogen-based fuels.
- The momentum is continuing to grow worldwide, but differences are seen between regions – based on differing market activities and opportunities.
- Moving from "whether" to "how" to develop low-carbon hydrogen highlights significant uncertainties, which need to be addressed if hydrogen is to reach its full potential. Can the challenges in various supply chain options be overcome? Can hydrogen play a role in tackling climate change in the short term? Can bankable projects emerge and the gap between engineers and financers be bridged? Can the stability of supply of the main low-carbon hydrogen production sources be guaranteed?
- Enabling low-carbon hydrogen at scale would notably require greater coordination and cooperation between stakeholders worldwide, to better mobilise public and private finance, and to shift the focus to end-users and people: by moving from production cost to end-use price, developing Guarantees of Origin schemes with sustainability requirements, developing a global monitoring and reporting tool on low-carbon hydrogen projects and better considering social impacts alongside economic opportunities.

By 2040, low-carbon hydrogen[1] could play a significant role in energy systems and energy transitions across the world. In the context of energy transition, it serves to support countries' efforts to achieve the Paris Agreement goals whilst contributing to the diversity and security of their energy portfolios.

The World Energy Council, in collaboration with EPRI and PwC, aims to provide new and critical insights to facilitate strategic sharing of knowledge between the Council's members and the other energy stakeholders and policy shapers, and contribute to a global dialogue on hydrogen's potential role in energy systems and in energy transitions. Following the release of the "Hydrogen on the Horizon" series in July and September 2021, the World Energy Council, EPRI and PwC, led a series of regional deep dives to better understand regional differences into low-carbon hydrogen development. These regional deep dives helped uncover the regional richness, differing dynamics for low-carbon hydrogen uptake and distinctive challenges and opportunities. These "regional paths" also provided new insights into the global scaling up of low-carbon hydrogen in the coming years, and its potential role in achieving the Sustainable Development Goals.

These news findings are synthesised in these World Energy Insights on Hydrogen.

Note on the Military Conflict in Ukraine
The analysis and forecasts available in this publication and any associated references do not reflect the military conflict occurring in Ukraine. Although we acknowledge that the situation in Ukraine and the resulting disruptions in energy markets will greatly affect the future of low-carbon hydrogen, this release is based on analysis prior to the February 2022 events.

[1] *"Low-carbon hydrogen" in this briefing encompasses all hydrogen production technologies and sources resulting in low carbon emissions: from renewable energy sources, nuclear, fossils combined with CCUS, etc.*

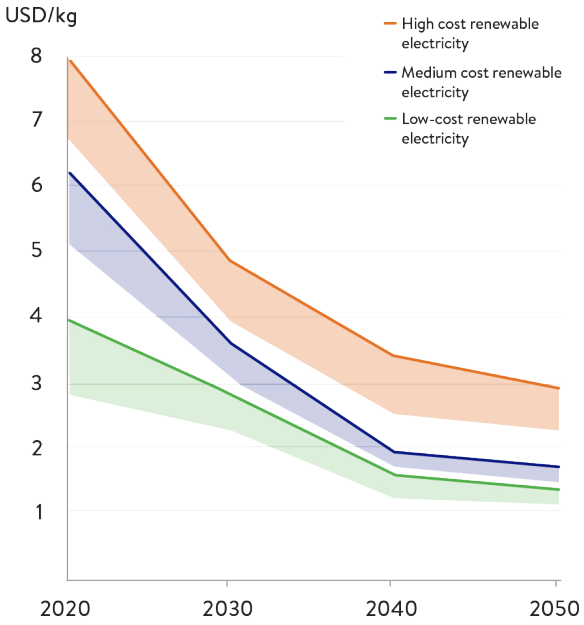
POTENTIAL FOR A SIGNIFICANT ROLE BY 2040

Building upon early technology deployment taking place today, by 2040 the demand for low-carbon hydrogen may exceed the current demand for fossil-based hydrogen today. In addition to replacing existing fossil-based hydrogen uses, low-carbon hydrogen opens opportunities for applications in new end-uses in a decarbonising world: moving from pilot projects to deployment at scale in sectors such as medium- and heavy-duty land transport, petrochemicals, iron and steel, rail, maritime shipping, and aviation. In some parts of the world, low-carbon hydrogen, pure or blended with natural gas, could also take off as a fuel for power generation, for industrial processes and for heating buildings.

The extent to which low-carbon hydrogen fulfils its potential depends heavily on the evolution of its key production technologies. Low-carbon hydrogen use could come from electrolysis (using renewable or nuclear generated electricity) or from fossil fuels with CCUS. The relative economics will depend largely on the resources available locally or on the lowest cost import option when local supply cannot fulfil local demand. The most cost-effective low-carbon hydrogen technology and transport method will vary in each region and could change over time as the cost of low-carbon hydrogen from renewable electricity is expected to fall relative to the cost of low-carbon hydrogen from fossil fuels. (Figures I & II)

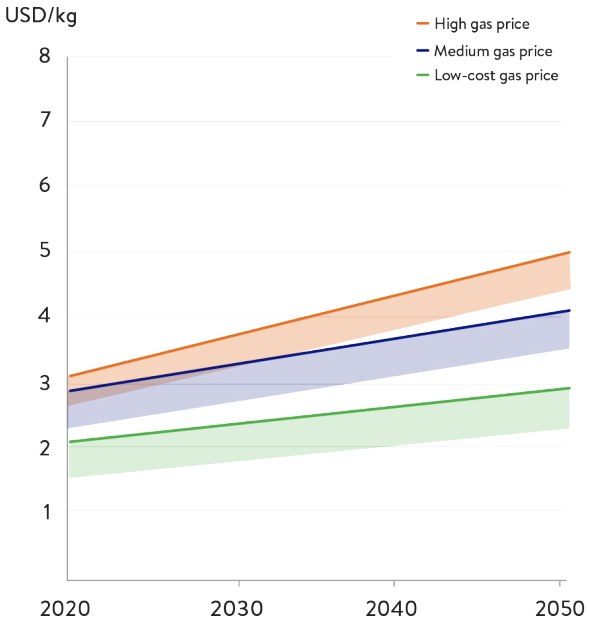
The high cost of transporting hydrogen means that most hydrogen will be consumed in the country or region where it is produced. The two largest energy markets, China and the USA, are likely to be more or less self-sufficient in hydrogen. Nevertheless, there is potential for significant global trade flows in hydrogen and hydrogen-based fuels / chemicals to develop by 2030 if sufficient regional and global cooperation emerge in the near future (Figure III).

Figure I. Projected cost by 2050 of low-carbon hydrogen from renewable electricity



Source: World Energy Council

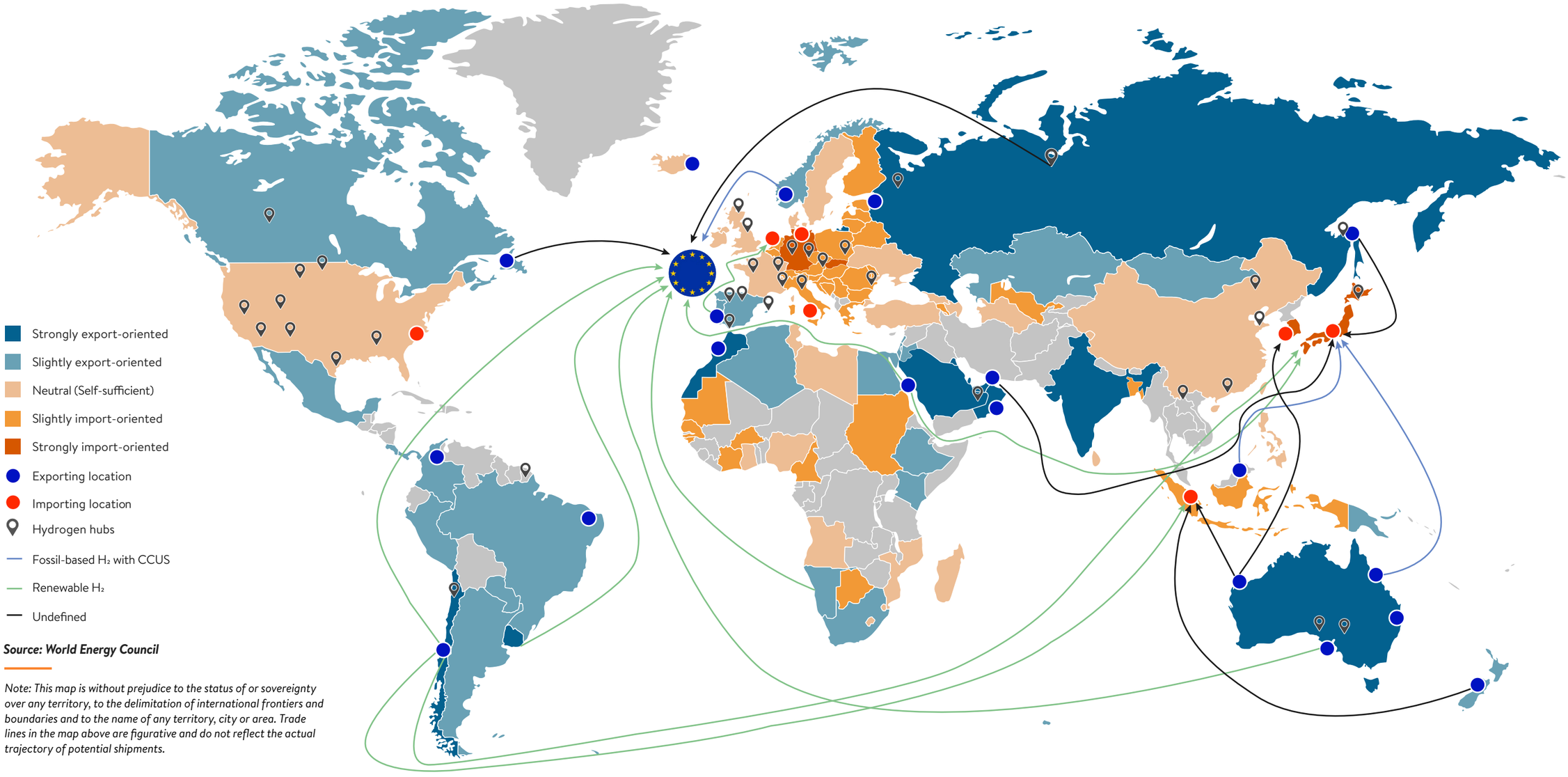
Figure II. Projected cost by 2050 of low-carbon hydrogen from natural gas with CCUS



Source: World Energy Council

The trade map highlights the potential for two major importing hubs, one centred around North Europe and the other around Japan and South Korea. The major exporting regions divide into those based on an abundance of cheap fossil fuels and CCUS opportunities (Australia, Canada, Middle East, and Russia), and those based on abundant renewable resources (Africa, Latin America, and Middle East).

Figure III. Map of potential low-carbon hydrogen import-export dynamics in 2040



Source: World Energy Council

Note: This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area. Trade lines in the map above are figurative and do not reflect the actual trajectory of potential shipments.

METHODOLOGY

The map of low-carbon hydrogen import-export dynamics in 2040 is based on multiple external sources and internal modifications. There are 5 country categories: Strongly export oriented, Slightly export oriented, Neutral (self-sufficient), Slightly import oriented, Strongly import oriented. Each country's assessment was based on energy experts' expectations for the respective countries' positioning in the global hydrogen trade by the year 2040. This was based on national hydrogen strategies, projects that have already been announced, and market trends, which together made it possible to estimate future trade routes.

The energy experts were identified within the Council's and PwC's experts' communities in the different regions. 80+ experts' responses were aggregated and synthesised to assign a score to each country's status. The final position in the import/export spectrum is based on the average score obtained amongst experts, subject to a minimum number of responses is achieved per country to ensure robustness of the score and taking into account the standard deviation of the responses for each country to reflect the uncertainty level (in case responses for a single country varied widely). Countries with high standard deviation scores were reviewed by the Council's team and an informed final score and status assigned accordingly.

Moreover, the map pinpoints major exporting and importing centres, along with the associated trade routes, and the classification of the commodity traded (low-carbon hydrogen with CCUS, renewable hydrogen, undefined, etc.). Major exporting and importing centres have been identified, and the routes are based on selected planned or announced international hydrogen trade projects or on bilateral partnerships that envisage future trading perspectives, which were identified using the World Energy Council's own sources, IEA - Global Hydrogen Review 2021, IRENA - Geopolitics of the Energy Transformation: The Hydrogen Factor 2022, and the Council's own assessment of publicly available trade projects and official partnership agreements and Memoranda of Understanding. For simplification purposes, trade routes connected to the EU flag symbolises trade with one or multiple EU countries. For bilateral partnerships outside the scope of any trade activities of low-carbon hydrogen fuels/derivatives, please refer to Figure 13.

Finally, the map also shows the major hydrogen hubs/valleys where most low-carbon hydrogen investments/activities are occurring Details are listed in Annex 2: List of low-carbon hydrogen valleys.

GROWING MOMENTUM FOR LOW-CARBON HYDROGEN

Interest in low-carbon hydrogen continues to grow rapidly, with 22 countries having published and established a national strategy (including 11 strategies since January 2021), more than 400 low-carbon hydrogen projects have been announced to date (IEA, 2021), and increasing interest from investors and financial institutions. The cost of low-carbon hydrogen production technologies is decreasing across the globe, with low-carbon hydrogen produced from renewable energy reaching parity with hydrogen produced from fossil fuels in locations where current gas prices are high.

The current military conflict in Ukraine has brought up the issue of security of supply back to the top of political agendas. Low-carbon hydrogen using renewable resources or nuclear electricity could occupy an increasing place in energy plans to support the diversification of supply and suppliers. In the short term, this could translate in more projects in renewable energy and nuclear, increasing support for R&D in alternative fuels and energy carriers, and additional bilateral partnerships being developed across countries for the potential future trade of low-carbon hydrogen. As for hydrogen derived from natural gas with CCUS, uncertainties are emerging in regard to its role in the short term due to the current volatility in natural gas supply stability and price.

While the momentum for low-carbon hydrogen is growing worldwide, e**ach region is taking a different route in deploying low-carbon hydrogen, and differing paths will remain to accommodate the specificities of each region, country, and city.** Differences in low-carbon hydrogen uptake across regions will exist due to differences in market opportunities and stakeholders' priority actions. Hydrogen's versatility makes it relevant in many countries, but applications and supply chains development should be tailored to each specific context. As regional similarities and potential synergies arise, **increasing regional cooperation should be seen on hydrogen development.** (Table I below)

RESOLVING THE UNCERTAINTIES

Moving from "whether" to "how" to develop low-carbon hydrogen highlights significant uncertainties, which need to be addressed if hydrogen is to reach its full potential.

- *Can the challenges in various supply chain options be overcome?* The low-carbon hydrogen supply chain is composed of a variety of production sources, transport and storage technologies, and potential end-uses. In addition, all hydrogen-related technologies and applications will evolve with time, with increasing options and potential paths available to each country, depending on their individual context. The plurality of options and the high evolving technological landscape in the nascent global low-carbon hydrogen market creates additional difficulty for decisions makers as to which solutions to invest in along the value chain. Moreover, the development of a national colour-blind hydrogen strategy can increase long-term visibility for project developers and facilitate the emergence of cross-country cooperation along the supply chain.

- *Can hydrogen play a role in tackling climate change in the short term?* **The timeline for low-carbon hydrogen project development is not sufficiently aligned with the need to address climate change.** There is an urgent need to develop infrastructure and increase volumes of both supply and demand - including replacing current fossil-based hydrogen - to achieve material low-carbon hydrogen penetration by 2030 for hydrogen to play a role in reaching Paris Agreement goals. However, infrastructure development at scale will struggle to be ready in time, particularly if there is no existing gas infrastructure which can be repurposed. Therefore, priority should be given to "quick win" projects, pilot projects and hubs, and projects that are integrated along the value chain in order to solve the chicken-and-egg problem between hydrogen supply and demand.

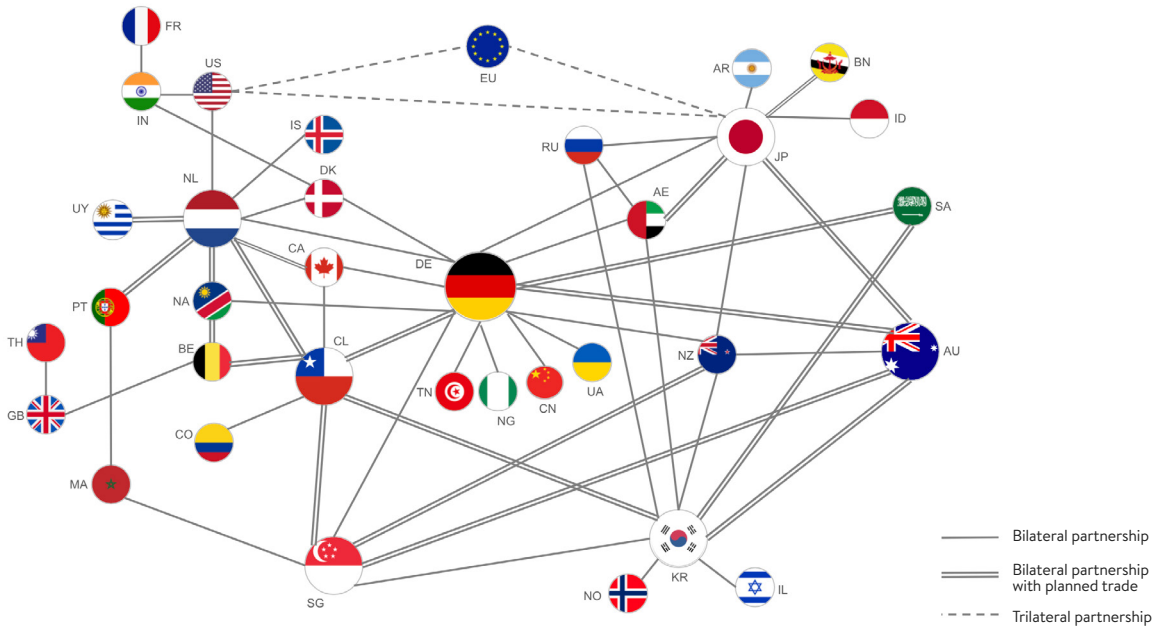
- *Can bankable projects emerge and the gap between engineers and financers be bridged?* **There is a gap between what technology providers could deploy and what bankers will finance.** What steps can be taken to ensure that new business models work, and that low-carbon hydrogen becomes competitive with alternative existing solutions? Globally, a shift in investment budgets towards green investments can be observed, joined by pandemic recovery funds across the world focused on sustainable investments. This sustainable finance and ESG movement can help governments attract financing to further develop hydrogen projects. However, without government support in de-risking the projects, they still face a financing problem.

- *Can the stability of supply of the main low-carbon hydrogen production sources be guaranteed?* Renewable hydrogen relies heavily on the supply of electricity from renewable resources that are at the mercy of weather fluctuations. Extreme weather events can significantly impact the supply of renewable energy, which could then create challenges and uncertainty with the **stability of renewable hydrogen supply.** Low-carbon hydrogen derived from fossil-fuels with CCUS also may have uncertainty of supply due to uncertainties in the supply of natural gas and/or to major fluctuations in its price.

ENABLING SCALE

For low-carbon hydrogen to develop at scale, key enablers have been identified with the energy community at the global, regional, and national level. Scaling up would first require greater coordination between stakeholders at the global level in the immediate term to help the market develop and better match supply and demand. In that context, bilateral partnerships between countries are continuing to develop and increasing include the trade of low-carbon hydrogen (Figure IV). Strong and coordinated climate action is particularly fundamental in driving low-carbon hydrogen interest – and with the appropriate policies in place, low-carbon hydrogen could achieve its true potential and help to achieve the long-term goals of the Paris Agreement. Mobilising public and private financing is also crucial at the global, regional, and national levels to de-risk investments, increase the number and volume of projects, and support infrastructure development. At the national level, one of the most critical enablers of hydrogen development is having a well-defined national strategy which includes: plans for market development and targets to provide long term visibility; regulatory priorities to unlock low-carbon hydrogen potential, notably adapting legislation to allow for clean molecules to be part of the energy mix; economic and financial mandates and incentives, including carbon pricing, blending quotas, and low-carbon fuel credits. National support for the development of hydrogen hubs is also key to facilitate the creation of local demand and supply in concert.

Figure IV. State of play of bilateral partnerships



Source: World Energy Council

In particular, there is an **urgent need to shift the focus onto the usefulness of energy for people, and to look at low-carbon hydrogen demand and the end-users.**

Firstly, **focus must be shifted to look at the low-carbon hydrogen end-user price.** Increase in low-carbon hydrogen demand is cost sensitive. The focus of the conversation should move from hydrogen production cost to final price for end users and include transport cost (challenging as there are many components, with some very difficult to estimate, such as transport infrastructure, local permitting, etc.), storage costs, profit margin, and provisioning costs at the final point of consumption. These costs may be much larger than the cost of hydrogen production itself and the end objective to make hydrogen competitive in the low-carbon future is not production at the lowest cost, but supply at the lowest price for the greatest benefit of societies and the environment.

Secondly, additional support should be focused on the end-users. More support on the demand-side is needed, targeting end-users that will consume hydrogen in their application. This can be achieved by **providing supply transparency and guarantees for the buyer.** In particular, experts unanimously called for **guarantees of origin and global sustainability requirements** to help the hydrogen market develop. Global cooperation on the topic needs to start today if clean hydrogen development is going to help achieve the goals of the Paris Agreement. However, it should be noted that a globally harmonised mechanism poses the risk of establishing a deliberately simplified or less ambitious framework (i.e., agreeing on

the lowest common denominator) and may require a longer time frame to be adopted, which might be incompatible with short-term cross-country trade plans. Current regulatory uncertainty on low-carbon hydrogen (e.g., lack of harmonised definitions of hydrogen production methods, carbon intensity rules, etc.) is delaying investment and ramp-up of industrial-scale projects. National and regional initiatives are advancing on this topic, but unilaterally, which can create barriers for global trade. Experts are therefore calling for an international, recognized institution to lead a global effort to standardize these definitions. Additionally, providing more support to end-users entails **encouraging the switch to low-carbon alternatives through incentives and other policy tools** (e.g., carbon price, Carbon Contracts for Difference (CCFDs), Carbon Border Adjustment Mechanism (CBAM), or quotas). Finally, supporting end-users requires **reducing uncertainty to de-risk investment.** While current prices and safety concerns hinder hydrogen scale-up, in the short term, Memoranda of Understanding, partnerships, and long-term contracts are shaping the market and providing visibility for risks takers. As the market develops, more flexibility and competitiveness can emerge.

Thirdly, **low-carbon hydrogen development should consider social impacts alongside economic opportunities.** More emphasis is needed on ensuring local low-carbon hydrogen demand is met first in applications where it makes economic sense compared to alternatives, particularly in countries with significant existing consumption of hydrogen or export ambitions. Developing low-carbon hydrogen usage downstream requires its own transport, infrastructure, and storage facilities, which can create new skills and jobs opportunities, particularly in countries with abundant renewable energy resources, due to hydrogen's versatility. This can enable the respective societies to capture more value linked to low-carbon hydrogen economy developments. A key success factor for low-carbon hydrogen uptake relates to the social licence and the resulting necessity to provide more education for the public around its role in abating climate change and the role it could play in energy systems in respect to increasing equity and justice. Training and outreach will be needed to increase hydrogen literacy within the general population, and to improve the existing skillset across the industry. In that respect, the development of **a global monitoring and reporting tool on low-carbon hydrogen projects** would help awareness and literacy efforts amongst the general public, in addition to tracking progress over time and supporting decision making.

Table I. Regional Insights

	AFRICA	ASIA-PACIFIC	EUROPE	LAC	MEGS	NORTH AMERICA
	A huge potential but little infrastructure: how does Africa enable an export market as well as grow a domestic one?	**Mainstreaming low-carbon hydrogen and its derivatives and capturing related economic opportunities**	**A high ambition to decarbonise as fast as possible, while increasing security of supply and tackling the flexibility issue**	**Increasing self-sufficiency and developing new regional cooperation**	**Low-carbon hydrogen driven by Circular Carbon Economy and sustaining energy export**	**Increasing self-sufficiency and developing new regional cooperation**
SDGS	2, 7, 8	8, 9, 13	7, 12, 13	2, 9, 12	7, 9, 12	9, 11, 13
Market activities / opportunities	**End-use priorities:** 1- Energy access, 2- Agriculture, 3-Export, 4- Industry **Low-carbon hydrogen production sources:** 1- Renewable hydrogen, 2- Natural hydrogen, 3- Hydrogen from natural gas with CCUS	**End-use priorities:** 1- Industry, 2- Mobility, 3- Power generation **Low-carbon hydrogen production sources:** 1- "Carbon-free" hydrogen (i.e., low-carbon; no prejudice of the type of hydrogen - renewable hydrogen, low-carbon hydrogen from natural gas and coal with CCUS)	**End-use priorities:** 1- Industry, 2- Mobility **Low-carbon hydrogen production sources:** 1- Renewable hydrogen, 2- Hydrogen from natural gas with CCUS, 3- Hydrogen from other sources (nuclear, waste, biogenic methane, methane pyrolysis, etc.)	**End-use priorities:** 1- Industry, 2- Mobility, 3- Agriculture, 4- Export (H2 & products using H2) **Low-carbon hydrogen production sources:** 1- renewable hydrogen, 2- hydrogen from all locally available fossil fuels with CCUS	**End-use priorities:** 1- Export, 2- Industry **Low-carbon hydrogen production sources:** 1- hydrogen from all locally available fossil fuels with CCUS, 2- renewable hydrogen	**End-use priorities:** 1- Industry, 2- Mobility, 3- Agriculture, 4- Export (H2 & products using H2) **Low-carbon hydrogen production sources:** 1- renewable hydrogen, 2- hydrogen from all locally available fossil fuels with CCUS
Regional paths	Developing low-carbon hydrogen could help Africa in tackling issues of **energy access, energy independence, food security and local employment** Africa has **sizeable renewable energy resources** to develop low-carbon hydrogen production & important **mineral resources** to be part of the value chain of energy transition technologies However, there are **many challenges to overcome:** some countries' concrete ability to take advantage of the hydrogen economy is limited by the lack of infrastructure and general awareness, political and economic challenges, and lack of demand security, as well as water stress **North Africa** has more favourable conditions - Morocco, Algeria and Egypt in particular could be first movers and exporters of hydrogen and its derivatives In the early stage of hydrogen development, there are opportunities to unlock in the hydrogen innovation space that could position African countries as technology-setters, not takers	Asia-Pacific region **at the epicentre of the movement towards a "hydrogen economy"** - Japan, South Korea and Australia released a strategy first **Integrated approach to low-carbon hydrogen-based fuels** that can support decarbonisation efforts across a multitude of applications and sustain economic growth via innovation and new technologies for export Interest increasing in other countries; although the overarching plans are yet to be released, inc. from key players **China and India** In the early stage of low-carbon hydrogen uptake: **defining priorities between fuels** could facilitate the scale up and more regional and global cooperation is needed to **tackle the obstacles to global trade development** (e.g., lack of harmonised definition of hydrogen sources, updating maritime regulations, etc.)	Impulse given by Germany - now Europe is **at the forefront of hydrogen development worldwide** The EU plans to rely heavily on low-carbon hydrogen to support its decarbonisation ambitions, with high targets for imports (from North Africa, Latin America, Gulf States, etc.) **Several challenges in the EU** - More dissonant voices: e.g., on blending; on which low-carbon production sources, pure hydrogen vs. intermediate steps (e.g., power to methane, ammonia, liquid fuels), etc. - Developing harmonised standards and streamlining regulations is key for low-carbon hydrogen ramp up **Timeline gap between the ambitious climate agenda and hydrogen infrastructure implementation:** very large infrastructure projects (notably for import) operational after 2030. In the meantime, within Europe, on-site projects and hydrogen hubs are developing, and off-site electrolysers in regions with high renewable energy capacities could supply part of the European demand	Wide interest to develop hydrogen production and use, **focusing mainly on hydrogen from renewable energy,** but considering all resources available on the continent Developing **local demand is the primary objective** to help decarbonise the economy **Chile is the early mover** and gave the impulse on hydrogen in the continent, which is now very dynamic; momentum is picking up and **regional cooperation is increasing** The continent is attracting **increased attention from potential importing markets** (e.g., Netherlands, Australia, Japan) Cooperation could increase to **attract more foreign investment** and install the LAC region in the global hydrogen market	Momentum in MEGS is driven by the **energy incumbents,** in addition to the region's Circular Carbon Economy agenda Investments are being implemented with the end goal of **sustaining energy exports** to existing markets in Europe and Asia Existing **vast oil and gas assets**, coupled with excellent **natural resources** for renewable energy production, are making the production of low-carbon hydrogen in the region among the most competitive in the world **Saudi Arabia, the UAE, and Oman** are driving the momentum for low carbon hydrogen Aspirations to become an **export hub** of low-carbon hydrogen and its derivatives **Foreign laws** and regulations can create **policy obstacles** that might hinder these goals, particularly regulations related to potential exports	Momentum is emerging in Canada and in specific states within the US. Goal is to increase and enhance **overall resiliency** of the energy systems over the coming decades **High technology readiness** is pushing the domestic market to pick up end-use applications particularly in the transport sector **Developed regulations and incentives** targeting clean mobility are pushing further the use of low-carbon hydrogen in the transport sector **Export ambitions** of low-carbon hydrogen and its derivatives are also emerging, especially as the region is an existing energy net exporter **Priority** is on the **creation of hubs** where supply and demand are located in the same place
Key Enablers	Regional & subregional cooperation, & cooperation with importing markets to develop African hydrogen technologies and to create a shared vision for hydrogen Gap assessments for human capital and infrastructure development Developing domestic demand in the transport, industry and agriculture sectors	Increasing bilateral and multilateral cooperation to progress the low-carbon hydrogen global supply chain and hydrogen trade Integrated approach to energy policies & mainstreaming hydrogen and its derivatives in many aspects of energy systems Supporting hydrogen-related technologies and increased use in mobility	Eliminating regulatory obstacles in the European Union (and misalignment between Member States) More support mechanisms for the production-side and switch incentives for the demand-side (e.g., CCFDs or quotas) Supporting the development of international trade More coordinated hydrogen diplomacy action in the EU	Regional cooperation to increase visibility for the continent and attract external investments Better identifying and building on each country's individual strengths for an integrated low-carbon hydrogen supply chain	Increasing regional collaboration and learning from previous failed attempts Developing local ecosystems and end-use applications in the local market as opposed to primarily creating an export hydrogen industry Finance subsidies and support mechanisms to enhance the bankability of large pilot projects	Scaling and reducing the cost of hydrogen transport and distribution Funding support for R&D andpilot and demonstration projects Creating hubs centres to help derisk future projects

SDGs legend

Out of the 17 sustainable development goals (SDGs), scaling up low-carbon hydrogen in the different regions could particularly help achieve the following:

- *2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture*
- *7: Ensure access to affordable, reliable, sustainable and modern energy for all*
- *8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all*
- *9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation*
- *11: Make cities and human settlements inclusive, safe, resilient and sustainable*
- *12: Ensure sustainable consumption and production patterns*
- *13: Take urgent action to combat climate change and its impacts*

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*awaiting membership approval

62–64 Cornhill
London EC3V 3NH
United Kingdom
T (+44) 20 7734 5996
F (+44) 20 7734 5926
E info@worldenergy.org

www.worldenergy.org | @WECouncil