Policy recommendations to accelerate hydrogen deployment for a 1.5°C scenario

Contents

Foreword

Hydrogen as a source of energy has long inspired innovators. In 1874, for example, Jules Verne predicted in his book *The Mysterious Island* that "water will one day be employed as fuel, that hydrogen and oxygen of which it is constituted will be used."

However, realizing this vision has been no mean feat. **Our own vision at WBCSD is for 9 billion people to be able to live well, within planetary boundaries, by mid-century. To achieve this vision, we need to start today. This will require an unprecedented effort to transform the systems that govern our businesses and societies to change the world for the better.**

In our *Vision 2050* report, we highlighted 10 key actions to rapidly and sustainably transform the energy system. The development of the hydrogen economy supports several of these key actions, in particular the deployment of sustainable fuels to decarbonize energy-intensive industries and long-distance transport.

Our *Vision 2050* report advocates for policies, such as carbon pricing, that will lead to the effective removal of fossil fuels subsidies and favor low- and zero-carbon solutions, such as hydrogen.

Achieving this transformation will require an unprecedented level of leadership and collaboration between business and society. In this document, we lay out key recommendations from the business community to policy-makers to accelerate the deployment of hydrogen to decarbonize part of the energy system in order to achieve net-zero emissions by 2050.

This is consistent with our role as a member of the United Nations Framework Convention on Climate Change (UNFCCC) Marrakech Partnership for Global Climate Action that is setting out the climate action pathways.

Realizing the long-held vision that hydrogen can serve as a source of energy to decarbonize part of the energy system will be difficult, but this report offers tangible outputs and outlines the necessary steps for hydrogen to contribute to decarbonizing societies.

Claire O'Neill
Managing Director,
Climate & Energy

Executive summary

Estimates from the Energy Transitions Commission (ETC) suggest that hydrogen will meet 15-20% of energy needs in 2050.[1] **WBCSD and its member companies call on governments, industry and society to accelerate the deployment of hydrogen with the lowest possible carbon intensity**[2] and create a global hydrogen market to achieve a decarbonized, secure and affordable future. There is momentum on the clean(er) hydrogen agenda; however, its cost still needs to rapidly decrease for it to play its part in accelerating society's decarbonization. Enabling policies can support this acceleration.

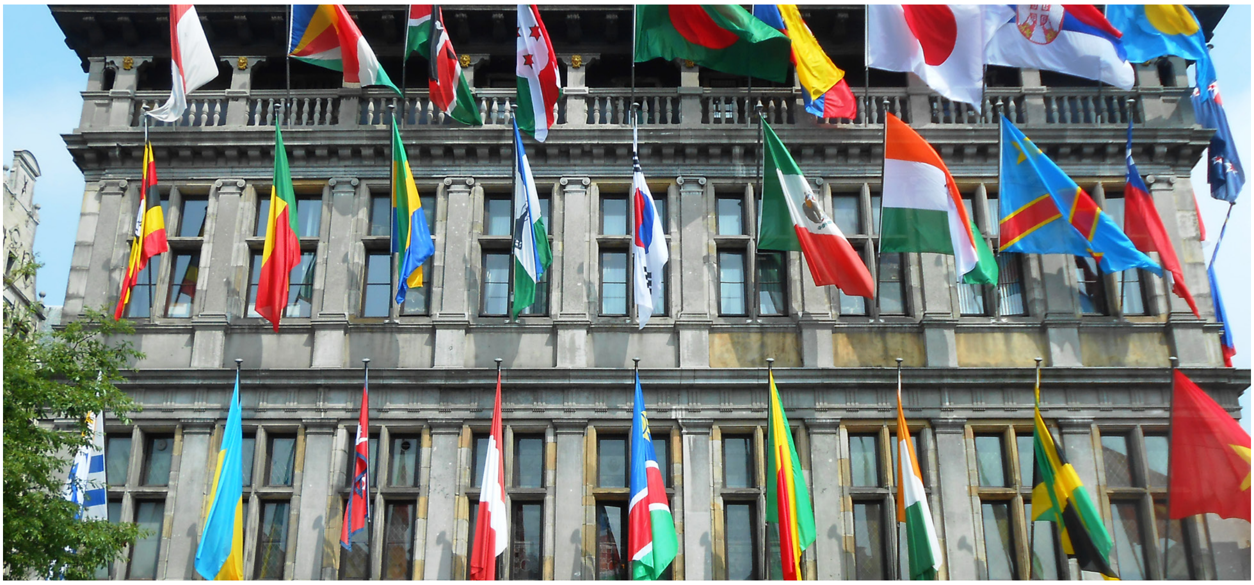
To accelerate the hydrogen economy, governments can:

- **Set clear targets and a prioritized roadmap for hydrogen deployment**, associated renewable energy and, where opportunities exist, carbon removal options to enable net-zero emissions (such as carbon capture and storage (CCS) or nature-based solutions);
- **Put a price on carbon** to ensure the pricing of externalities (such as greenhouse gas (GHG) emissions) into more carbon-intensive fuels, improving the relative economic attractiveness of hydrogen;
- **Support the emerging market and, in particular, both the production and the demand side** until projects become economically attractive.

Those support mechanisms should reward hydrogen projects according to their capacity to enable both the targets and the pace of decarbonization required to meet a 1.5°C scenario, as well as economic viability, scalability and long-term sustainability.

To do so, consistent global frameworks are essential. This is why WBCSD members, representing businesses from a wide range of sectors, are collectively presenting this set of policy recommendations.

For the sake of simplicity, in this document we sometimes refer to "hydrogen" without qualifying it; but we always mean hydrogen with the lowest possible carbon intensity, consistent with a 1.5°C scenario and net-zero emissions society in 2050.



Key messages

Governments have an essential role to play in accelerating the deployment of hydrogen with the lowest possible carbon intensity[3] in support of the Paris Agreement for a 1.5°C scenario.
They can do so by:

1. Embedding **hydrogen into country decarbonization strategies**, setting clear priorities and targets for hydrogen production and consumption.

2. Putting a **price on carbon** because it is one of the most effective and cost-efficient means of driving deep decarbonization across economies and as such creates a market for hydrogen where its use is competitive.

3. Financially supporting hydrogen development and R&D according to their capacity to enable both the targets and the pace of decarbonization required to meet a 1.5°C scenario, as well as economic viability, scalability and long-term sustainability.

4. Updating and harmonizing hydrogen regulations and standards, keeping a stringent focus on safety while reflecting the risks associated with the production method for environmental regulations.

5. Adopting an internationally recognized, full life-cycle based CO_2 equivalent greenhouse gas (GHG) methodology to calculate the carbon intensity of hydrogen and implementing a global, verifiable, traceable and tradable certification and guarantee of origin scheme.

6. Ensuring all hydrogen produced and used has the lowest possible carbon intensity and is consistent with a 1.5°C scenario and net-zero society in 2050. On the way to net-zero emissions, WBCSD member companies recommend the following taxonomy (on a full life-cycle basis), adding where relevant the source of primary energy (for example, renewable):

Reduced-carbon hydrogen:
≤ **6** kg CO_2eq/kg H_2 or c. 50 g CO_2/MJ; only relevant as a steppingstone to achieving lower carbon hydrogen for existing higher intensity production installations;

Low-carbon hydrogen:
≤ **3** kg CO_2eq/kg H_2 or c. 25 g CO_2/MJ;

Ultra-low carbon hydrogen:
≤**1** kg CO_2eq/kg H_2 or c. 8 g CO_2/MJ.

7. Raising awareness among end-users and relevant stakeholders of the **benefits and necessary safety measures** associated with hydrogen.

8. Developing multilateral cooperation agreements to implement international hydrogen trading and accelerate the **deployment of the needed infrastructure.**

1 Why this report?

The Intergovernmental Panel on Climate Change's (IPCC) 6th Assessment Working Group1 report, *Climate Change: The Physical Science Basis*,[6] released in August 2021, sent a resounding message that global warming is happening faster, affecting every region on Earth, in multiple ways. And the role of human influence on the changing climate is undisputed: greenhouse gases from human activities are responsible for approximately 1.1°C of warming since 1850-1900.

The report states that, while achieving a 1.5°C world is still possible, stabilizing the climate will require strong, rapid and sustained reductions in greenhouse gas emissions and the reaching of net-zero CO_2 emissions. It will require a radical and urgent transformation of all systems at an unprecedented scale. **The World Business Council for Sustainable Development (WBSCD) and our member companies believe that hydrogen will play a vital role in driving the energy transition to a net-zero carbon future and achieving the 1.5°C goal.**

The fertilizer, refining and chemical sectors currently use hydrogen either directly or as an intermediate (some 70 million tons produced for this purpose yearly); and its use could grow to some 800 million tons yearly, meeting 15-20% of final energy demand by 2050.[7] This increase relies on hydrogen supporting the decarbonization of hard to abate sectors (heavy industry requiring high-temperature heat that it is not easy to electrify), heavy-duty transportation and the use of hydrogen for energy storage (such as providing a complement to hydro-pumping storage and batteries for seasonal load balancing and storage purposes), as a reducing agent replacing coke in steel making, and as feedstock for synthetic fuels or other energy-dense molecules such as ammonia and methanol.

It is essential to rapidly decarbonize the existing uses of hydrogen (whose production today emits as much GHG as the United Kingdom and Indonesia combined[8]). The substantial increase required in hydrogen production must also be consistent with a net-zero pathway by 2050 and achieving the Paris Agreement 1.5°C goal.

There is significant momentum to develop a hydrogen economy, as illustrated by the fact that during 2020, 10 countries or regions developed a "hydrogen strategy" (compared to only 3 between 2018 and 2019). Many more countries in Latin America, Asia and Europe are drafting their hydrogen strategies now.[9] Yet lower carbon hydrogen (whether "blue" from natural gas with substantial CCS, "green" from electrolysis powered by renewable electricity, "pink" from nuclear-powered electrolysers, or other less common technologies) faces some significant hurdles; it needs to become more cost competitive with the existing unabated "grey" (from unabated steam methane reforming) or "black" (from unabated coal gasification) hydrogen.

Governments have an essential role to play in accelerating the phasing out of grey hydrogen and the growth of lower and eventually net-zero carbon hydrogen. By setting up supportive and consistent frameworks, governments enable industry to make the necessary investments to transform this part of the energy system. This contributes to making the energy transition consistent with Sustainable Development Goal 7: Affordable and Clean Energy for All. In the wake of the global pandemic and the need for a green recovery, a "just transition" offers the possibility to transfer many of the skills already used in the fossil fuel and mining industries, with employment growth estimated at 30 million new jobs globally by 2050.[10]

This document aims to highlight key recommendations from the business perspective that would help overcome initial cost and technical barriers **and accelerate the deployment of hydrogen with the lowest possible carbon intensity.**

7 AFFORDABLE AND CLEAN ENERGY

2 Define high-level roadmaps and country strategies for hydrogen

To help create a stable framework for investments, countries and regions should **establish a high-level strategy and roadmap for the development of hydrogen**, in particular according to their geographical, economic and commercial advantages. This should fit with their overall decarbonization strategy and tie into their nationally determined contributions (NDCs) in line with the Paris Agreement. Considerations should also include energy security, balancing with energy equity and environmental sustainability.[11]

To help business build viable projects and investment cases, the strategy and roadmap should contain:

- **Overall ambition for the country or region in terms of hydrogen production and use cases,** with milestones for the short and longer term, highlighting benefits and added value and defining research areas of high priority.
- **Prioritized roadmap for development based on the most economically viable options and where decarbonization potential is highest**, especially where direct electrification is not suitable or viable, and taking a systemic view, including long-term developments in the energy landscape.
- **A roadmap for the use of existing and the development of new infrastructure**, for example using a staged approach starting with clusters or valleys, initially co-locating the hydrogen production and (already existing) end-use to reduce transport and storage costs, then developing (or repurposing existing) transport, storage and, where relevant, import/export infrastructure to enable wider development. In addition, the roadmap should include a strategic consideration of the supply chain (resources, equipment and capabilities) needed to realize such infrastructure.

EXAMPLES

The EU hydrogen strategy[12] published by the European Commission in July 2020, sets out how hydrogen development in Europe supports the overarching goal of a net-zero society by 2050 and the interim goal of at least 55% GHG emissions reductions by 2030, in support of the Paris Agreement. It gives priority to and focuses public aid on renewable hydrogen development, recognizing the need for other forms of low-carbon hydrogen in the short term to decarbonize both current hydrogen production and to support hydrogen uptake.

The Dutch Klimaat Akkoord[13] implements the National Climate Act by defining more than 600 actions in an adaptive Climate Agreement based on clear goals (-49% by 2030) where hydrogen is playing an important role in the wider decarbonization framework. It includes a programmatic and phased program to upscale hydrogen with well-defined short-, medium- and long-term targets (2019 – 2021 preparatory program; 2022 – 2025 scaling up to 500 MW of established hydrogen capacity; 2026 – 2030 scaling up to 3–4 GW of established hydrogen capacity).

The allocation of a direct support budget focuses on demonstration facilities and pilot projects (EUR €30–40 million/ year).

Chile's strategy[14] focuses on the development of green hydrogen, thanks to the enormous potential to scale up wind and solar electricity in the country. Its immediate priority is the domestic market, with a rapid expansion in hydrogen exports by ship and positioning the country as a leading contender in international trading. It sets clear short- and medium-term targets for 2025 and 2030 in terms of solar electricity generation and hydrogen production.

3 Implement long-term carbon pricing policies

Carbon pricing is one of the most effective and cost-efficient means of driving deep decarbonization pathways across economies – and therefore creating a market for hydrogen where its use is competitive.[15]

We believe that effective direct and indirect carbon pricing policies that ensure environmental integrity are a low-cost means to achieve deep emission reductions while maintaining competitiveness, creating jobs, encouraging innovation, enabling investments in low-carbon solutions and minimizing social costs.

In addition, governments should allocate revenues from carbon pricing instruments to investments aimed at developing low-carbon alternatives such as hydrogen.

WBCSD and its member companies call for governments to:

- **Put a price on carbon** and develop clear and consistent long-term carbon pricing policies as part of their nationally determined contributions (NDCs) to support the accelerated transition to a decarbonized future, build resilience and achieve the SDGs.
- **Adopt robust carbon pricing instruments**. We need a global framework that delivers meaningful emissions reductions and drives competitiveness, innovation and investment, all while ensuring environmental integrity at minimal social costs. This will help accelerate hydrogen deployment as it will replace more carbon-intensive fuel sources.

Detailed guidance on how to best design carbon pricing instruments and minimize overlapping policies is available in the World Bank guide to carbon pricing assessment and decision-making.[16]

- **Reach agreement on strong rules to implement Article 6 of the Paris Agreement** by the time the 26th Conference of the Parties (COP26) to the United Nations Framework Convention on Climate Change (UNFCCC) takes place, in a manner that ensures environmental integrity and avoids double-counting. This would support governments to take additional mitigation action and provide incentives to business to invest in cost-effective emissions reductions.
- **Adopt policies to address concerns about carbon** leakage to ensure a harmonized and coherent decarbonization framework.

EXAMPLES

Norway was one of the first countries in the world to introduce a carbon tax (1991). The country levies the tax on all gas, oil and diesel combustion operations on the continental shelf and on releases of CO_2 and natural gas, in accordance with the CO_2 Tax Act on Petroleum Activities. The government sees this as one of the most important means of cost-effectively cutting greenhouse gas emissions.[17]

In Europe, the **EU Emissions Trading Scheme** (EU ETS) drives cost-effective investments in the decarbonization of the industry sectors to which it applies and generates money for the Innovation Fund (IF) by auctioning 450 million EU ETS allowances between 2020 and 2030. During that period, the fund may grow to reach EUR €10 billion.

There are examples of **indirect carbon prices**, such as:

- The **Netherlands** uses income from energy taxes to fund the sustainable energy transition subsidy (SDE++) with the specific goal of stimulating sustainable energy production and CO_2 reductions. The subsidy must ensure that the energy transition remains feasible and affordable, while creating long-term perspectives based on technology-neutral auctioning (EUR €5 billion for 2021 for five main categories, including hydrogen production by electrolysis).
- Some governments have defined a **shadow carbon price or the social cost of carbon**, which is not the level at which they tax carbon but reflects the carbon price under which a shift in technology is beneficial to society, helping those governments allocate funds accordingly to accelerate clean technology deployment.
- In **Hong Kong**, the government has mandated a change in the fuel mix, away from coal to much lower carbon intensity generation, in line with its own carbon-intensity target, approving the necessary investments and increases in regulated electricity tariffs to cover the additional costs involved. The government has itself contributed to the increased costs that electricity consumers will pay, with a focus on regular payments to residential customers to ease the transition. These were set at a fixed level, rather than as a proportion of consumption, hence having a greater benefit for the poorest customers.

The EU Carbon Border Adjustment Mechanism (CBAM)
The European Union plans to impose carbon emission costs on imports of goods, including steel, cement and electricity. Importers would buy digital certificates, with each one representing one ton of carbon dioxide emissions embedded in their imported goods. If carbon prices in countries exporting to Europe are similar to those in Europe, the tariff would not apply. This would reflect favorably on lower carbon products such as those made with hydrogen, for example steel.

4 Define rules and include hydrogen in the overarching decarbonization framework

It is crucial that hydrogen policies and regulations fit well within existing frameworks and aim to decarbonize society in a cost-effective manner. In particular, governments should:

- **Design hydrogen policies and rules to meet decarbonization goals aligned with the Paris Agreement**, enabling a framework to support early-stage projects, both from the production side and the use side (see details in section 5) and identifying and **accelerating the hydrogen business models that will enable the highest decarbonization possible at the lowest cost**. Hydrogen should complement other decarbonization options to address harder to abate sectors and enable the country to allocate resources optimally to achieve its emissions reduction targets. Design such policies in a way that high-value hydrogen applications (high purity) can mature effectively in parallel with early-stage and transitional developments (such as blending).
- Where possible, **adopt international safety and technical standards (including quality/ interoperability)** for hydrogen production, transport, storage, distribution and end-use based on surveys and limitations of the intended infrastructure (such as when repurposing an existing gas installation or blending). Ensure that there is a **regulatory body** to provide the necessary assurance related to the implementation of those standards, especially as new developers with less experience in industrial or chemical risks enter the market. **A safe hydrogen industry is paramount to enabling hydrogen to meet a significant share of energy demand in the future and reach public acceptance**.
- Implement a program to inform and educate the public about hydrogen's advantages and safety risks.
- When developing local standards, aim to **harmonize** those standards with neighboring countries to facilitate future hydrogen flows across borders (such as pipelines), taking into account market integration and the physical and safety limitations of the local infrastructure. Eventually, this will require the integration and interoperability of the gas market and hydrogen market, from both a commodity and infrastructure perspective.

EXAMPLES

The International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) Regulations, Codes, Standards & Safety (RCSS) Working Group is acting as a catalyst for international cooperation and to facilitate the harmonization of codes and standards in the infrastructure and transport space.[18]

The Center for Hydrogen Safety is a global non-profit organization dedicated to promoting hydrogen safety and best practices to enable the safe handling and use of hydrogen across all applications, including those in the energy transition.[19]

- **Update regulations** that create hurdles for project developers because environmental permit regulations are complex, unclear, unfit or inconsistent across sectors and countries; where possible, **harmonize them internationally** to better reflect the environmental risk associated with hydrogen production, transport and use.

EXAMPLES

Some environmental regulations treat "green" hydrogen (from water electrolysis) in the same manner as "grey" hydrogen (from steam methane reforming), even though no direct GHG emissions or hydrocarbons are involved in green hydrogen and there are therefore fewer pollution risks, making the permit process overly complex and long.

In some countries, due to current dangerous goods regulations, it is only possible to generate hydrogen on a chemical site, which limits opportunities for other production sites (such as for green hydrogen).

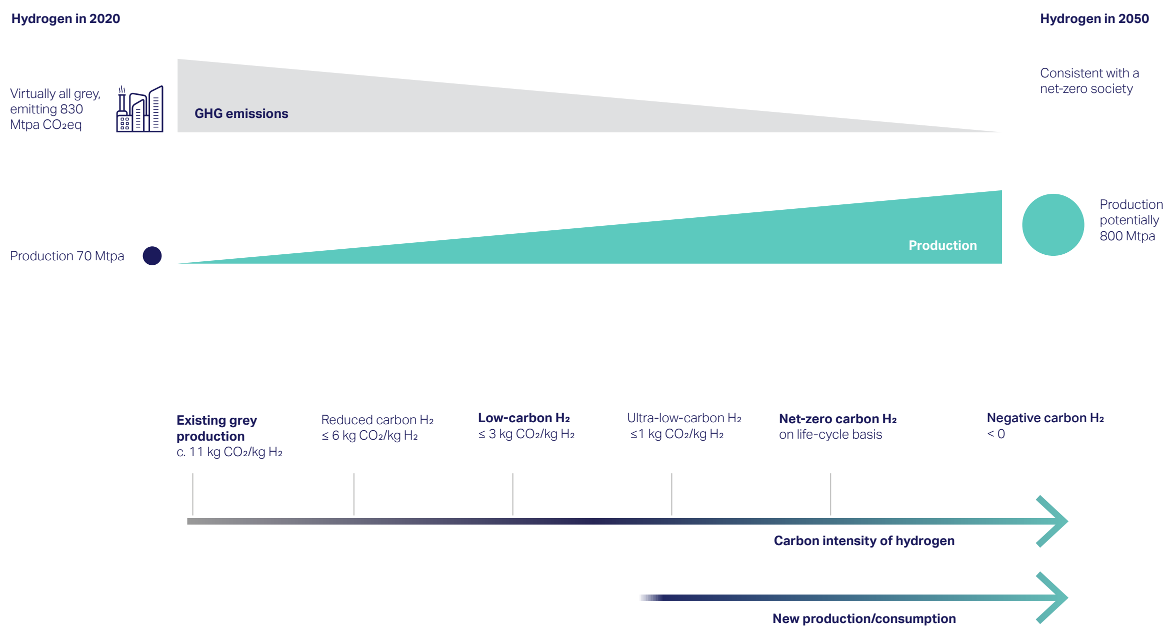
- **Ensure that long-term goals to increase renewable electricity capacity and power infrastructure also support the growth of the hydrogen economy**. Many jurisdictions are in the process of defining how to consider hydrogen production from electrolysers connected to the grid as renewable, meaning they are linked (directly or virtually) to (sometimes additional) renewable electricity capacity.

  While this principle of additionality helps in achieving a needed increase in renewable capacity, it may require some flexibility in terms of temporal correlation because electrolyser use is a key factor in decreasing the cost of renewable hydrogen in the short term. Instruments like power purchase/supply agreements or any credible green supply agreement help maximize options and create a competitive environment for renewable hydrogen.

- **Implement a global, verifiable certification system and a guarantee of origin scheme that allow end-users to know the origin, quality (purity) and life-cycle GHG emissions of hydrogen.**[20] This increases transparency and consumer empowerment, and encourages global trade. Ensure consistency and compatibility with GHG emission or carbon footprint certification schemes for other commodities and seek synergies with wider demand for proof or origin mechanisms seen in other sectors (for instance information technology infrastructure for registry such as blockchain).

- **All hydrogen produced and used should be of the lowest possible carbon intensity and consistent with a 1.5°C scenario and net-zero society in 2050**. On the way to net-zero emissions, we recommend the following taxonomy (on a full life-cycle basis), adding where relevant the source of primary energy (such as renewable):
    - **Reduced-carbon hydrogen: ≤ 6 kg CO_2eq/kg H_2** or c. 50 g CO_2/MJ – only relevant as a steppingstone to lower carbon hydrogen for existing higher intensity production installations
    - **Low-carbon hydrogen: ≤ 3 kg CO_2eq/kg H_2** or c. 25 g CO_2/MJ
    - **Ultra-low carbon hydrogen: ≤1 kg CO_2eq/kg H_2** or c. 8 g CO_2/MJ

Figure 1: Stepping stones based on the carbon intensity of hydrogen



EXAMPLES

CertifHy in Europe has developed an early-stage certification scheme and defines guarantees of origin for low-carbon hydrogen (from non-renewable sources) and for green hydrogen from renewable sources.[21] This scheme is also planning to set up a pilot program for cross-border transactions with an import project from Morocco to the European Union.

WBCSD member company **Acciona** has developed GreenH2Chain, a blockchain-based technology that guarantees the renewable origin of green hydrogen throughout the entire value chain, regardless of delivery method. This technology solution will allow renewable hydrogen consumers to quantify, record and monitor the decarbonization process of their own energy supply.[22]

- **Establish a coordinating body to facilitate public and private partnerships and R&D funding** and the development of pilot and demonstration projects. Determine the period, type and level of subsidy through a competitive allocation process that helps close the investment and operational cost gaps and prioritizes the largest decarbonization impact. This can be in the form of partnerships, programs and co-funding that cover the entire hydrogen value chain to decrease the cost of capital.

5 Design specific support mechanisms

Low(er) carbon hydrogen requires some new technologies and investments face economic hurdles; **governments should aim to support early-stage projects to accelerate the deployment and growth of a low-carbon hydrogen economy**. **In particular:**

- **Ensure that support mechanisms facilitate investments in, and reward, hydrogen developments according to their capacity to enable both the targets and the pace of decarbonization required to meet a 1.5°C scenario, as well as economic viability, scalability and long-term sustainability.**
- To objectively measure decarbonization potential, **adopt a recognized, international, life-cycle analysis based CO_2eq GHG calculation method**. This would enable the development of CO_2 reduction dependent taxation regimes that accelerate low(er) carbon hydrogen demand, while creating financial support to build supply infrastructure.
- **Design a market framework** to create the right conditions for a global hydrogen market.

For the production side

- **Identify and support** (through both capital expenditure and operational expenditure subsidies, loans/ financial guarantees, public investments, contracts for difference, facilitating long-term offtake contracts, fiscal incentives) **early-stage projects and partnerships to kickstart hydrogen clusters or valleys where it is possible to synchronize and collocate production and demand** (as those are likely to be most cost-effective in the short term).
- **Define supportive tax regulations:** The review of tax regulations should ensure energy tax frameworks support the required uptake of hydrogen by reducing the risk for developers and providing stable and fair fiscal treatment to encourage decarbonized energy. For instance, some governments have designed energy tax regimes without considering the purchase of an energy product (such as electricity) for conversion to another energy product (such as hydrogen gas), potentially leading to "double" taxation.
- **Give clear market signals** (such as the adoption of global safety and technical standards, hydrogen market legislation, trade policies) to create a future global, well-functioning trade market for hydrogen. This will allow the building of a platform aimed at exchanging products or excess volumes, or to source additional volumes. For the benefit of society, make clear rules for the roles of the different participants where transmission and distribution system operators act as neutral market facilitators and where market operators invest in development and trade.

  In addition, a global market for hydrogen would enable decarbonization globally in the most efficient way, for example by enabling countries with limited renewable resources to purchase hydrogen from countries developing large-scale export.
- **Stimulate alignment at a country or regional level via bilateral and multilateral partnerships to facilitate international hydrogen trade**.

EXAMPLES

Government subsidies have been particularly successful in helping bridge the cost gap for wind energy and driving market development. In 2016, Dong Energy (now Orsted) won a tender for a wind farm that still required EUR €7.27 ct per kWh in government support. Six months later, the Blauwwind Consortium won a tender in the Netherlands for a 700 MW wind park, requiring only a EUR €5.45 ct per kWh government subsidy. And in March 2018, Chinook won the first tender in history for a wind farm that it would realize without a financial subsidy.

To meet its emissions targets, **Germany** has decided to launch a EUR €7 billion stimulus package to create a demand-driven market for hydrogen produced at competitive costs, while it will spend another EUR €2 billion on forging partnerships with countries that can efficiently produce hydrogen.[23]

Contract for difference
The **UK government** has initiated the fourth round in the contracts for difference scheme to support up to 12 GW of renewable energy projects.[24] Divided into three "pots", the first is for established technologies such as solar and wind, the second is for non-established technologies, including floating offshore wind, advanced conversion technologies and tidal stream, and pot 3 is solely for offshore wind. Contracts for difference support mechanisms, when implemented well, can provide certainty to help make a project bankable as it offers stability and predictability to future revenue streams. In addition, this design by "pots" ensures that different (complementary) technologies are not competing against each other.

Partnerships to accelerate technology deployment
Masdar, Siemens Energy and a group of partners have signed a memorandum of understanding to build a solar-powered electrolyser to showcase green hydrogen production as part of a demonstration project at Masdar City (United Arab Emirates). The demo facility will also involve the construction of a kerosine synthesis plant to convert most of the green hydrogen into sustainable aviation fuel.[25]

Twenty-three transmission system operators[26] (including WBCSD member SNAM) **from 21 countries** are collaborating to develop the **European Hydrogen Backbone** by repurposing existing gas infrastructure and making targeted investments in new dedicated hydrogen pipelines and compressor stations. The aim is to develop dedicated and affordable hydrogen transport over long distances, interconnecting many European countries and enabling hydrogen imports. It could receive state aid beyond the strict rules for member state aid systems as an Important Project of Common European Interest (IPCEI).[27]

WBCSD member companies TotalEnergies and Engie have signed a cooperation agreement to develop and operate the **Masshylia project**,[28] France's largest renewable hydrogen production site powered by solar farms, with a total capacity of more than 100 MW. The 40 MW electrolyser will produce 5 tons of renewable hydrogen per day to meet the needs of the biofuel production process at TotalEnergies La Mède biorefinery, avoiding 15,000 tons of CO_2 emissions per year.

It is one of the candidates to join the IPCEI to support hydrogen projects in EU member states.

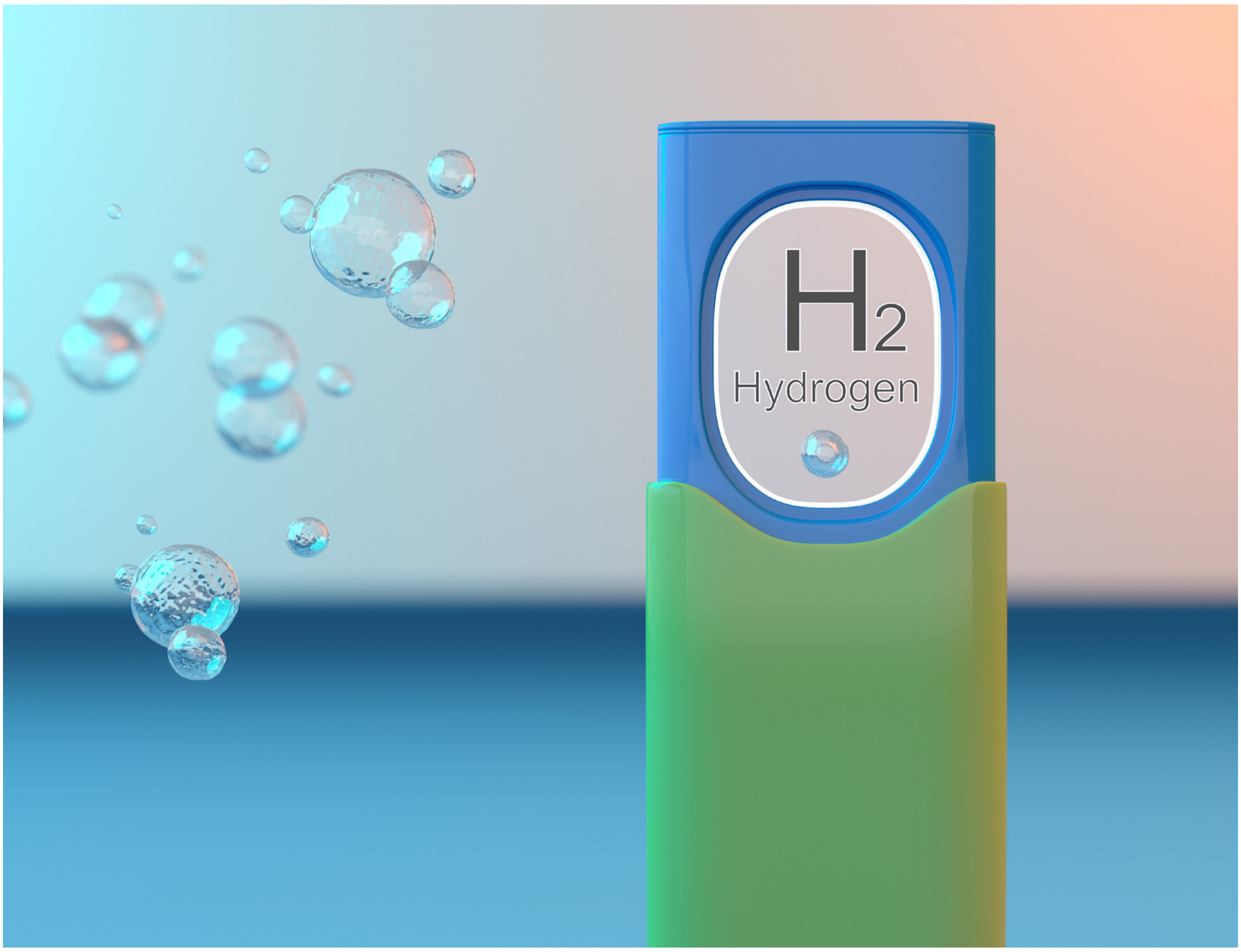
WBCSD member company bp is developing a world-scale **blue hydrogen production facility in the UK**. It is targeting 1 GW of hydrogen production by 2030, with an ambition to achieve high plant CO_2 capture rates (up to 98%) through advances in gas reforming and carbon capture technologies. bp has signed agreements with multiple partners to explore how clean hydrogen can support the decarbonization of multiple sectors located in Teesside, including industry, clean power and steam, transport and the gas network.

H2Teesside will capture and send for storage up to 2 million tons of CO_2 per year via the Northern Endurance Partnership (NEP) – equivalent to capturing the emissions from the heating of 1 million households in the UK. The UK government has set itself the target of having carbon capture, use and storage (CCUS) clusters operating by the mid-2020s and is developing business models that would support investments in CO_2 transport and storage infrastructure, as well as the capture of CO_2 from hydrogen facilities, industry and power plants.

As an example of collocating new renewable hydrogen projects with existing demand, WBCSD member company Iberdrola has formed a partnership with Fertiberia in **Puertollano** to produce **green ammonia with a 20 MW electrolyser**. The fertilizer plant will also use the oxygen generated from the process to improve efficiency and further reduce GHG emissions.

This initial project will already provide some 1,000 tons of hydrogen per year and reduce the fertilizer plant's CO_2eq emissions by nearly 40,000 tons. Studies are in progress to extend the capacity 40-fold, to 830 MW of electrolysis by 2027.

The **NorthH2 project** (a consortium of several companies, including WBCSD members Shell and Equinor, supported by the Groningen provincial authority) aims to set up large-scale green hydrogen production using offshore wind power (4 GW by 2030 and 10 GW by 2040, producing around 1 million tons of hydrogen a year).



Two other WBCSD member companies, Enel and Eni, are collaborating to develop **green hydrogen as feedstock for refineries.** Two pilot projects consist of 10 MW electrolysers that will start operations in 2023. Both projects are also candidates to join the IPCEI to support hydrogen projects in member states.

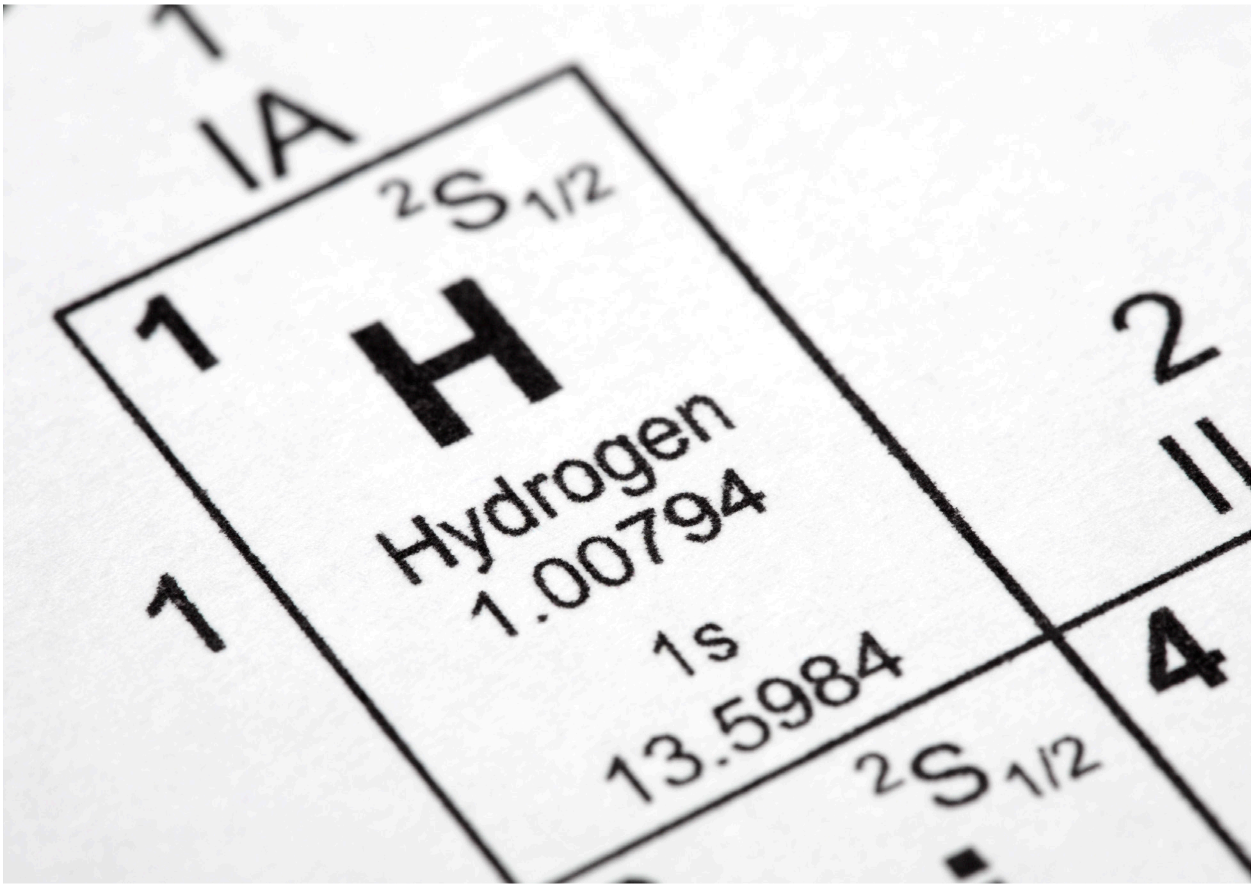
Trade contracts between export/import countries (see a more comprehensive list in IRENA's *Green hydrogen supply: A guide to policy making*[29] report)

Germany and the Netherlands signed a call to action to foster collaboration on green hydrogen and green chemicals, and formulated six recommendations to help both countries advance their ecological and economic ambitions.[30]

On the initiative of the Australian and Japanese governments, the **Hydrogen Energy Supply Chain** (HESC) pilot began operations in March 2021 and involves developing a complete hydrogen supply chain, from producing hydrogen gas, to transportation for liquefaction and exporting the liquefied hydrogen to Japan.[31]

Japan and the United Arab Emirates signed a memorandum of collaboration to work together on technology to produce hydrogen and create an international supply chain. The two countries will also work together to boost hydrogen demand in the Emirates.[32]

Chile and the Port of Rotterdam (a WBCSD member company) signed a memorandum of understanding for the development of a new hub for green hydrogen exports and imports.[33]



For the demand and use side

- **Level the playing field** by including hydrogen as a decarbonization option in already existing low-carbon mandates
- **Accelerate the adoption of hydrogen in end-use sectors where it is competitive** (such as steel, cement, chemicals, fertilizers, heavy transport; where electrification is challenging) by developing policies that complement existing low-carbon initiatives, such as contracts for difference, low-carbon product standards and fiscal levers.
- **Grow the market by:**
  - Ensuring that demand generation is a focus of policy and national strategy because, from a country perspective, hydrogen both supports decarbonization and can improve energy security and autonomy (when produced domestically).
  - Supporting early-stage projects by using long-term offtake contracts to supply heavy vehicles and captive fleets. Because hydrogen as a fuel for (heavy) vehicles also plays a role in eliminating pollution associated with fossil fuels, it is particularly interesting in cities and densely populated areas.
  - Allocating incentives to pilot and demonstration projects that are the most promising for a decarbonized future to facilitate technology deployment and improve economics through scale.
  - Blending small quantities of hydrogen in existing gas networks/infrastructure can in some cases help support the growth of the hydrogen economy in the short term and provide a "flexible offtaker" until such time as higher value use cases become anchored. If choosing this option, it is necessary to establish clear safety and technical boundaries (such as quality specifications, blending rates) based on surveys of the local infrastructure and, where possible, harmonize them with interconnected countries to facilitate hydrogen flow across networks. This is likely a temporary solution to help grow the hydrogen market and scale up low-carbon hydrogen production at the beginning, as in the medium and long term other solutions, such as electrification, may be more energy efficient in decarbonizing residential applications in most places and it is possible to use hydrogen in pure form in higher value cases.

EXAMPLES

Mandates

Canada has proposed regulations for the Clean Fuel Standard to drive investment and growth in its clean fuel sector by increasing incentives for the development and adoption of clean fuels and technologies and processes. The goal of the Clean Fuel Standard is to significantly reduce pollution by making common fuels cleaner over time. It will require liquid fuel suppliers to gradually reduce the carbon intensity of the fuels they produce and sell for use in Canada over time, leading to a decrease of approximately 13% (below 2016 levels) in the carbon intensity of the liquid fuels used in the country by 2030.

In 2008, **California** approved the Low Carbon Fuel Standard Program (LCFS) to reduce the carbon intensity of transportation fuel used by at least 30% by 2030, in line with California's 2030 GHG target.[34]

A first-ever **European Union**-wide CO_2 emission standard for heavy-duty vehicles, adopted in 2019, sets targets for reducing the average emissions from new vehicles for 2025 and 2030.

The regulation also includes a mechanism to incentivize the uptake of zero- and low-emission vehicles, in a technology-neutral way.[35]

Contracts for difference

The **European Investment Bank** aims to work with relevant EU Member States to develop tailored instruments to support the roll out of low-carbon hydrogen, including potential support schemes such as carbon contracts for difference, to stimulate industries to switch from fossil fuels to low-carbon hydrogen.[36]

Financial support for R&D and demonstration projects

In the **US**, the proposed COVID-19 stimulus bill includes funding from the Department of Energy related to hydrogen and fuel cells.[37] This appropriated funding includes USD $150 million for the Hydrogen and Fuel Cell Technologies Office located within the Office of Energy Efficiency and Renewable Energy. The legislation also provides for USD $30 million in funding for the Solid Oxide Fuel Cell Program.

In addition, at the time of printing, the US is also looking at an infrastructure bill that would allocate USD $ 9.5 billion to push down the cost of clean hydrogen (by the creation of a Clean Hydrogen R&D Program), establish at least four regional clean hydrogen hubs and authorize multi-year grants to advance clean hydrogen research, development and demonstration projects, including for production, processing, delivery, storage or use.[38]

HyDeal, a group of 30 European energy players, supported by the European Investment Bank and other infrastructure funds, has launched a series of projects and partnerships with the aim of delivering 100% green hydrogen at the price of fuel across Europe: EUR €1.5/kg by 2030, including transmission and storage.[39]

The **Breakthrough Energy Catalyst Program**[40] fosters public and private partnerships to build large-scale, commercial demonstration projects for clean technologies in order to lower their costs and accelerate their deployment. Green hydrogen is one of four focus areas.

6 Conclusion

The deployment and rapid scaling up of hydrogen with the lowest possible carbon intensity[41] will be crucial to helping countries and businesses alike meet their net-zero emissions commitments by 2050. This involves a transformation of the energy system, with increased deployment of renewable energy and carbon removal mechanisms to enable decarbonization on a pathway consistent with a 1.5°C scenario. It will require unprecedented collaboration between the industrial, transport and power sectors, as well as between private and public entities, to overcome challenges. **It will require policy-makers to take steps to create a stable investment framework that will accelerate hydrogen deployment and uptake**, creating numerous opportunities for employment and economic development along the way.

The time to transform is now to achieve the goal of all people living well and within planetary boundaries by 2050.

Endnotes

1. Energy Transitions Commission (ETC) (2021). *Making the Hydrogen Economy Possible.* April 2021. Retrieved from https://www.energy-transitions.org/publications/making-clean-hydrogen-possible/

2. That intensity may differ according to varying historical, geographical and policy contexts.

3. That intensity may differ according to varying historical, geographical and policy contexts.

4. From the full life cycle, meaning from the capital expenditure or infrastructure emissions and transport to the supplier that places hydrogen on the market, to the end use point.

5. This definition is similar to the European Union taxonomy.

6. Intergovernmental Panel on Climate Change (IPCC) (2021). *Climate Change: The Physical Science Basis*. Retrieved from https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/

7. Energy Transitions Commission (ETC) (2021). *Making the Hydrogen Economy Possible*. April 2021. Retrieved from https://www.energy-transitions.org/publications/making-clean-hydrogen-possible/

8. International Energy Agency (2019). *The Future of Hydrogen*. Retrieved from https://www.iea.org/reports/the-future-of-hydrogen

9. International Renewable Energy Agency (IRENA) (2020). *Green hydrogen supply: A guide to policy making*. Available at https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Nov/IRENA_Green_hydrogen_policy_2020.pdf

10. Hydrogen Council (2017). “Hydrogen, Scaling up”. Retrieved from https://hydrogencouncil.com/en/study-hydrogen-scaling-up/

11. See the energy trilemma as defined by the World Energy Council at https://www.worldenergy.org/transition-toolkit/world-energy-trilemma-index

12. European Commission (2020). *A hydrogen strategy for a climate-neutral Europe.* Retrieved from https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf

13. Klimaatakkoord (2019). National Climate Agreement - The Netherlands. Retrieved from https://www.klimaatakkoord.nl/documenten/publicaties/2019/06/28/national-climate-agreement-the-netherlands

14. Ministry of Energy, Government of Chile (2020). *National Green Energy Strategy*. Retrieved from https://energia.gob.cl/sites/default/files/national_green_hydrogen_strategy_-_chile.pdf.

15. See the WBCSD *Carbon Pricing - WBCSD Policy Paper 2019:* https://www.wbcsd.org/Programs/Climate-and-Energy/Climate/Climate-Action-and-Policy/Resources/Carbon-Pricing-WBCSD-Policy-Paper-2019

16. World Bank (2021). *Carbon Pricing Assessment and Decision Making: A guide to adopting a carbon price*. Retrieved from https://openknowledge.worldbank.org/bitstream/handle/10986/35387/Carbon-Pricing-Assessment-and-Decision-Making-A-Guide-to-Adopting-a-Carbon-Price.pdf?sequence=1&isAllowed=y

17. Government of Norway (2020). “CO2-avgiften - regjeringen.no.” Retrieved from https://www.regjeringen.no/no/tema/okonomi-og-budsjett/skatter-og-avgifter/veibruksavgift-pa-drivstoff/co2-avgiften/id2603484/

18. International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE). “Working Groups and Task Forces”. Retrieved from https://www.iphe.net/working-groups-task-forces

[19] Centre for Hydrogen Safety. Retrieved from https://www.aiche.org/chs

[20] This relies on the adoption of a standard methodology to calculate the life-cycle GHG emissions of hydrogen. See https://www.iphe.net/working-groups-task-forces

[21] Note the CertifHy calculation for carbon intensity of the hydrogen does not account for infrastructure (Capex) emissions, which WBCSD recommends including for the calculation method to be comprehensive.

[22] Acciona (2021). "ACCIONA develops first platform to guarantee renewable origin of green hydrogen". 2 February 2021. Retrieved from https://www.acciona.com/updates/news/acciona-develops-first-platform-guarantee-renewable-origin-green-hydrogen/

[23] Federal Ministry for Economic Affairs and Energy of Germany (2020). *The National Hydrogen Strategy.* Retrieved from https://www.bmwi.de/Redaktion/EN/Publikationen/Energie/the-national-hydrogen-strategy.html

[24] Offshore Wind (2020). "UK Targets 12 GW of Renewables in Round 4 CfD Auction". 24 November 2020. Retrieved from https://www.offshorewind.biz/2020/11/24/uk-targets-12-gw-of-renewables-in-round-4-cfd-auction/

[25] Mubadala (2021). "Mubadala and Siemens Energy sign MoU to accelerate green hydrogen capabilities in Abu Dhabi". 17 January 2021. Retrieved from https://www.mubadala.com/en/news/mubadala-and-siemens-energy-sign-mou-accelerate-green-hydrogen-capabilities-abu-dhabi

[26] Note: Any large-scale collaboration and partnerships should respect all applicable anti-trust and competition laws.

[27] Gas for Climate 2050 (2021). "European Hydrogen Backbone grows to 40,000 km, covering 11 new countries". 13 April 2021. Retrieved from https://gasforclimate2050.eu/news-item/european-hydrogen-backbone-grows-to-40000-km/

[28] TotalEnergies (2021). "Total and Engie partner to develop France's largest site for the production of green hydrogen from 100% renewable electricity". 13 January 2021. Retrieved from https://www.totalenergies.com/media/news/press-releases/total-and-engie-to-develop-france-s-largest-site-of-green-hydrogen

[29] International Renewable Energy Agency (IRENA) (2021). *Green hydrogen supply: A guide to policy making*. Page 41. Retrieved from https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/May/IRENA_Green_Hydrogen_Supply_2021.pdf

[30] National Advisory Committee on Electrochemical Conversion & Materials (2021). *Call to action GER-NED Hydrogen and Green Chemistry*. Retrieved from https://www.nwo.nl/sites/nwo/files/media-files/Call%20to%20action%20GER-NED%20Hydrogen%20and%20Green%20Chemistry%20%28April%202021%29.pdf

[31] IHS Markit (2021). "Australia, Japan begin operations of complete, integrated supply chain for hydrogen plant". 23 March 2021. Retrieved from https://ihsmarkit.com/research-analysis/australia-japan-begin-operations-of-complete-integrated-supply.html

[32] Reuters (2021) "Japan, UAE to collaborate on hydrogen technology, supply chain". 8 April 2021. Retrieved from https://www.reuters.com/article/japan-hydrogen-emirates-idINKBN2BV1CA

[33] Government of Chile (2021). "Chile signs green hydrogen export memorandum of understanding with Europe's largest port". Retrieved from https://chilereports.cl/en/news/2021/03/19/chile-signs-green-hydrogen-export-memorandum-of-understanding-with-europe-s-largest-port

[34] California Air Resources Board (n.d.). "Low Carbon Fuel Standard". Retrieved from https://ww2.arb.ca.gov/sites/default/files/2020-09/basics-notes.pdf

[35] European Commission. (n.d) "Reducing CO_2 emissions from heavy-duty vehicles". Retrieved from https://ec.europa.eu/clima/policies/transport/vehicles/heavy_en

[36] European Investment Bank (2020). *EIB Group Climate Bank Roadmap 2021-2025*. Retrieved from https://www.eib.org/attachments/thematic/eib_group_climate_bank_roadmap_en.pdf

[37] Baker Botts (2020). "Major Tax, Appropriations, and Policies for Hydrogen and Fuel Cell Industry Passed by Congress". Retrieved from https://iclg.com/briefing/15352-major-tax-appropriations-and-policies-for-hydrogen-and-fuel-cell-industry-passed-by-congress

[38] Recharge News (2021). "Green, blue and pink: Bipartisan US infrastructure bill allocates $9.5bn to push down the costs of clean hydrogen". Blog, 3 August 2021. Retrieved from https://h2-ccs-network.com/blog/green-blue-and-pink-bipartisan-us-infrastructure-bill-allocates-9-5bn-to-push-down-the-costs-of-clean-hydrogen/

[39] Open Grid Europe (OGE) (2021). "HyDeal Ambition: Europe-wide green hydrogen at the price of fossil fuels". Press release. 10 February 2021. Retrieved from https://oge.net/en/press-releases/2021/hy-deal-ambition-europe-wide-green-hydrogen-at-the-price-of-fossil-fuels

[40] Breakthrough Energy (n.d.). "Scaling Innovation: The Catalyst Program – Accelerating the Deployment of Clean Technologies". Retrieved from https://www.breakthroughenergy.org/scaling-innovation/catalyst

[41] That intensity may differ according to varying historical, geographical and policy contexts.

ACKNOWLEDGEMNTS

We would like to thank the member companies who contributed to this document as part of the hydrogen workstream, in particular: Acciona, bp, Chevron, CLP, Dow, EDF, EDP, Enel, Engie, ERM, Equinor, Iberdrola, Neste, Petronas, TotalEnergies, Shell, Snam, Vale, Yara, Yokogawa.

DISCLAIMER

This publication has been developed in the name of WBCSD. Like other WBCSD publications, it is the result of a collaborative effort by members of the secretariat and representatives from member companies. A wide range of members reviewed drafts, thereby ensuring that the document broadly represents the perspective of the WBCSD membership. Input and feedback from members was incorporated in a balanced way. This does not mean, however, that every member company agrees with every word.

Examples of government policy implementation included in this document are for illustrative purposes only and should not be considered as endorsements by WBCSD or its member companies.

ABOUT WBCSD

WBCSD is a global, CEO-led organization of over 200 leading businesses working together to accelerate the transition to a sustainable world. We help make our member companies more successful and sustainable by focusing on the maximum positive impact for shareholders, the environment and societies.

Our member companies come from all business sectors and all major economies, representing a combined revenue of more than USD $8.5 trillion and 19 million employees. Our global network of almost 70 national business councils gives our members unparalleled reach across the globe. Since 1995, WBCSD has been uniquely positioned to work with member companies along and across value chains to deliver impactful business solutions to the most challenging sustainability issues.

Together, we are the leading voice of business for sustainability: united by our vision of a world where more than 9 billion people are all living well and within planetary boundaries, by 2050.
www.wbcsd.org

Follow us on Twitter and LinkedIn

World Business Council
for Sustainable Development

Geneva, Beijing, Delhi, London, New York, Singapore

www.wbcsd.org