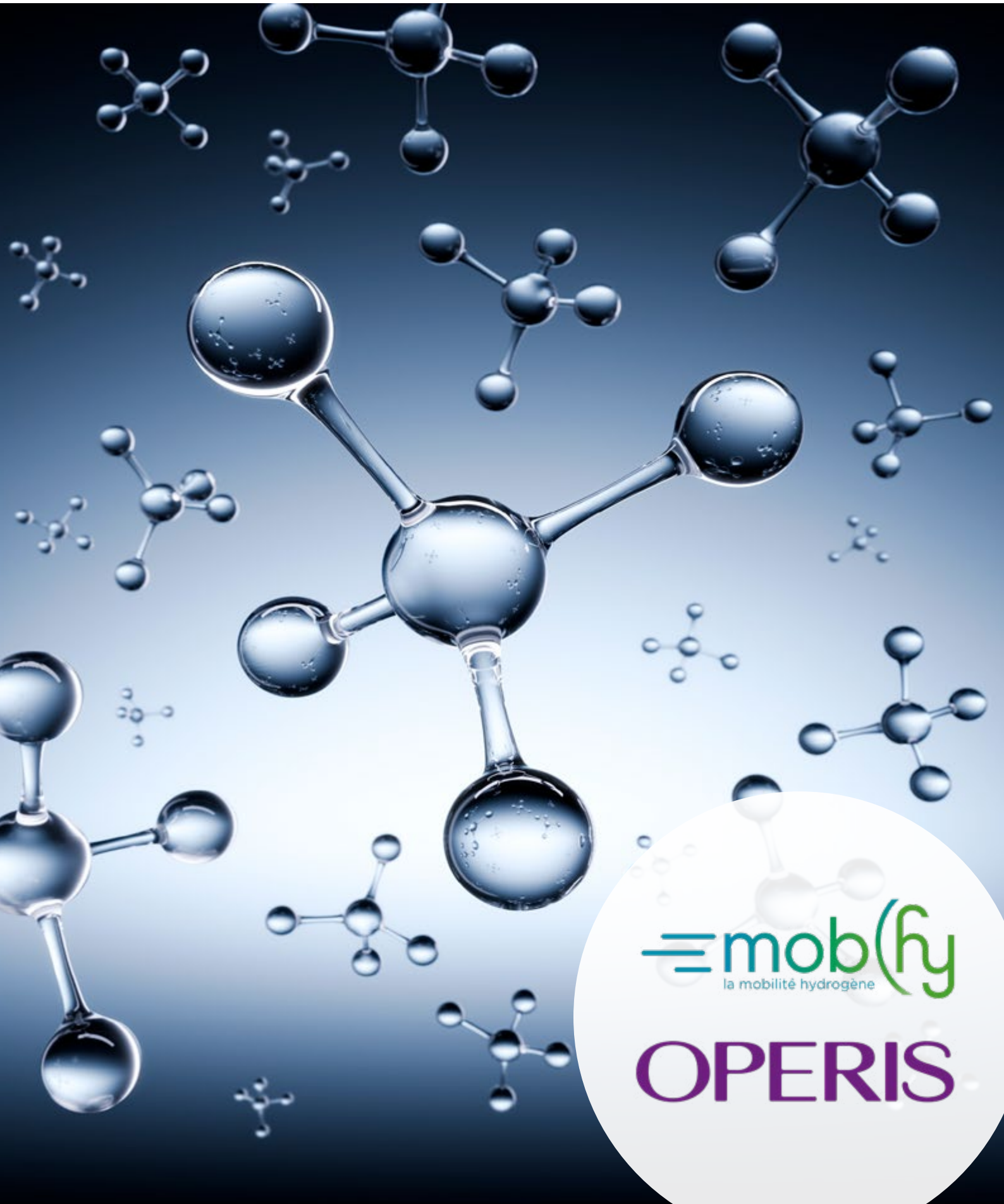
AN ESSENTIAL GUIDE TO
HYDROGEN



mob(fy)
la mobilité hydrogène

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INTRODUCTION: WHY HYDROGEN?

As the global public debate about climate change has increased in intensity, Hydrogen (H_2) has become a trending topic. Scientists, climate activists, and politicians praise its potential as a carrier of energy, and a number of roadmaps and strategies for making greater use of hydrogen have been published at country and regional levels.

THE NEED FOR A SOURCE OF CLEAN ENERGY

According to a World Meteorological Organization (WMO) report in April 2021, global temperatures have risen by 1.2 degrees Celsius above the pre-industrial baseline over the last century, due to increasing pollution and the greenhouse effect. Finding alternative clean energy sources is critical to limiting further increases. The potential of hydrogen to decarbonise some of the most challenging sectors relies on green hydrogen, i.e. hydrogen produced using renewable energy.

The global annual production of hydrogen is currently about 70 million tonnes. Hydrogen is in active use in various sectors – from oil refineries to steel production and the chemical industry (e.g., ammonia production), while small-scale power from hydrogen is also being actively deployed.

There are a growing number of applications for hydrogen on the horizon, in particular transportation: hydrogen is already in use to power some of London's bus fleet, whilst several pilot projects involve water, rail and air transport.

NETWORK EFFECTS REQUIRE GOVERNMENT SUPPORT

From production through to storage, transportation, and distribution, hydrogen requires the same economies of scale that other energy sources currently benefit from. Overcoming the initial problem of scaling requires government support both in terms of investment, and providing the required regulatory and financial framework. The EU's Hydrogen Strategy for a Climate-Neutral Europe is one example, a three-phase project focused on utilising renewable hydrogen technologies across hard-to-decarbonise sectors.

This Guide outlines some of the key applications of hydrogen currently being pursued worldwide. It also highlights the critical regulatory and financial frameworks needed for hydrogen to become widely used. However, the key to understanding the nature of hydrogen projects today is knowing that there is a diverse array of sources and uses for the gas, which we will discuss in the next section.

Photo by Agustín Lautaro

THE DIFFERENT SHADES OF HYDROGEN

In the energy sector, when talking about hydrogen we refer to the H_2 hydrogen molecule, which is the colourless, odourless (and highly flammable) gaseous form that hydrogen takes under standard conditions. However, in industry parlance, you'll often hear the terms grey hydrogen and green hydrogen – alongside other shades of hydrogen, including blue and white.

THE HYDROGEN RAINBOW

The different shades of hydrogen refer to the production methods and their environmental impacts. The National Grid website mentions ten different colours of hydrogen, but we will focus on three here: grey, blue, and green. Despite the increased use of renewable, low-carbon or fossil hydrogen following a 2021 European directive, this note refers to the colour system for ease of reference.

Grey hydrogen is produced using fossil fuels without any offsetting or recapture of the associated carbon emissions. In this process, water and natural gas are mixed at high pressure and high heat, producing not only hydrogen but also carbon dioxide. CO_2-eq emissions for each kg of H_2 produced through steam reforming of natural gas or coal gasification (in China only) are equivalent to 12kg of CO_2-eq and 20kg of CO_2-eq respectively.

Blue hydrogen is produced using non-renewable energy sources but using a process that meets low emission standards, such as fossil fuels coupled with carbon capture.

Green hydrogen is produced using renewable energy sources, with the electrolysis of water as the primary technology. The European directive further specifies a 3kg CO_2-eq carbon footprint limit for each kg of H_2 produced to qualify as green.

[1] Various sources refer to this method of H2 production as red, purple, or yellow (e.g., https://www.nationalgrid.com/stories/energy-explained/hydrogen-colour-spectrum)

The rainbow of hydrogen colours also includes turquoise hydrogen, using thermal splitting of methane to give solid carbon rather than CO_2 as a by-product, and pink hydrogen, produced using nuclear power[1] . Finally white hydrogen occurs naturally under specific geological conditions (e.g., in Mali) or as a by-product of other industrial processes.

About 95% of current hydrogen production is grey hydrogen, often produced using methane, but sometimes other, even more polluting, fuels. In this article, we focus on the use and production of green hydrogen since this offers the most significant carbon reduction potential.

MOVING FROM GREY TOWARDS GREEN

Grey hydrogen makes up such a large chunk of the total because the fossil fuel sources used in its production are cheaper than the renewable or low carbon alternatives. Any move to green hydrogen will require initial regulatory intervention or financial support to address the negative external costs from grey hydrogen and to level the financial playing field.

A move to blue hydrogen would be preferable to sticking with the status quo, but blue hydrogen relies on imperfect technologies such as carbon capture and methane reforming, whose reliability and effectiveness are still debated. Carbon capture, for example, is not currently one hundred per cent effective as there is, in the long run, a risk of carbon leaking out of its storage. Moreover, this technology does not reduce dependence on gas production.

THE DIFFERENT SHADES OF HYDROGEN COMPLICATE THE PICTURE

The different ways in which hydrogen can be produced significantly complicates the hydrogen energy equation.

For example, a bus running on hydrogen will have zero emissions during its trip whether green or grey hydrogen is used. If the bus runs on grey hydrogen, however, the emissions generated in producing the hydrogen need to be accounted for and will be significantly higher than those produced throughout the green H2 production process. A simple analysis of the carbon footprint of a vehicle using grey hydrogen shows a similar level of (indirect) CO_2 emissions to the emissions of a comparable vehicle with an internal combustion engine (ICE). These emissions are not visible, since they are emitted at the time of production of the H_2 rather than by the vehicle itself. They do contribute to global warming nonetheless and therefore restrict the appeal of grey H_2 for the Net Zero agenda.

Because the cleanest forms of hydrogen can also be, relatively speaking, more expensive to manufacture, the different shades of hydrogen affect not just the emission status of a project (or in our example, a bus journey), but also the economics of those projects.

Photo by Pawel Czerwinski

HYDROGEN APPLICATIONS TODAY

EXISTING INDUSTRIAL HYDROGEN USE CASES

While hydrogen is increasingly used as fuel, the petrochemical industry has a long history of hydrogen consumption. Current hydrogen consumption, mostly grey, is mainly in the fertiliser production sector and its by-products, such as polymers, as well as in oil refining.

Increasing environmental standards for hydrocarbon desulphurisation are driving the oil refining sector to consume more and more hydrogen. Previously the quantity of hydrogen extracted during the cracking process, once re-injected during the diesel de-sulphurisation process, was sufficient to meet environmental standards, allowing the sector to be self-sufficient. Stricter environmental standards have however led to the sector becoming an increasing net consumer.

Substituting the current level of grey H_2 consumption by green H_2 would save approximately 630,000 million tonnes of CO_2eq per year, assuming green H_2 at 3kg CO_2-eq/kgH_2 and grey H_2 at 12kg CO_2-eq/kgH_2.

Other industrial sectors could also modify their processes to use green hydrogen. This is particularly true of steel production, which accounts for 9% of global CO_2 production.

AMMONIA PRODUCTION

55%

PETROLEUM REFINING

25%

METHANOL PRODUCTION

10%

OTHER

10%

Data from Hydrogen Europe
Photos by: Antonino Visalli; Juniper Photon; Victor and Roman Fox

According to the Granttan Institute, steel production generates a large amount of CO_2 because of the use of coal as a chemical reductant for iron ore. It is however possible to use pure hydrogen as an alternative reductant and avoid the emissions caused by the use of coal.

Due to the current cost of hydrogen, this process is more expensive. Nonetheless, some countries have started to invest in producing green steel using hydrogen instead of coal. For example, in Sweden, Volvo has used this technique to make lorries, and the country's hydrogen steel production has been ramping up.

EMERGING USES OF HYDROGEN

There are many power-from-hydrogen projects, but these are currently operating at a small scale. The International Energy Agency (IEA) has a list of these projects on their website and analysing these shows that most projects currently have a capacity well below 5MW. However, the number and scale of these projects are increasing, with a lot more already under construction.

Hydrogen is emerging as an attractive decarbonisation solution for the transport sector – with hydrogen as a fuel now accounting for 0.5% of new low-carbon vehicles. Despite relatively heavy tank and fuel cell of a H2 mobility system, the energy density of hydrogen makes it competitive with batteries for high payloads (i.e. over 3.5t) as the weight of an electric truck increases linearly (and punitively) with the increase in the number of batteries. This is also why applications have emerged for hydrogen planes, trains and buses.

A hydrogen (or fuel cell) vehicle has a H_2 tank instead of an electric vehicle's (EV) battery. Fuel-cell vehicles offer quiet and emission-free mobility – eliminating CO_2 and NOx. They are refuelled relatively quickly compared to EVs. However, due to the head start EVs already have and the focus they receive from governments, manufacturers, and users alike, they may very well crowd out the market and prevent the rise of hydrogen cars in the personal vehicle market. Their widespread development also faces the hurdle of the infrastructure they would require, such as hydrogen fuel stations, which are in far fewer numbers than even EV charging points.

Some figures on london's buses

2020

- 20 buses
- Cost of vehicles: £500,000/ bus
- Cost of refuelling infrastructure: £2,000,000
- H_2 used: hydrogen co-product of the chlorine industry
- Refuelling time: 5 minutes
- Autonomy: sufficient for one day of service (350 – 400 miles)
- Quiet
- No emissions inside the city (no CO_2, no NOx)

2023

- H_2 used: renewable hydrogen from electrolysis
- Estimations: Assuming that a bus does 60,000km/year, this avoids about 750,000l of diesel or the emission of 1,900 tonnes of CO_2/year

2030

--> 100% zero emissions buses in London

Photos by: omada

HYDROGEN AS A STORE OF ENERGY

In comparison with electricity, one of hydrogen's most significant advantages is its capacity to be stored for long periods. It makes it a fantastic storage solution for energy by allowing electricity networks to bridge the gap between intermittent supply of renewable energy like solar and wind power, and demand. Whilst battery technology also allows to achieve this delicate balancing intra-day, H_2 can be stored over much longer periods. Generators will need to weigh the loss of energy efficiency through conversion from H_2 back into electricity against:

- the curtailment losses thus avoided, and/or;
- the price arbitrage opportunities of storing energy when the wholesale price is low and selling it when high.

After being stored, H_2 can be used in different ways:

- stored and converted into electricity when demand and wholesale electricity prices are high, but generation is restricted by nature,
- used directly in the various industries described above, or
- injected into the natural gas network (P2P, P2G).

Today, H_2 storage is divided into three main technologies. The most common is physical storage, such as compressed storage up to 900 bars or liquefied storage at -253°. It is also possible to chemically transform it into another more stable molecule such as methane or to trap it in specific solutions such as Liquid organic hydrogen carriers (LOHC). The last method is similar to a physical method already known for gas, which is to compress hydrogen underground in old salt mines for example.

The choice of storage technology will depend on the location, volumes handled, distances travelled and the final application.

HYDROGEN NETWORK ECONOMICS: HOW CAN WE MAKE IT WORK ?

In an emerging industry such as hydrogen, broad adoption depends on network economics as hydrogen will only make economic sense if it is in relatively widespread use. Hydrogen needs to become cheaper than the alternatives – that's when users will switch.

Yet, the pricing of hydrogen depends on many factors – from production capacity to the underlying technology. Reported prices can be as low as 1.5-2 EUR/kg and as high as 11-13 EUR/Kg depending on the colour of hydrogen, the level of subsidies and whether one looks at the cost of production on-site or the retail prices after transport.

Although variation in prices is high today, there is a consensus on the downward trend. This price decrease is expected to come from cost reductions across the value chain, whether for production, storage, transport, or distribution – and it mirrors the drop in price for other renewables as these sources of energy scaled. So, how are hydrogen network economics evolving?

HYDROGEN PRODUCTION AND STORAGE

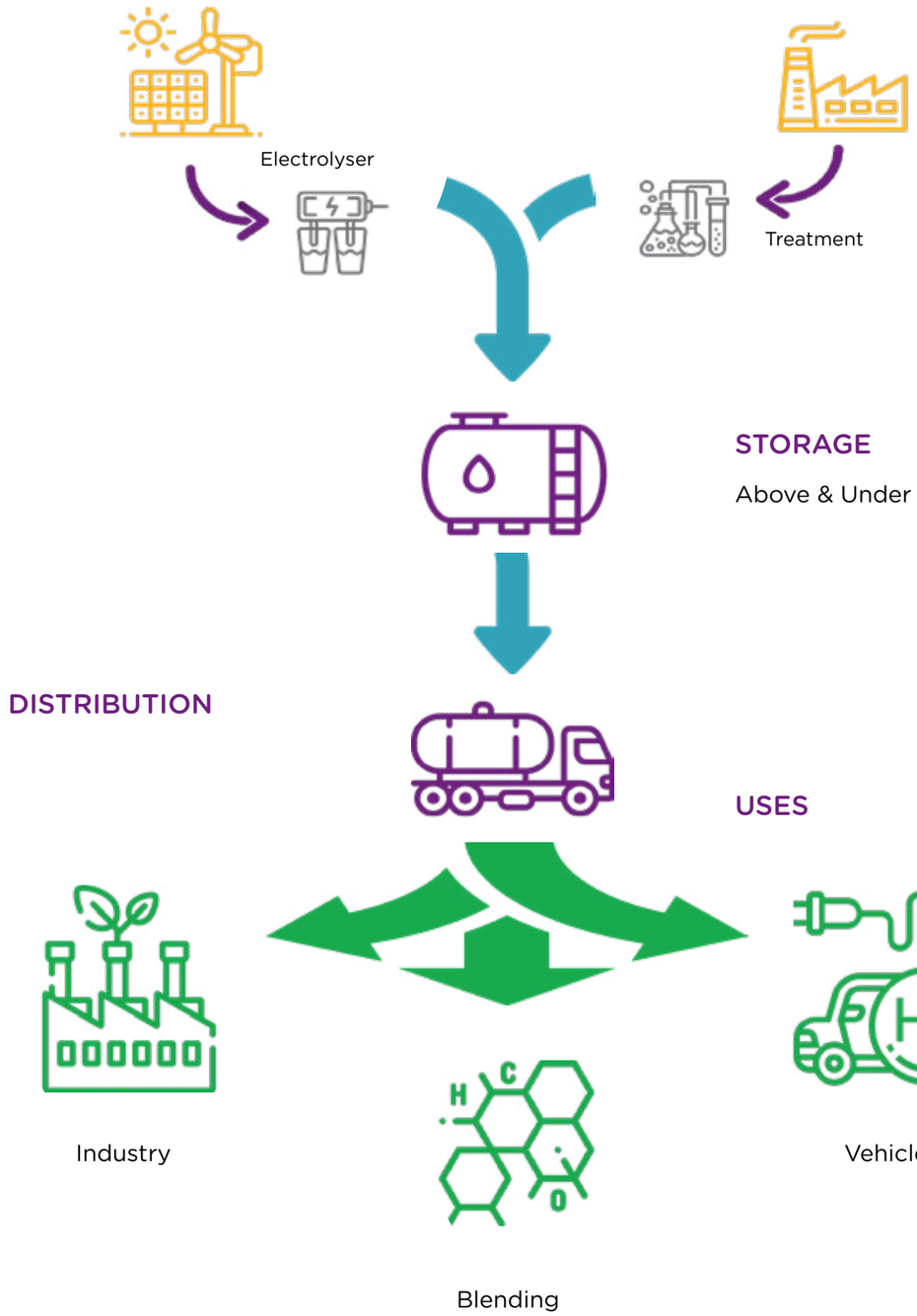
The scaling up of hydrogen production, with the development of giga electrolysers, will work alongside the forecasted drop in green electricity prices to drive down the cost of hydrogen production costs in the future. Higher demand for green hydrogen should lead to economies of scale due to the low marginal cost of increasing equipment capacity such as electrolysers and compressors; this would support a price drop. Hydrogen storage matters too, bridging the gap between production profiles and consumption profiles. We are seeing various improvements across the types of hydrogen storage – physical, material and geological. Arguably, physical storage by compression has achieved the technological maturity and technological viability to be in widespread use. The physical challenges of liquified storage (ultra-low temperatures, natural losses of H_2 when stored, toxicity of ammonia) make this solution impracticable for long-term storage.

HYDROGEN NETWORK

SOURCES

Renewable Energies

Industrial Processes



TRANSPORTATION OF HYDROGEN

Hydrogen can be transported in different ways: as a high-pressure compressed gas, a liquid gas (like LNG) or uncompressed gas through pipelines. Each method has its pros and cons; some are better over short distances while others can leverage the existing gas network to reach longer distances.

Thinking about pipelines, one way to keep the cost of hydrogen down and reduce the initial expense is to convert existing natural gas pipelines into hydrogen ones or to gradually decarbonise the natural gas network by injecting a proportion of green hydrogen. European gas network operators estimate that the network can accept 6% hydrogen without requiring any investment, or up to 20% with some upgrade to the existing network[2]. This version of hydrogen transport would allow decarbonisation to proceed quickly and absorb the surplus production before new sectors such as mobility develop.

From an entire network perspective, all three transportation solutions are complementary, with pipelines taking a central role in connecting countries with high renewables and hydrogen potential and capacity with less endowed countries, as is intended by the European Hydrogen Backbone initiative.

[2] Source: The European Hydrogen Backbone forecasts a cost of €27-64 billion to convert up to 40,000km of the existing natural gas network to hydrogen by 2040.

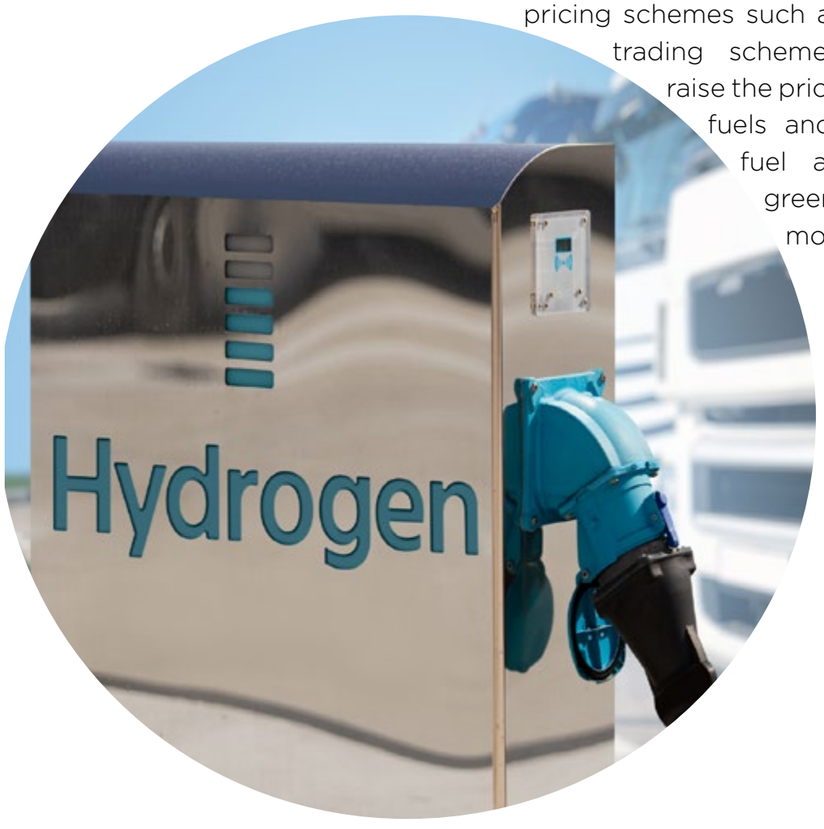
DISTRIBUTION AND USER ACCEPTANCE

Whether it is existing grey hydrogen markets or new green hydrogen ones, the retail price will be a crucial factor, as we just outlined, but it is not the only one. Until an extensive distribution network is available, hydrogen production will likely need to remain near industrial clusters that can use the supply.

Having multiple users nearby will reduce the risk to the hydrogen producer of their off-taker disappearing and leaving them with no source of income. Ports and industrial parks are thus natural places to build the initial hydrogen hubs, eventually joining up to form the network.

When it comes to hydrogen buses and trucks, the main hurdle is a dedicated system of refuelling points. Industrial hydrogen hubs could easily add hydrogen refuelling depots. In turn, more hydrogen refuelling stations could significantly impact the number of heavy goods vehicles using hydrogen.

To increase user acceptance, hydrogen prices need to fall but the cost of fossil fuel alternatives will need to become more expensive too. In this context, carbon pricing schemes such as the EU's emission trading scheme, should gradually raise the price of carbon-emitting fuels and make carbon-free fuel alternative such as green hydrogen become more competitive.



Photos by PhonlamaiPhoto, Scharfsinn86

GOVERNMENT PLANS FOR HYDROGEN

Motivated by hydrogen's considerable environmental benefits and the substantial estimated economic benefits (both directly from the new industry and indirectly by encouraging growth in adjacent sectors), many governments are prioritising considerable investments and political support through dedicated hydrogen strategies.

Over and above the environmental benefits, hydrogen as an emerging field also represents the opportunity for countries to develop a new centre of expertise for their economy, thereby driving growth from new technology developments and job creation.

The Hydrogen Council estimates that the hydrogen industry will create thirty million jobs and represent USD 2.5tn in annual sales by 2050. According to McKinsey, 75 countries representing over half the world's GDP have net zero carbon objectives, with more than 30 including hydrogen-specific strategies within these ambitions.

Let's now look at some examples of regional and national plans to support growth in hydrogen projects.

HYDROGEN INVESTMENTS IN EUROPE

The EU Green Deal's objective of net zero by 2050 puts its Hydrogen Strategy for a Climate-Neutral Europe at its centre. The EU's hydrogen strategy aims firstly to decarbonise the current hydrogen production through the expansion of electrolysis and secondly to increase the use of hydrogen in sectors where it can replace fossil fuels.

The EU hydrogen strategy expects a cumulative investment of €3bn–€18bn for low-carbon fossil-derived hydrogen and between €180bn–€470bn for renewable hydrogen (produced using mainly solar and wind). On a country-by-country basis, the following targets have been announced:

- **France**: EUR 7.2bn investment support through to 2030, aiming to support 150,000 jobs. About half is provided in the first phase through to 2023, addressing three priorities: industry, transport and trade, research and development. It includes a target for installed electrolysis capacity of 6.5 GW by 2030, the most ambitious target within the EU so far.
- **Germany**: EUR 9bn investment for the German National Hydrogen Strategy (NHS), with EUR 7bn deployed domestically, and EUR 2bn in international partnerships. The NHS identifies green hydrogen as a replacement for grey hydrogen in industrial processes including steel and chemicals production. Expected electrolysis capacity of up to 5 GW is to be built by 2030.
- **Netherlands**: EUR 10m in 2021 and EUR 35m per year afterward to accelerate cost reductions of green hydrogen – alongside another EUR 15m towards carbon capture. The Dutch National Hydrogen Strategy (DNHS) for sustainable hydrogen covers green hydrogen and blue hydrogen. It aims to scale up to 500 MW of established electrolysis capacity by 2025 and up to 3-4 GW in 2030, in conjunction with developing the demand for hydrogen and regional infrastructure.
- **Spain**: For 2021-2023, EUR 1.5bn of public funding would be allocated to boost renewable hydrogen through Next Generation EU. Additionally, the government is encouraging private investment through grants and tax incentives, they are targeting USD 10bn of private financing by in the 2020s. By 2030, Spain aims to install 4 GW of electrolysis capacity, starting with 300-600 MW by 2024, and the focus is on replacing 25% of the c. 500,000 tons of fossil fuel-based hydrogen consumed by industry every year – and putting thousands of hydrogen-powered vehicles on Spain's roads and railways by then.
- **United Kingdom**: The UK's hydrogen strategy as well as its Green Industrial Revolution plan target 5 GW of low carbon H2 production capacity for 2030. A range of measures will support it, including a £240m Net Zero Hydrogen Fund and new hydrogen business models, including a revenue mechanism to attract up to £4bn of private sector investment.

COMPARISON OF HYDROGEN STRATEGIES AND POLICY DRIVERS BY COUNTRY[3]

Publication	June 2018 Sept. 2020	June 2020	Mar. 2020	Apr. 2020	Sept. 2020 (SNAM)	Aug. 2021
H2 - Technology						
Technology leadership						
Hydrogen for export						
Imports for hydrogen						
Budget	€7.2bn	€9bn	€325m	€1.5bn	€5bn	€4.8bn
2030 Capacity targets	6.5GW	5GW	3-4GW	4GW	5GW	5GW

HYDROGEN INVESTMENTS IN ASIA

In Asia too, hydrogen is seen as a pivotal way to diversify the energy mix. Particularly in China, the beneficial impact on air quality is seen as a key reason to encourage hydrogen in mobility. Japan, South Korea, and China hold over 55% of fuel cell patents and more than 65% of hydrogen-related patents (FCHJU 2019). Japan and South Korea anticipate large-scale imports of hydrogen, whereas Australia and New Zealand's hydrogen strategies focus on the potential for exports:

- **Japan**: In 2021, annual government support for hydrogen projects was at JPY 70bn. It was the first government to adopt a hydrogen framework with its 2017 Basic Hydrogen Strategy, followed by a 3rd strategic roadmap in March 2019. Japan considers hydrogen to increase energy self-sufficiency, decarbonise the economy and improve industrial competitiveness by positioning Japan as a fuel cell technology exporter. It aims to have around 800,000 fuel cell vehicles, 1,200 fuel cell buses and 900 hydrogen refuelling stations in place by 2030.
- **Australia**: A key element of the country's National Hydrogen Strategy is to create clusters of large-scale demand, such as ports and cities and to use hydrogen in transport, industry, and gas distribution networks. Since 2015, the Australian Government has committed over AU$140 million to hydrogen projects along the supply chain[4].

As an example of co-operation between Asian countries, a pilot project was announced to produce and transport hydrogen from Australia to Japan. Shortly thereafter, the Japanese and Australian governments signed a joint statement of co-operation on hydrogen and fuel cells in January 2020. Japan also received its first shipment of foreign-produced hydrogen from Brunei in late 2019.

While Asia focused on developing the market for hydrogen, using grey and brown hydrogen first to create a demand and then gradually switch to carbon-free alternatives, Europe has taken another route by focusing on green hydrogen from the start. Differences in import or export orientation are also significant.

[3] Source: Oxford Institute for Energy Studies 202, Martin Lambert, Senior Research Fellow, OIES Simon Schulte, Head of Gas Markets, EWI 1. Contrasting European hydrogen pathways: An analysis of differing approaches in key markets

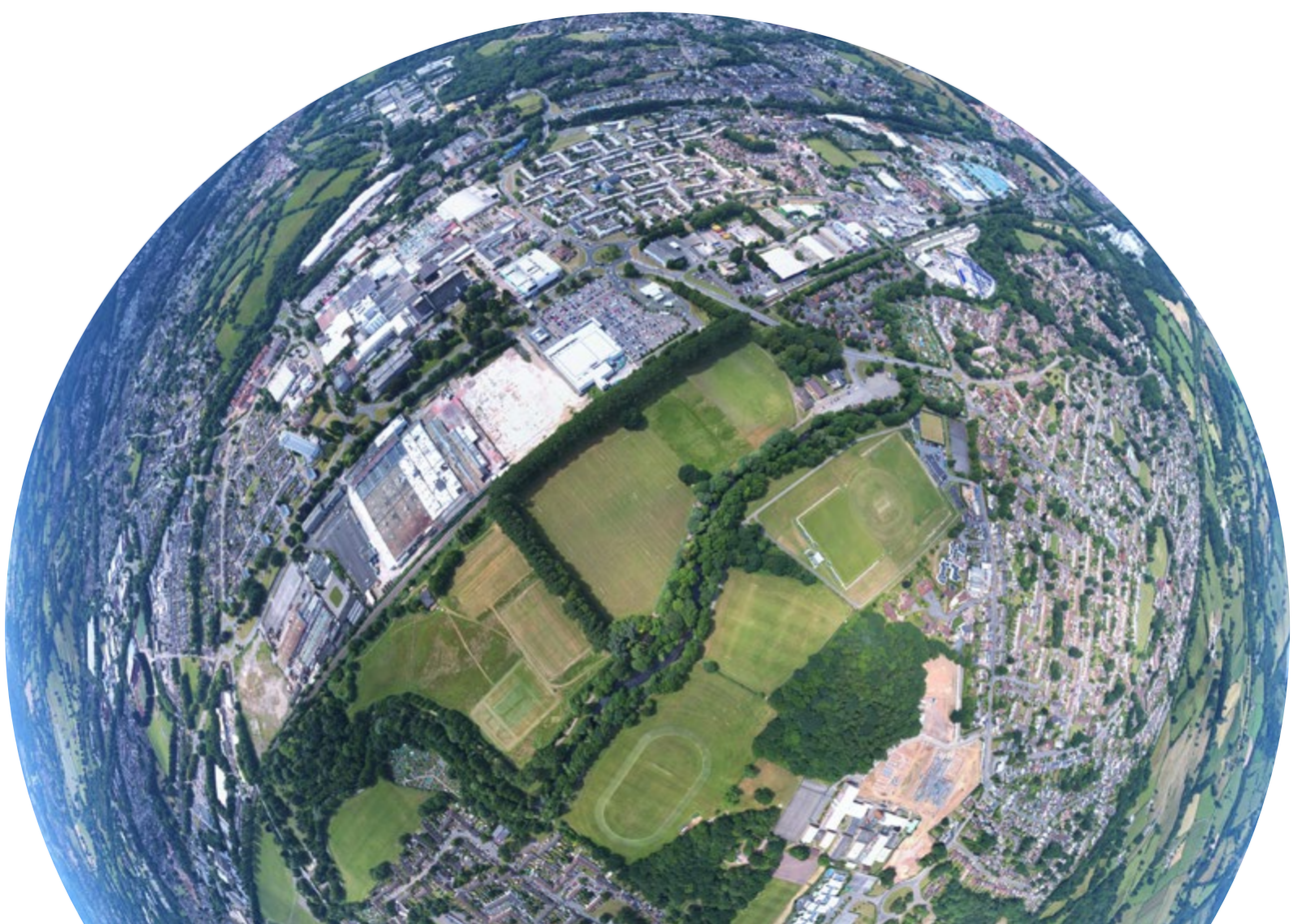
4 Source: COAG Energy Council

THE REST OF THE WORLD

In regions where cheap renewable electricity can be generated on a large scale, such as in the Middle East and Africa, opportunities to develop an export sector for hydrogen have similarly been identified. The African Green Deal across multiple North and West African countries and the existence of natural hydrogen reserves in Mali are just two examples.

Canada has been keen on hydrogen, with the Hydrogen Strategy for Canada emerging in December 2020, targeting hydrogen for up to 30% of Canada's end use energy by 2050. The estimated investment is between USD 5bn and 7bn over the next five years.

Looking at the US, the Department of Energy funding for hydrogen and fuel cells has ranged from approximately USD100m to USD280m per year over the last decade, focusing on fuel cells and mobility.



WHAT'S NEEDED TO SUPPORT HYDROGEN PROJECTS?

A consistent, reliable framework matters when it comes to big-ticket investments such as hydrogen projects. What is the current state of affairs when it comes to the regulatory and financial framework? And what financial support is available?

REGULATORY FRAMEWORK

In addition to the EU's Hydrogen strategy and various incentives, individual countries have their own regulatory framework. For instance, in France, hydrogen production, storage, and distribution are classified by different ICPE (Installation Pour la Protection de Environment) nomenclatures. That differs from the framework in Germany, Spain, and the Netherlands. The same goes for the choice of hydrogen colour to promote, the tolerance level for hydrogen intake in the natural gas pipelines, whether hydrogen transport and storage are regulated markets or private ones, etc.

To have a fully functional European hydrogen market, a lot of effort will have to unify these different local practices and standards. As well as a regulatory framework, there is also the need for a financial framework and financial support that offers future price stability.

Photos by Louis Reed hzp

FINANCIAL SUPPORT FRAMEWORK

There are several different ways in which financial support could be provided.

For example, EU and national governments could efficiently target their support by offering cheaper financing for hydrogen construction projects along with R&D and construction grants and tax breaks. From a private sector perspective, clusters of companies could form joint ventures, which would spread the cost of developing a local hydrogen facility. It would also give them partial ownership of their future energy supply and could offer substantial savings in the long run.

At least over the next 15 years, hydrogen producers will be comparatively more expensive than their natural gas peers. As there are fewer users, they also suffer from higher risk in the reliability of their revenue stream. Options for financial support include:

Off-take agreements

For initial projects, specific power purchase agreements (PPAs) would guarantee demand. Off-takers may be able to offer higher prices by showing their green credentials to markets and issuing green bonds which are typically issued at a premium.

ROCs

Renewables obligation certificates are a system where gas companies would be required to hold a number of these ROCs whilst hydrogen producers would be issued the certificates for their production. The hydrogen producers could then sell these ROCs as an additional revenue stream.

CFDs

Contracts for difference enable different producers to bid to make hydrogen at either an agreed strike price or an agreed price relative to a benchmark (such as the natural gas price). The auction system rewards the most competitive producers. As no company is going to want to run at a loss, it also ensures that the minimum bids should be sufficient to compensate the producers and allow for some profit.

These financial support options are all based on support frameworks for either solar or wind projects. As shown in the graph opposite, these initiatives helped reduce the current price of solar PV modules to less than 1% of their price in the 1970s.

Evolution of solar PV module cost, 1970-2020[4]

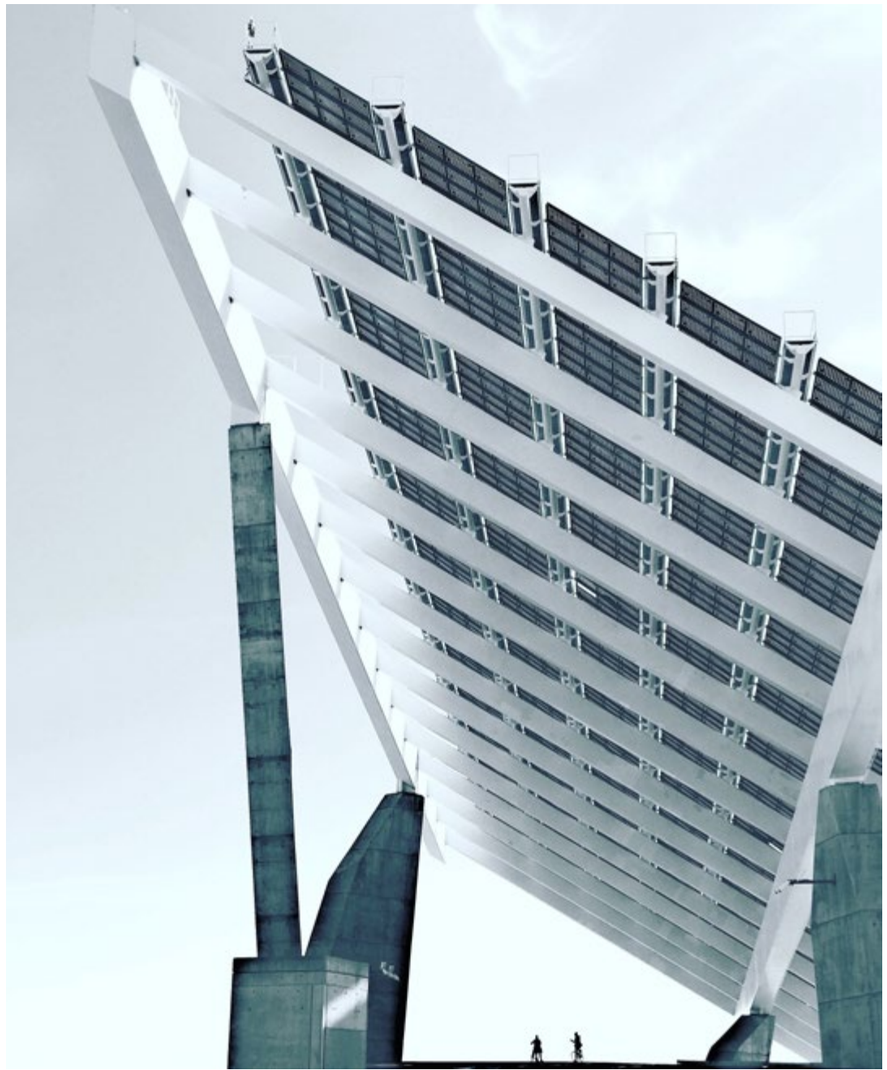
Each of these mechanisms offer advantages and disadvantages, reviewed in the table below.

Scheme	Power Purchase Agreements	Renewable Obligation Certificates (ROCs)	Contracts for Difference (CfDs)
Description	Producers agree a fixed price for a given quantity of production over a pre-determined length of time (often 10-20 years).	Renewable generations are given certificates. Polluting companies must obtain these or face a fine. Income generated through sale of certificates and distribution of fines to certificate holders.	Producers bid to make hydrogen at an agreed price relative to a benchmark. The most competitive bids are awarded contracts (often 15-20 years).
Pros	• Reliable revenue stream for producer and reliable hydrogen inflow for buyer • Easier to raise finance with revenue certainty • Revenues should be fixed to make the production profitable	• Set both the subsidy for hydrogen and the cost for gas • Increasing the certificates requirements and the fine level should make gas less competitive while boosting hydrogen	A system would need to clearly define what types of hydrogen are eligible, otherwise this would boost blue over green hydrogen.
Cons	• Requires abuyer and a producer to align • Many buyers may be relunctant to enter into such long term agreements if prices are predicted to fall	• This should find the minimum price for subsidies that still mkaes production profitable. • Encourages competition and should bring downprices over time.	• Clear seperation of different hydrogen colours required. • Governments me be relunctant to commit funding for long periods of time given current debt levels.

[4] Source: IEA, Evolution of solar PV module cost by data source, 1970-2020, IEA, Paris
https://www.iea.org/data-and-statistics/charts/evolution-of-solar-pv-module-cost-by-data-source-1970-2020

INCENTIVES CURRENTLY IN PLACE

Today, the existing financial support schemes use grants to help with equipment and construction costs. Still, additional support to cover operating income is expected to be introduced in the coming months. The exact form under which the operating income support will be provided has not been settled yet but is likely to take the form of contracts for difference or power purchase agreements. Some of the incentives currently in place include:



- **French National Hydrogen Strategy:** France set aside €7bn to help scale up the low carbon hydrogen sector. Of this, there will be €1.8bn specifically to help the industry transition to hydrogen usage. A further €2bn has been pledged to help electrolysis projects to produce green hydrogen.

- **The European Hydrogen Valleys Partnership:** The regions included in the scheme (which covers much of north-western Europe) will support getting EU funding to build local integrated hydrogen technology. The exact financing available from the EU is dependent on the project.

- **European Clean Hydrogen Alliance**: Set up by the European Commission and designed to bring together 'industry, national and local public authorities, civil society and other stakeholders', this scheme includes members from across the hydrogen value chain and aims to foster a €430bn hydrogen industry. It is supported by up to €1bn available for research funding.

Many schemes support hydrogen projects, including the EU Innovation Fund, Important Projects of Common European Interest (IPCEI) and the European Green Deal Call. While not hydrogen-specific, these schemes will have money made available for the sector.

Photos by David Cristian and Nicholas Doherty.

CONCLUSION

Hydrogen can substantially impact carbon emissions, including the ability to displace polluting sources of energy in industries where finding clean alternatives is particularly challenging. However, for hydrogen to become a widely used fuel, the hydrogen network needs to expand significantly. That, in turn, requires a critical mass of hydrogen projects.

Given the current price of hydrogen and alternatives, the commercial upside of hydrogen projects is not always clear at the moment. Supportive Government policies are needed, which we increasingly see across both Europe and Asia. Further intervention would tilt the commercial scales in hydrogen's favour.

At the same time, hydrogen projects need supporting frameworks that reduce the systemic risks of a developing market and increase the certainty of outcomes for the commercial players entering these projects. These frameworks are slowly emerging, making it far easier for stakeholders to come together to support hydrogen projects.

Over time the necessary support and a growing number of projects will help hydrogen fulfil its role in mitigating the damaging effects of climate change. Whilst hydrogen does not solve the overconsumption of electricity against current production capacity, it contributes to a more balanced energy mix.

The first signs of major growth in the hydrogen industry are starting to emerge, with more and more local level hydrogen projects being planned, built and operated. This presents opportunities for private sector participants to get involved in early-stage projects in the coming years. These offer exciting investment opportunities, especially for companies familiar with the existing project finance process, and will allow for a potential head start for companies to become industry leaders in what may be one of the world's largest sectors in a few decades time.

Photos by Sharon Pittaway

Mob'Hy's core business is the production of green energy. Founded in 2020, the firm is a sister company of Vent d'Est, a renewable energy specialist, including wind, solar and bioenergy since 2005.

Mob'Hy was born from the desire of the founding partners and the team at Vent d'Est to generate clean and affordable energy that creates value for the consumers and the local community.

Building from Vent d'Est's expertise in developing and operating wind farms in France, Mob'Hy supports clients with managing the entire hydrogen production process. The firm evaluates, develops and manages hydrogen production and distribution facilities projects. Mob'Hy's mission is to optimise these projects and create a pan-European production network.

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