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THE POTENTIAL OF HYDROGEN: A GUIDE TO KEY EUROPEAN MARKETS

CONTENTS

FOREWORD

Since the previous edition of the Hydrogen Guide, significant steps have been taken towards the development of a low carbon hydrogen economy in Europe, driven by decarbonisation and energy security considerations.

As developments and ventures proliferate, investors are increasingly looking to commit substantial capital in the context of significant regulatory flux.

This guide considers the regulatory landscape across the hydrogen value chain in seven key jurisdictions:

- France
- Germany
- Italy
- The Netherlands
- Portugal
- Spain
- The United Kingdom

This guide is intended to assist developers, investors and other market participants to navigate:

- the changing regulatory framework for hydrogen across the value-chain
- the emerging standards for low carbon hydrogen

If you would like to discuss this guide or would like further information on any aspect of it, please get in touch with your usual contact.

27 June 2023

This guide is a collaboration between our Best Friends firms, consisting of BonelliErede in Italy, Bredin Prat in France, De Brauw Blackstone Westbroek in the Netherlands, Hengeler Mueller in Germany, Slaughter and May in the United Kingdom, and Uría Menéndez in Portugal and Spain. Each is a market leader in its respective jurisdiction, each has a formidable international reputation in its own right, and all are authorities in cross-jurisdictional best practice.

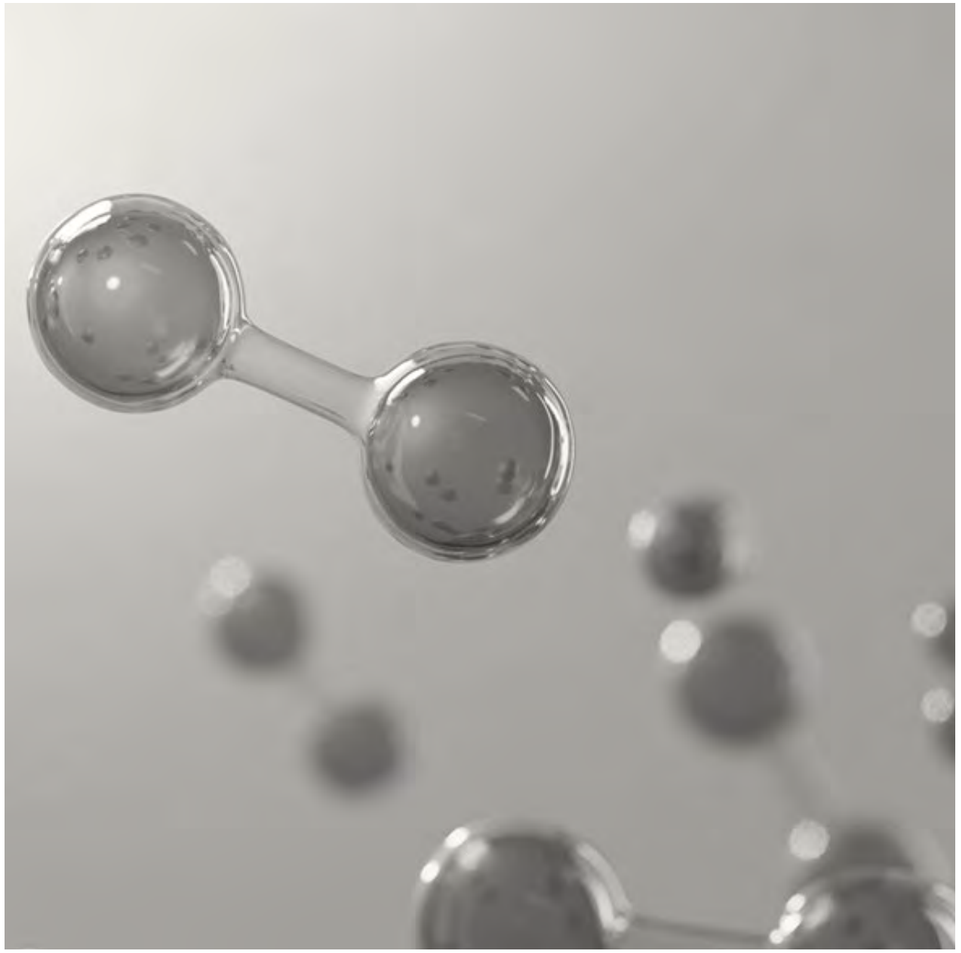
We regularly work together on energy and infrastructure instructions, and are actively engaged on hydrogen mandates in all the jurisdictions mentioned in this guide.

KEY TAKEAWAYS AND DEVELOPMENTS

Key takeaways

- As momentum continues to build towards the development of a global hydrogen economy, the disconnect between (high) political and commercial ambitions on the one hand and (rather slow) regulatory progress on the other is becoming more apparent. Whilst material progress is being made, practical deployment and operationalisation of projects are, in some cases, being held back by the need to review and revise laws, codes and standards, as well as the time required to allocate funding to hydrogen projects.
- Whilst at a high-level countries share common objectives, at a national level, approaches differ in relation to production capacity ambition, production method, and maturity of policy and regulation.
- Steps are underway to streamline and conform national regulatory frameworks in some areas, particularly as European Union (EU) policy influences national frameworks of EU member states. The EU has adopted a strategic approach for the development of a low carbon hydrogen economy described in the EU Hydrogen Strategy, and supplemented by the EU Energy System Integration Strategy and REPowerEU, focusing predominantly on green hydrogen.
- The UK's policy is distinct from that of the EU and adopts a technology neutral approach to low carbon hydrogen production. However, the UK market will inevitably be influenced by decisions in the EU due to the UK's close connection with European energy markets and supply chains, as well as its significant trading relationships with EU member states.
- The emergence of a regional or international hydrogen standard will be needed to support the development of a coherent hydrogen economy. At the EU-level important progress has been made to define renewable hydrogen, seen as a pre-cursor to the implementation of national standards in many EU member states. However, national eligibility requirements have emerged in some EU member states that have sought to progress projects in the meantime. In the UK, the Low Carbon Hydrogen Standard (LCHS) has provided more certainty to UK production projects but, with separate requirements applicable to renewable transport fuels, more still could be done to reduce complexity.
- Looking to the future, we expect the focus on hydrogen production to continue in all jurisdictions reviewed. However, given the limitations on production capacity in many jurisdictions and the need to balance hydrogen supply and demand, we anticipate that attention will increasingly be on the development of hydrogen infrastructure. In particular, international cooperation will be required to develop hydrogen interconnectors between EU member states and to facilitate hydrogen imports into the EU. To achieve this, we are likely to see the establishment of transnational entities (such as the European Network of Network Operators for Hydrogen and the North Adriatic cross-border Hydrogen Valley).

Production	All jurisdictions under review have set out their hydrogen production ambitions, but differ in relation to the level of ambition and production method, which is of course influenced by the size and focus of the economy of each country (e.g. the size of its industrial sector) as well as its underlying energy mix. All countries have established grant funding schemes to support hydrogen production projects in their jurisdictions, with funding also available at the EU level. Some jurisdictions, such as the Netherlands and the UK, have already taken steps to introduce operating support schemes seeking to incentivise low carbon hydrogen production by increasing its competitiveness compared with high carbon fuels.
Infrastructure	The development of hydrogen transport networks and storage is now emerging as a priority in a number of jurisdictions, as production volumes and market demand are increasing.
End uses	All jurisdictions reviewed are prioritising the use of hydrogen in the industrial and transport sectors. The focus on other sectors varies, with some jurisdictions attributing higher potential to heat and power than others.
Imports and exports	As national strategies bed-down, distinct import and export markets are beginning to emerge.



Overview of developments in the past 12 months

Important progress has been observed in the following areas in the past 12 months:

- **Existing regulation:** Steps are being taken to revise existing regulation to accommodate low carbon hydrogen and expedite projects. For example, both Italy and France have passed measures to speed up administrative processes for hydrogen.
- **Production:** The proposals for an EU Hydrogen Bank are a significant step for supporting domestic EU hydrogen production and for the procurement of low carbon hydrogen from outside the EU. In the Netherlands, key policy decisions have been made in relation to offshore hydrogen production with the Wadden Islands set to become the world's largest offshore production project. A number of production projects were awarded support – for example Spain awarded funding through programmes "H2 Pioneers" and "H2 Value Chain", whilst other jurisdictions - such as France, Portugal and the UK - took important steps in the process of awarding support to production projects in their jurisdictions.
- **Standards:** Progress was made on defining standards for green hydrogen and low carbon synthetic fuels with the publication, in the EU, of two delegated acts. This is significant given how it will influence requirements in EU member states.
- **Imports and exports:** Germany and the Netherlands have announced that, whilst the hydrogen markets are still in the ramp-up phase, they will support the import of hydrogen to meet growing demand which cannot be met by their limited domestic production capacity.
- **Infrastructure:** Hydrogen infrastructure has moved up the agenda, particularly in the Netherlands, the UK and in Spain. In the Netherlands important decisions as to where and how networks should be developed have been taken. The UK began a consultation on the business models for hydrogen transportation and storage and Spain has introduced rules on permitting and connection of hydrogen production projects to natural gas pipelines or directly to customers.
- **End uses:** Whilst the focus was predominantly on production, offtakers are increasingly considering the steps required to convert to low carbon hydrogen. To encourage uptake, Italy awarded grants to support hydrogen industrial valleys and hydrogen usage in the railway sector, including the construction of refuelling stations and the procurement of trains.

For further information on individual country developments, please see the relevant country annex to this guide.

INTRODUCTION: WHY THE HYPE ABOUT HYDROGEN?

Net zero pledges have resulted in a raft of policies and proposals for regulation focused on developing production and demand for low carbon hydrogen. The attraction of clean hydrogen for EU and UK policy makers is particularly driven by its potential to reduce emissions in sectors which cannot be readily electrified.

Low carbon hydrogen may also help solve the issue of the variability in renewable power generation. Production of electrolytic hydrogen, using electricity generated by intermittent renewable sources such as wind and solar, means the resulting hydrogen molecules can be stored and subsequently reconverted into electricity or used outside of the electricity sector (such as in transport or industry), although not without losses in conversion.

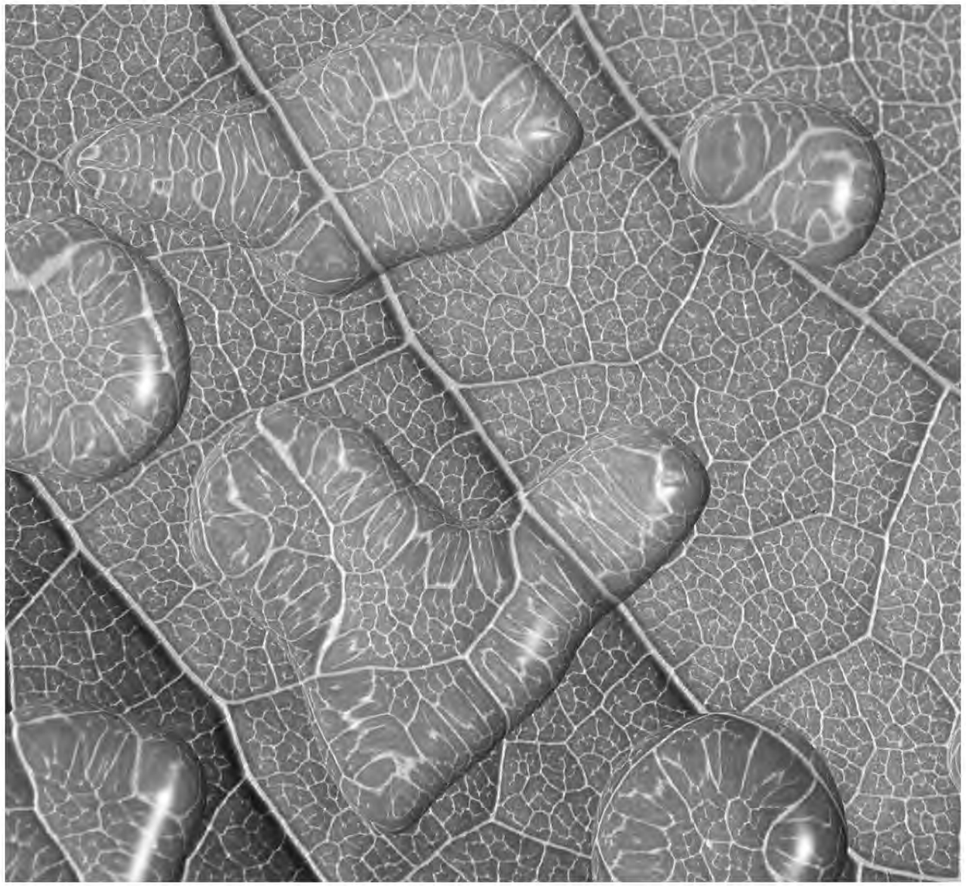
Finally, as a result of the conflict in Ukraine, ambition for low carbon hydrogen in the EU and in the UK has increased sharply. Low carbon hydrogen has the potential to reduce reliance on fossil fuel imports, reducing reliance on natural gas imports and addressing security of supply concerns.

The emergence of a global low carbon hydrogen economy

Hydrogen is one of the most abundant elements on earth, but as the exploitation of rare, natural hydrogen deposits is still in the early exploration phase, currently it must be produced.

According to the International Energy Agency (IEA), in its Global Hydrogen Review 2022 (September 2022), in 2021 global hydrogen production was 94Mt produced mainly from unabated fossil fuels, resulting in close to 900Mt of CO_2 emissions. Current uses, for example, include processing oil in refineries and in chemicals.

However, low carbon hydrogen is seen as a potentially important energy carrier for the energy transition. Unlike electricity, which is hard to store and transport over distance, hydrogen could be more similar to fossil fuels, enabling a global market in low carbon fuel to develop.



Forecasts for the potential of hydrogen in the future energy mix vary. However, all agree that there is a role for low carbon hydrogen in the energy transition. The role that low carbon hydrogen plays varies by country and by region.

In its Global Hydrogen Review 2021, the IEA noted that the delivery of its estimates by 2050 requires US$1,200 billion of investment in low carbon hydrogen supply and use through to 2030. As well as the emergence of national markets, the IEA envisages the development of global trade in hydrogen in its net zero scenario, with large volumes exported from gas and renewables-rich areas in the Middle East, Central and South America, and Australia to demand centres in Asia and Europe.

This scale of low carbon hydrogen production poses significant technical, economic and regulatory challenges including:

- developing sufficient electrolyser manufacturing capacity
- ensuring the availability of sufficient renewable and low carbon electricity generation capacity and the grid capacity to transport the electricity produced
- the deployment of Carbon Capture and Storage (**CCS**) capacity
- the development of demand for low carbon hydrogen
- the development of hydrogen storage and distribution capacity, including dedicated hydrogen pipelines or non-pipeline distribution capacity
- promoting the adoption of low carbon hydrogen and addressing the price differential between existing and low carbon hydrogen production methods.

In its Global Hydrogen Review 2022, the IEA reported that the cost of production of hydrogen from unabated natural gas ranges from US$4.8-7.8/kg, an increase of up to three times compared to the 2021 figure of US$0.5-1.7/kg. This is compared to US$5.3-8.6/kg for blue hydrogen (2021 figure of: US$1-2/kg) and US$4-9/kg for green hydrogen (2021 figure of US$3-8/kg). The IEA notes that Russia's invasion of Ukraine caused a surge in natural gas prices over the past year, improving the competitiveness of green hydrogen, but these may decline again in the longer term.

As a result of the challenges listed above, electrification is, in many cases, the preferred decarbonisation option. However, where this is not possible, policy and regulatory intervention is required to overcome these challenges, and to develop appropriate frameworks and regulation to support low carbon hydrogen across the hydrogen value chain.

The colours of hydrogen

It has become common practice to colour-code hydrogen. The "colour" depends on how it's produced, and whether residual emissions are captured. This colour-coding system is still not universally accepted and is not used in many jurisdictions. However, for the purposes of this guide, we will use the colours below to refer to the different production methods.

GREY
Produced by stripping hydrogen from methane using Steam Methane Reformation (SMR). This is the prevailing, existing hydrogen production method.

BLUE
Produced in a similar fashion to black or grey hydrogen but uses CCS to capture up to 95% of emissions (but not a zero emissions process).

BLACK
Produced from other fossil fuels such as coal or oil.

PINK
Produced from electrolysing water using nuclear power.

GREEN
Produced by using renewable electricity to electrolyse water. It can also be produced by SMR, converting biogas or biomass, with CCS.

TURQUOISE
Produced from natural gas, but by bubbling it through a molten metal in a process called 'pyrolysis' with no CO2 gas emissions.

WHITE
Produced through exploitation of naturally occurring, geological hydrogen found in underground deposits.

POLICY OVERVIEW: EXPANDING THE ROLE OF HYDROGEN IN EUROPE

Hydrogen policy in Europe varies by jurisdiction, presenting a challenge for international investors. However, despite sometimes fragmented and divergent policy, steps are underway towards harmonisation in some areas, particularly as EU policy influences national frameworks. Nevertheless, there remain significant differences in the scope and ambition of each country's hydrogen strategy.

European ambition increasingly influences national policy

National policies adopted in EU member states need to be considered against the backdrop of the wider EU strategy. The EU has adopted a strategic approach for the development of a low carbon hydrogen economy described in the EU Hydrogen Strategy and supplemented by the EU Energy System Integration Strategy. Focused on green hydrogen, the plan envisages the following milestones:

Present –2024:

At least 6GW of electrolyser installed capacity and production of up to 1Mt of green hydrogen.

2025 - 2030:

At least 40GW of electrolyser installed capacity and production of up to 10Mt of green hydrogen.

2030 - onwards:

Green hydrogen technologies will be fully implemented in all hard-to-decarbonise sectors

The EU Hydrogen Strategy milestones were further supplemented by the European Commission's REPowerEU Plan published in May 2022 and adopted by the European Parliament and Council in February 2023, introducing RePowerEU chapters in the recovery and resilience plans. This set a target of 10Mt of domestic green hydrogen production and 10Mt of green hydrogen imports by 2030.

The UK's policy, although distinct from that of the EU due to its technology neutral approach, will inevitably be influenced by decisions in the EU due to the UK's close connection with European energy markets and supply chains, as well as its significant trading relationships with EU member states.

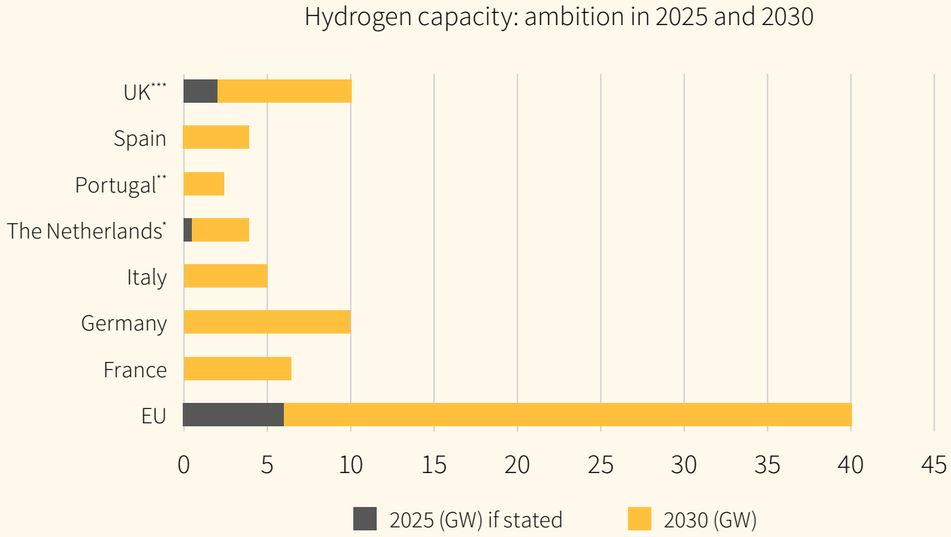
Significant differences exist in national approaches

At a national level, approaches differ in relation to production capacity ambition, production method, and maturity of policy and regulation.

Figure 1 highlights the stated hydrogen production ambitions of each country, with the UK and Germany having the highest goals for 2030 of the countries reviewed. However, the level of ambition cannot be viewed in absolute terms, but must be considered in the context of the economy of each country (e.g. the size of its industrial sector). None of the countries reviewed had a stated policy goal beyond 2030, although many had published forecasts of the potential of the sector beyond this date.

In order to avoid giving rise to any legitimate expectations, which may increase the risk of administrative review in the event of a change of policy, all countries reviewed have not fixed legally binding targets but rather expressed their 2030 goals as ambitions.

PRODUCTION CAPACITY AMBITION TO 2030



*The Netherlands's aim is 4GW by 2030. In addition, the Netherlands is aiming for 1.5-1.8Mt of blue hydrogen production by 2030.

** Portugal's aim is 2GW-2.5GW by 2030.

*** The UK's 2025 ambition is 2GW in construction or operation by 2025.

Countries also differ as to the production method, or colour of hydrogen, they are seeking to promote. For example, the Netherlands and Italy are focusing on both blue and green hydrogen. Germany, Portugal and Spain are focused primarily on promoting green hydrogen, whilst France is promoting the deployment of electrolytic hydrogen. The UK is adopting a technology neutral approach. The difference in approach can also be partly explained by differences in each country's available energy resources (e.g. renewable resources, nuclear fleet) and its CCS policy.

TABLE 1: TYPE OF HYDROGEN BY COUNTRY

	Colour of hydrogen*
EU	Green
France	Green and pink
Germany	Green (domestic), blue and turquoise (imported)
Italy	Green and blue
The Netherlands	Green and blue
Portugal	Green
Spain	Green and blue (in specific cases)
UK	Green (including biomass gasification with CCUS), blue and pink

* Note: not all jurisdictions refer to the colours of hydrogen within their policies and, in these cases, the appropriate colour has been assigned for ease of comparison but this does not necessarily reflect published policy.

Finally, the pace of policy adoption and development of regulation differs according to jurisdiction. For example, France has adopted a national strategy which is supported by an underlying ordinance to provide the necessary regulatory framework and is underpinned by a funding commitment of around €9 billion by 2030. Germany has adopted a national strategy but is taking a step-by-step approach, focused initially on establishing an R&D strategy to encourage investment in the sector, whereas the Netherlands and the UK have already taken steps to introduce operating support schemes seeking to incentivise low carbon hydrogen production by increasing its competitiveness compared with the high carbon fuels. Italy has adopted the Preliminary Guidelines on the National Strategy for the Development and Use of Hydrogen (Preliminary Guidelines) but is yet to set a national hydrogen strategy although one is expected soon.

A more detailed overview of policy and regulation is found in the relevant country annex to this guide.

EXISTING REGULATION: REFORMS TO THE REGULATORY LANDSCAPE FOR HYDROGEN

Scaling up the hydrogen economy requires an appropriate legal framework, which provides legal certainty for large and long-term investments. The existing regulatory framework for hydrogen is often fragmented and comprised within a diverse mix of law, regulation and codes ranging from environmental and health and safety laws, to gas quality requirements. In many jurisdictions, law-makers are seeking to review and streamline existing rules applicable to hydrogen to facilitate the deployment of low carbon hydrogen. However, despite a proactive approach, regulatory reform is inevitably a slow process. As a result, developers and investors are bringing forward initiatives in the context of a changing legal environment.

Policy co-ordination will influence market development

In the EU, developments in many member states will be linked to harmonisation initiatives at the EU level. The European Commission's proposals of December 2021 for a Hydrogen and Decarbonised Gas Package, recasting (amongst other things) the Third Energy Package on natural gas, includes proposals relating to:

- the regulatory framework for hydrogen, with a special focus on hydrogen facilities (e.g. hydrogen pipelines, storage facilities and terminals) and activities (e.g. production, transport, supply and storage of hydrogen)
- integration and access of renewable and low carbon gases (including green hydrogen) to the existing gas network and
- creation of a new governance structure, the European Network of Network Operators for Hydrogen, to establish technical rules and promote the international coordination and interconnection among EU countries.

Separately, investors in hydrogen projects and ventures across the value chain will be closely monitoring the implementation of an EU Foreign Subsidies Regulation (**FSR**). The FSR is expected to impact acquisitions (including joint ventures) involving a financial contribution by a non-EU country, where the EU-based target company, one of the merging parties or the joint venture generates an EU turnover of at least €500 million, and where the parties to the transaction received from the non-EU countries combined aggregate foreign financial contributions of more than €50 million in the preceding three years. It will also impact bids in public procurements involving a financial contribution by a non-EU country, where the estimated contract value is at least €250 million and the bid involves a foreign financial contribution of at least €4 million per third country. Given the breadth of what may be counted as "foreign financial contributions", including state-funded R&D grants or tax incentives, companies and investors active in EU hydrogen projects may find themselves unwittingly within the ambit of the FSR.

But local rules are developing in the interim

All jurisdictions are considering incentives for hydrogen production and the implementation of standards for low carbon hydrogen. For detailed analysis of related policy and regulation, please see the sections relating to production and standards of this guide.

In addition, reviews and reforms to the existing regulatory framework are underway in every market. For example:

- France, Italy, the Netherlands, Spain and the UK are considering, or have passed, changes to the development and planning framework for hydrogen production, distribution, transport or storage, to better accommodate electrolytic and low carbon hydrogen
- Italy, the Netherlands, Portugal, Spain and the UK are reviewing technical standards including limits on blending of hydrogen into existing natural gas networks
- France, Spain, Germany, Portugal and the UK are considering (and the Netherlands is implementing) changes to network rules, including licensing, regulatory oversight, unbundling of pure hydrogen gas grids, and
- Germany is considering (and the Netherlands is implementing) market interventions to stimulate hydrogen demand in key use sectors such as industry (including the steel and chemical sectors) and transport.

For further information please see the relevant country annex to this guide.

PRODUCTION: SCALING UP HYDROGEN PRODUCTION

Low carbon hydrogen production is a priority for all the jurisdictions reviewed in this guide. One of the key challenges however is the problem of growing hydrogen production capacity and demand simultaneously. On the one hand, the business case for producing low carbon hydrogen is limited by its comparatively higher production costs which means, without support, it cannot compete with the market prices offered for conventional, high carbon hydrogen or fuels. On the other, hydrogen users face limited volumes and higher prices for low carbon hydrogen, restricting demand development.

A supportive regulatory environment is essential for project development

Support for hydrogen production may take the form of financial or non-financial support. In addition to financial support (described further below), the importance of the policy and regulatory frameworks cannot be underestimated. Projects are underway in a number of the jurisdictions reviewed to ensure that the regulatory environment for hydrogen production is capable of delivering national targets and does not pose a barrier to project or market development. New measures must integrate with the existing regulatory framework for hydrogen, which is also subject to review in a number of respects.

In the matrix below, we provide an overview of the regulatory environment for hydrogen production projects as at the date of publication. However, as noted in the section on existing regulation, the current regulatory framework is under review and reforms are proposed in many jurisdictions.

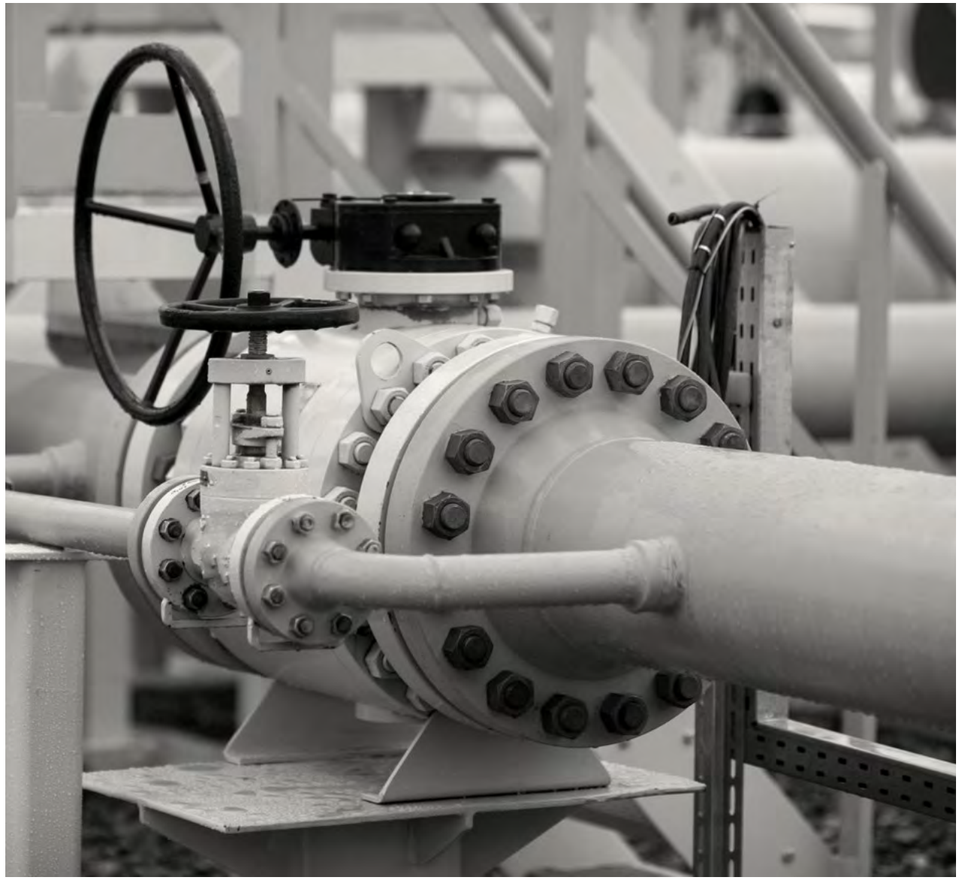


TABLE 2: HYDROGEN PRODUCTION: A REGULATORY OVERVIEW

	Production ambitions	Import target	Colour/s	Emissions intensity limit	Hydrogen Standard?	Development and planning regime	Production licence required?	Development support (e.g. grants)	Operating support - revenue	Operating support - other	Demand-side measures	Mitigation of project on project risk
France	6.5 GW of electrolytic hydrogen by 2030	(✗)	🟢🟣	(✓)	(✓)	✓	✗	✓	✓	✗	✗	✗
Germany	10 GW by 2030	✓	🟢 domestic 🔵🟢 imported	✓ Zero (✓)	✓ Zero (✓)	✓ offshore & onshore	✓	✓	✗	✓	(✓)	(✗)
Italy	5 GW by 2030	(✗)	🔵🟢	✓ Zero	✓ Zero	✓	✓	(✓)	(✓)	(✓)	✓	(✗)
The Netherlands	Green hydrogen: 500 MW by 2025; 4 GW by 2030; 8GW by 2032 Blue hydrogen: 1.5-1.8 Mton by 2030	Until 2025: 0,1 – 0,2 Mton Until 2035: 1,5 - 3 Mton H_2 equivalent	🔵🟢	✗ in favour of EU regulation	✗ in favour of EU standard	✓ offshore & onshore	✗	✓	✓	✓	✓	✗
Portugal	2.5 GW by 2030	✗	🟢	✗ will use EU standard	✗ will use EU standard	✓	✓	✓	(✓)	✗	✗	(✗)
Spain	4 GW of green hydrogen by 2030	✗	🟢	✓ Zero	✓	✓	✓	✓	✗	(✓)	✗	✗
United Kingdom	10GW by 2030 50% to be electrolytic	✗	🔵🟢🟣🔷	✓	✓	✓ offshore & onshore	✗	✓	(✓)	✗	✓	(✓)

Key

✗ No with regard to status quo ✓ Yes with regard to status quo ( ) Measures are proposed or under development but are not yet in force

Frameworks for financial support for hydrogen production are crystallising

Governments have widely acknowledged the need for financial support for hydrogen production to overcome barriers to market development. Public funding, ranging from grants and tax exemptions, to operating support is available. However, the type of support available, the eligibility criteria and conditions of the support vary by jurisdiction. In addition, depending on the nature of the support, state aid or subsidy control approvals may be required. A summary of measures is found below, with more detailed information available in the country annex.

A. France

France's National Hydrogen Strategy aims for 6.5GW of new-build, near zero hydrogen produced through electrolysis by 2030. This is to be supported by:

- a public support scheme for the production of electrolytic hydrogen that meets the required emissions threshold (still to be defined pending the adoption of a specific decree) in the form of operating support or a mix of operating support and Contracts for Difference (**CfD**) to support investment, established under the ordinance n°2021-167 dated 17 February 2021 relating to hydrogen (**Hydrogen Ordinance**), and
- Hydrogen Important Projects of Common European Interest (**Hydrogen IPCEI**) funding. Ten projects, approved by the European Commission, will be implemented in the industrial sector, including a significant number aimed at the mass production of low carbon hydrogen, as well as electrolyser manufacturing (amongst other projects).

B. Germany

Support in Germany is focused on green hydrogen through electrolysis, aiming for 10GW by 2030, however blue and turquoise hydrogen imports are envisaged for an interim period. Funding is available:

- for German projects under the Hydrogen IPCEI which alone is expected to contribute more than 2GW towards the 2030 target
- under an additional grant funding programme, Hydrogen Technologies 2030, which aims to accelerate research activities regarding the mass manufacturing of electrolysers (**H2Giga**) as well as the offshore production of hydrogen (**H2Mare**)
- approximately €900 million for non-EU production projects for import into Germany under H2Global. At least for an interim phase, these funds will also be available to offset the difference between the prices for foreign production and the domestic sale price, each price being established based on an auction mechanism, and
- under an exemption for producers of green hydrogen from the obligation to pay grid fees, electricity tax and further surcharges to the electricity price.

C. Italy

According to the Preliminary Guidelines, in order to implement the low-carbon hydrogen strategy in Italy, around €5-7 billion will be specifically allocated to hydrogen production investments, while around €2-3 billion will be allocated to investments in infrastructure for the distribution and the consumption of hydrogen. Currently, support is available under the Italian National Recovery and Resilience Plan (**IRRP**), which provides for:

- €500 million for the redevelopment of brownfield sites for the production of hydrogen to be used for local transportation and industry
- €450 million for the start-up of a large industrial plant for the production of electrolysers with approximately 1GW of electrolysis capacity by 2026 and the development of further technologies needed to support hydrogen end-use and

- €160 million of support for research and necessary legislative reforms to facilitate the production (as well as use, transport, and distribution) of hydrogen.

D. The Netherlands

By 2030 the Netherlands is aiming for 4GW of green hydrogen installed capacity, and 8GW by 2032, and 1.5-1.8Mt of blue hydrogen production by 2030. To achieve this support schemes are in place and being extended for research into, scaling up and rolling out of hydrogen including:

- applied research and innovative pilot projects via subsidies under the MOOI (Mission-oriented Research, Development and Innovation), DEI+ (Energy Innovation Demonstration Scheme), and HER+ (renewable energy subsidy module)
- the extension of state aid under the Hydrogen IPCEI is being considered
- operating support for green hydrogen production is in place via the SDE++
- operating support scheme for blue hydrogen is in place via SDE++ (subsidies of CCS)
- a temporary extra support scheme is in place for construction of electrolyser capacity with a reserved budget of €250 million (in addition to the current SDE++, DEI+ and HER+) (< 50MW)
- tax compensation for companies for the purchase of, or investment in, amongst other things, small scale production of hydrogen (for own use)
- other support is also under consideration such as linking the development of offshore wind energy and hydrogen and introducing a blending obligation, and
- a temporary support scheme under the EU Temporary Crisis and Transition Framework is under public consultation to support, amongst other sectors, the building of new hydrogen pipelines and/or electrolysis production facilities.

E. Portugal

The Portuguese National Hydrogen Plan (**PT H2 Plan**) sets out various incentive and funding measures applicable to production projects. Support includes:

- an initial, partial or total exemption from payment of the tariff for hydrogen projects to access the distribution or transmission gas grid
- operating support aimed at funding the difference between the energy source which will be replaced – i.e. natural gas – and the initial production cost of green hydrogen via a variable premium on top of the price of natural gas to reflect the additional cost of green hydrogen, so that the additional cost of green hydrogen production is not reflected in the price paid by users
- the preferential tax treatment of hydrogen production plant operators, and
- proposals for grants or incentives for hydrogen production, such as the creation of a financial mechanism to support hydrogen sale prices.

In addition, the Portuguese Recovery and Resilience Plan (**PRRP**) approved by the European Commission provides for investment of €185 million in the hydrogen and renewable gases sector, available for a variety of projects, including projects for the production of green hydrogen using electrolysis, the funding of which is now regulated by the Incentive Scheme in Support of Renewable Hydrogen Production and other Renewable Gases Regulation. A significant part of the funding has been awarded, with a total of €102 million granted to 21 green hydrogen projects as of February 2023.

F. Spain

Public support will be available under the PERTE ERHA scheme, with up to €1.5 billion of funding available, a significant proportion of which is for green hydrogen projects. The PERTE ERHA funds will be awarded from 2023 to 2026 through two main programmes, namely, programmes "H2 Pioneers" and "H2 Value Chain" which comprise specific incentive sub-programmes including the following (note applications are now closed):

- **Programme H2 Pioneers:** €150 million in grants and public subsidies for innovation in the hydrogen value chain, with a special focus on the development of manufacture capacity of hydrogen equipment. The entire budget, consisting of €150 million, has already been allocated according to information available on the Spanish Government's website.
- **Programme H2 Value Chain**
  - Incentive Programme 1: €30 million in grants and public subsidies for integrated projects that combine, in an aggregated manner, the production, distribution and use of hydrogen in the same territorial location. According to the Spanish Government's website, €11.9 million has already been awarded.
  - Incentive Programme 3: €100 million in grants and public subsidies for large-scale hydrogen production through electrolysis (open to projects with electrolysis capacity higher than 20MW). A final proposal awarding the entire budget, consisting of €100 million, has already been published on the Spanish Government's website.
  - Incentive Programme 4: €40 million in grants and public subsidies for innovation in the hydrogen value chain, with a special focus on research, development and innovation activities. A final proposal, awarding approximately €32.4 million, has been published on the Spanish Government's website.

G. UK

The UK is aiming for 10GW of hydrogen production capacity by 2030, with at least half of this to be from electrolytic hydrogen. Existing and proposed support for hydrogen production has been summarised in the Hydrogen Investor Roadmap and comprises:

- grant funding of up to £240 million under the Net Zero Hydrogen Fund
- operating support under a new hydrogen business model, part of the Industrial Decarbonisation and Hydrogen Revenue Support (**IDHRS**) scheme. Bilateral CfDs are proposed for:
  - new build blue hydrogen and electrolytic hydrogen production facilities (known as a Low Carbon Hydrogen Agreement (**LCHA**)), and
  - the retrofitting of existing, grey hydrogen production capacity with carbon capture capability.
- the UK Renewable Transport Fuel Obligation (**RTFO**), a quota scheme with tradable certificates aimed at reducing emissions in the transport sector
- a range of innovation funding is being made available under a number of schemes forming part of the Net Zero Innovation Portfolio and the Industrial Energy Transformation Fund, and
- up to £18 billion of financial capacity available from UK Infrastructure Bank (a UK Government-owned policy bank) for all sectors including hydrogen, which has been identified as an investment opportunity in its first strategic plan.

H. EU

Support will also be available from the EU from different sources and programmes included in the Hydrogen Public Funding Compass (e.g. NextGenerationEU, Horizon Europe, Innovation Fund, InvestEU) to support the development of green and low carbon hydrogen projects across the hydrogen value chain within the EU.

In addition, the European Commission's July 2021 proposal for the revision of the Council Directive 2003/96/EC of 27 October 2003 (**Energy Taxation Directive**) aims to promote the production and consumption of green and other low-carbon hydrogen by establishing lower minimum levels of taxation for such products than those which would be applicable to fossil fuels. For example, it proposes establishing a minimum tax rate of €0.15/GJ which will be applicable both to renewable fuels of non-biological origin (**RFNBO**) and, for a 10-year transitional period, to other low carbon hydrogen used in motor fuels. This is a more favourable tax rate than the proposed rate applicable to petrol which, by way of comparison, would be subject to the highest minimum rate of generally €10.75/GJ when used as a motor fuel after the end of the transition period. The proposal is still subject to discussion within the Council and it is unclear when (and in what form) it might be approved.

What is the Hydrogen IPCEI?

Important Projects of Common European Interest address market failures or other important systematic failures in the EU. Projects spanning the entire low carbon hydrogen value chain (production, storage, transmission, distribution and industrial applications) may become Hydrogen IPCEIs. A project must ordinarily involve at least four EU member states and its benefits must extend to a wider part of the EU. Projects declared as IPCEIs are more likely to receive state aid and may be subject to a simplified notification process as common requirements for the grant of state aid (such as the existence of a market failure) will have already been recognised in relation to these projects.

According to the European Commission, assessment of the first Hydrogen IPCEIs was completed in summer 2022 with 41 projects located in 15 EU countries selected to receive up to €5.4 billion in public funding. A second group of 35 clean hydrogen projects in 13 EU countries was approved in September 2022 which will receive up to €5.2 billion in public funding. Further IPCEIs on hydrogen are expected in 2023.

A comparison of existing and proposed financial support measures to stimulate low carbon hydrogen production in the key markets reviewed is found to the right.

TABLE 3: HYDROGEN PRODUCTION FINANCIAL SUPPORT OVERVIEW

	France	Germany	Italy	The Netherlands	Portugal	Spain	UK
Nature of existing support (open to applications)	IPCEI funding	Grant funding for domestic and international projects IPCEI funding Grid fee/tax/levy exemptions	Grants IPCEI funding	Grants Operating support for blue hydrogen under SDE ++ (CCS) Operating support for green hydrogen under SDE++ IPCEI funding A temporary additional support scheme aimed at increasing hydrogen production from new-build electrolysers (Tijdelijke opschalingsregeling Waterstof via Elektrolyse)	Grants	Grants IPCEI funding	Grants Quota scheme under the RTFO Operating support for blue hydrogen and electrolytic hydrogen
Proposed support (not yet open to applications)	Operating support and CfDs	CfDs for industry transitions	Operating support for domestic projects	Extension of IPCEI funding Tax/levy exemptions A new temporary support scheme under the EU Temporary Crisis and Transition Framework	Full or partial exemption from gas grid connection fees Operating support Tax incentives Grants	Tax/levy incentives	N.A.
Production methods supported	Mainly electrolytic hydrogen	Green electrolytic hydrogen Blue and turquoise hydrogen for import	All low carbon hydrogen production methods	Green electrolytic hydrogen Blue hydrogen (CCS)	Special focus on green electrolytic hydrogen	Under development, but with a special focus on green electrolytic hydrogen	N.A. All low carbon hydrogen production methods
New-build or retro-fit?	New-build	New-build	New-build and retro-fit	New-build and retro-fit	New-build	New-build	New-build and retro-fit

STANDARDS: NAVIGATING EMERGING HYDROGEN STANDARDS

Whilst there are a number of voluntary hydrogen standards (e.g. CertifHy and TÜV SÜD), there is growing recognition that an international standard for low carbon hydrogen is required. However, this will take time to develop and for consensus to form. In the interim, we are seeing national and regional standards develop. Whilst policy-makers recognise the value of harmonisation, it is essential that this proliferation of standards does not create a barrier to the development of a global low carbon hydrogen economy. In this section, we consider proposals for low carbon hydrogen standards both nationally and at the EU level.

Initially national approaches are being developed

With many EU member states actively engaged in developing both national and international hydrogen markets (for example, Germany and the Netherlands are participating in the H2Global initiative discussed later in this guide) the need for clear standards is widely recognised.

However, whilst EU-wide standards were still awaiting approval (see further below), most countries required some evidence of the low carbon quality of hydrogen in order for hydrogen projects to be eligible for public grants or public funding. Two main approaches may be discerned (used separately or in combination):

1. Reference to the carbon emissions intensity of the hydrogen produced, and/or
2. Reference to the production methods and the source of energy used.

These requirements may be imposed either in a national hydrogen standard or as part of the eligibility criteria within the application process for a public support regime.

For example, the Spanish RTR Plan includes a requirement that the electricity used by a hydrogen producer must be of renewable origin, and that the supply of electricity to the hydrogen producer must be carried out through direct lines or under long-term power purchase agreements (PPAs) with electricity sourced from newly commissioned generation projects.

By contrast, in France a CO2 emissions threshold is proposed rather than the qualification of product as low carbon being based on the source of electricity used. It should be noted, however, that the threshold is expected to be met by production using grid electricity, as the generation mix in France is dominated by nuclear power. Similarly, the UK LCHS requires that hydrogen production meets an emissions threshold of 20g CO_2e/MJ (Lower Heating Value) in order to be considered low carbon under the new support regime (although different requirements apply under the RTFO).

Where a national standard is proposed, the purpose of the standard, production methods permitted and application differs by jurisdiction. A summary of approaches used or under development is found below.

TABLE 4: EMERGING HYDROGEN STANDARDS IN FRANCE, GERMANY, THE NETHERLANDS, SPAIN AND THE UK

	Purpose	Technology restrictions?	When applied?	Applicable to imports?	In use?
France	Eligibility requirement for public support or Government grants	Technology neutral	At point of production	Yes, guarantees of origin issued by EU countries will be recognised provided they comply with Directive (EU) 2018/2001 (**RED II**) requirements and are equivalent to the French framework	No Details awaited pending the adoption of specific decrees.
Germany	Eligibility requirement for support schemes	Electrochemical process using only non-funded renewable electricity	At point of production	Yes	Yes, but subject to revision following EU legislation
The Netherlands	Eligibility requirement for support schemes	Electrolysis directly connected to the grid or using renewable energy (wind / solar) or via CCS	At point of production	Yes	Yes, in use for support schemes and for issuance of guarantees of origin, but subject to revision following EU legislation
Spain	Eligibility requirement for public support and Government grants. Guarantees of origin	Electrolysis using renewable energy	At point of production	Yes, guarantees of origin issued by EU countries will be recognised provided they comply with RED II requirements	Yes, already in use for grant eligibility and issuance of guarantees of origin
UK	LCHS - Eligibility requirement for public grants and production revenue support under the IDHRS RTFO – Requirement for certificate award	LCHS -Technology neutral RTFO – Renewable energy	At point of production under the LCHS At point of sale to the customer under the RTFO	Not currently but certification scheme to be established by 2025	Yes under RTFO and LCHS in use for grant funding LCHS will also be an on-going obligation under the IDHRS

Whilst the emergence of standards and eligibility requirements are necessary to ensure that public funds are channelled towards projects and businesses which will support carbon reduction commitments, policy-makers need to ensure that the multiplicity of standards and requirements do not jeopardise the emergence of global trade in hydrogen.

The EU is making progress towards establishing an EU-wide standard

Although progress has been made at the EU level to define the requirements which must be met for hydrogen produced to qualify as "renewable" and "low carbon", the debate is not over yet. We outline the main measures in play below. For further information please see the EU annex.

The main EU rules establishing the standards and methodology for what constitutes "renewable" hydrogen in the transport sector are: RED II, the Renewable Hydrogen Delegated Act and the GHG Savings Threshold Delegated Act. These Delegated Acts were adopted by the European Commission pursuant to article 27.3 RED II on 10 February 2023 and were published in the Official Journal on 20 June 2023, following the expiry of the requisite period for objection by the European Parliament and the Council. Although the requirements regarding the calculation and qualification of RFNBOs (including green hydrogen) produced from electricity are currently only applicable in the transport sector, they may be extended to other sectors if proposals for the revision of RED II (**RED III**) are adopted.

With regards to renewable guarantees of origin, article 19 of RED II includes provisions relating to the establishment of a guarantee of origin scheme for the purposes of demonstrating to end consumers the share of energy from renewable sources in a supplier's energy mix. As mentioned above, some EU member states, such as France and Spain, are now extending these rules to cover renewable gases, including green hydrogen.

In relation to "low carbon" hydrogen, the proposal for an EU directive on common rules for the internal markets in renewable and natural gases and in hydrogen (COM/2021/803 final) of 15 December 2021, part of the Hydrogen and Decarbonised Gas Package, defines this as "*hydrogen the energy content of which is derived from non-renewable sources, which meets a greenhouse gas emission reduction threshold of 70%*" (the package is currently subject to negotiation between the EU institutions). This greenhouse gas reduction threshold (i.e., 70%) is aligned with the threshold set out under the GHG Savings Threshold Delegated Act for recycled carbon fuel and is intended to apply both to hydrogen produced in the EU and to imports.

Separately the Climate Delegated Act (2021/2139 of 4 June 2021) approved by the European Commission in the context of the EU Taxonomy Regulation – intended to provide investors with tools to assess which economic activities should be deemed as "sustainable" – also provides greenhouse gas thresholds in connection with hydrogen production and other hydrogen-related activities.

Although significant progress has been made, further work is needed to align and streamline the different definitions of low carbon and green hydrogen amongst EU member states. In the meantime, the industry must navigate the patchwork of requirements applicable in the relevant jurisdiction and monitor how the rules introduced at the EU level are transposed into EU law by member states. For first movers making early investments according to national requirements, there may be a risk if more stringent regional standards are introduced without appropriate transition or grandfathering provisions.

Methodologies for defining green hydrogen emerging in the EU and the UK

Following significant debate, an EU-wide position on what constitutes green or "renewable" hydrogen is emerging. Article 27 of RED II currently outlines the requirements for RFNBOs to count towards the target for a minimum share of renewable energy within the transport sector (although, as noted above, these requirements are expected to apply more widely to all RFNBOs regardless of their end-use). In this regard regulation can be seen to be lagging behind project development timetables. Green hydrogen production projects are actively seeking to agree terms with potential off-takers for the hydrogen supply but are having to do so without a firm view of how the requirements of RED II and the Renewable Hydrogen Delegated Act will be implemented. For further information please see the EU annex.

RED II provides that only electricity obtained from a direct connection to a renewable generation plant may count as renewable transport fuel unless it can be demonstrated that the grid-derived electricity is from purely renewable sources and is claimed only once and only in one end use sector. The Renewable Hydrogen Delegated Act has clarified these rules.

A number of options exist for hydrogen to qualify as renewable, including scenarios such as where the hydrogen production facility (**HPF**) is directly connected to a renewable generation facility (**RGF**), and where the HPF uses grid-sourced electricity but is located in a bidding zone with a high penetration of renewables or is using renewable power that would otherwise be curtailed. In other scenarios where the HPF sources electricity from the grid, the main requirements are:

- **Additionality.** The requirement that the RGF came into operation no earlier than 36 months before the hydrogen production plant. This requirement only applies as of 1 January 2038 for HPFs commencing operations prior to 1 January 2028.
- **No operating aid or investment aid.** Again, this requirement only applies as of 1 January 2038 for HPFs commencing operations prior to 1 January 2028.
- **Temporal correlation.** Before 1 January 2030 hydrogen is required to be produced during the same calendar month as the renewable electricity was generated (or charged into a storage unit) and, on and from 1 January 2030, this changes to within the same hour, and
- **Geographic correlation.** The RGF is located in the same bidding zone - or in an interconnected bidding zone if certain requirements are met – as the HPF.

The requirements relating to additionality and temporal correlation have been significantly relaxed since the European Commission's consultation on the original proposal. While the debate was on-going in the EU, the UK adopted its LCHS. This includes a requirement for a 30-minute temporal correlation between the renewable electricity generated and the hydrogen produced, with no transition period for implementation. Whilst the LCHS does not require additionality, the UK's Department for Transport updated guidance on RTFO compliance in 2022 to include this requirement for RFNBOs used in the transport sector. For further information regarding the LCHS and RTFO, please see the UK country annex.

IMPORTS AND EXPORTS: THE INTERNATIONAL MARKET IS TAKING SHAPE

As the role of hydrogen in national economies becomes clearer, a number of the jurisdictions reviewed are assessing their domestic production capacity and the extent to which this can meet national demand. Where a shortfall is forecast, a key question is how this may be met. As a result, countries are beginning to consider their low carbon hydrogen import and export policies, as well as the political and commercial relationships, and physical infrastructure required to be put in place to implement these policies.

Certain jurisdictions are expecting to import significant volumes

All of the jurisdictions reviewed all are currently focused on meeting their national demand using domestic production, however some already recognise that there will be shortfalls. Of the jurisdictions reviewed, Germany and the Netherlands in particular forecast high demand for hydrogen but limited production capabilities and, therefore, expect to rely on imports. In relation to Germany, this requirement has been acknowledged by the industry and Government alike: by 2030, around 70% of overall hydrogen demand of 95 to 130 TWh is expected to be imported. As a result, the German Government is in the process of setting up a separate hydrogen import strategy and has concluded several bilateral agreements on hydrogen cooperation (with Norway in March 2023 and with Canada in August 2022). Germany also led the development of the H2Global scheme to stimulate production for import into the EU (please see the box for details).

H2Global

The German Federal Ministry for Economic Affairs and Climate Action (**BMWK**) established the H2Global Foundation in mid-2021 to seek to accelerate the development of RFNBO production projects. The mandate of the H2Global Foundation and of the corporate intermediary which it has now established, the Hydrogen Intermediary Company GmbH (**HINTCO**), is conceptually simple: HINTCO will enter into 10-year purchase agreements with RFNBO project developers (including those located outside of the EU), under which HINTCO will agree to purchase certain quantities of RFNBOs at a specified price, thus providing sellers with sufficient offtake certainty to take a final investment decision in respect of their RFNBO production projects. HINTCO will then separately re-sell the RFNBO to EU consumers under 1-year supply agreements, with any shortfall or loss of HINTCO being funded from grants made by BMWK (which has already earmarked €900 million for this purpose). The first auction round for the purchase of green ammonia is underway with up to five offtake agreements expected to be granted in this first auction. In March 2023, the Netherlands reached agreement with Germany to take part in H2Global.

A number of the countries reviewed are positioning themselves to meet this demand for imports by exporting hydrogen to other EU member states. Several EU member states envisage becoming hydrogen hubs, both importing and exporting hydrogen, as well as developing national production capacity:

- The Netherlands has signed Memoranda of Understanding with countries inside and outside the EU for the import and export of (mostly) green hydrogen. Example countries include Australia, Oman, Canada, Chili, Namibia, Portugal, Spain, Uruguay and the United Arab Emirates.
- Portugal is aiming to become a green hydrogen importation hub for the subsequent export and supply to Europe by land and sea. Portugal envisages exporting hydrogen by 2026, however no specific targets have been set.
- Spain forecasts that it will be exporting hydrogen by 2030. In particular, Spain plans to upgrade its existing interconnectors with France and Portugal as part of the H2MeD project to facilitate hydrogen imports and exports (please see the EU annex). In addition, the Spanish and EU authorities recognise that a potential connection with North of Africa through the Iberian Peninsula could be considered if countries such as Morocco and Algeria develop sufficient production capacity to export green hydrogen that is compliant with EU standards.

Other jurisdictions such as Italy and the UK are focused on meeting their national demand through domestic production and self-consumption in the first instance but are now beginning to consider the potential for imports and exports into their jurisdictions. In relation to the UK, the Government is currently consulting on the certifications required to be met by hydrogen imported to and exported from the UK.

For further details in respect of each jurisdiction, please see the relevant country annex.

TABLE 5: SUMMARY OF CURRENT POSITION IN RESPECT OF IMPORTS AND EXPORTS

	Are imports envisaged into the jurisdiction for domestic consumption?	Are exports of domestic production envisaged from the jurisdiction?	Is domestic production in the jurisdiction primarily for national consumption?
France	✗	✗	✓
Germany	✓	✗	✓
Italy	✗	✗	✓
The Netherlands	✓	✗	✓
Portugal	✗ (but imports for onward distribution as a hydrogen transit hub envisaged)	✓	✓
Spain	✗ (but imports for onward distribution as a hydrogen transit hub envisaged)	✓	✓
United Kingdom	Under consideration	Under consideration	✓

The EU may be preparing to pool its buying power

At the EU level, the European Commission's REPowerEU Plan, published in May 2022, envisages 10Mt of green hydrogen imports by 2030. Recognising that its ambitions will require significant financing, the European Commission made proposals for the establishment of a Hydrogen Bank on 16 March 2023. Pillar 2 of the proposals relates to hydrogen imports. An auction is proposed to be established for imports to the EU and could (subject to consultation) take the form of a fixed green premium hydrogen auction for which suppliers from third countries or EU off-takers contracting with third country producers can apply. Following the success of the first tender for joint gas purchasing at EU level, under the EU Energy Platform, there are unofficial reports that the scheme may act as a blueprint for the purchase of other critical raw materials as well as hydrogen.

However, hydrogen imported into the EU will also be within scope of the new EU Carbon Border Adjustment Mechanism which will levy an equivalent carbon price on imports of certain goods—including hydrogen—into the EU. That means importers of hydrogen into the EU will need to report (from 1 October 2023) and pay for certificates (starting from 1 January 2026) to account for the embedded scope 1 and 2 emissions from the production of imported hydrogen.

INFRASTRUCTURE: THE NEED FOR HYDROGEN INFRASTRUCTURE

Scale up of production and demand for low carbon hydrogen is required prior to the roll out of significant hydrogen infrastructure. As a result, policy and regulatory progress towards hydrogen storage and transport networks is generally less well developed in all jurisdictions. However strategic network planning is underway in all jurisdictions.

At the national level, the development of hydrogen transport networks and storage is now becoming a policy priority in many jurisdictions. Security of supply concerns have re-focused efforts to consider national infrastructure requirements and to coordinate cross-border hydrogen infrastructure in order to meet revised targets.

A summary of measures to stimulate low carbon hydrogen storage and distribution in key markets is found below. Please see the relevant country annex for further details.

France	**Goal? No** The Government is authorized to make an ordinance relating to the regulation of the underground storage of hydrogen and to organise tenders relating to the development of hydrogen storage. France has adopted a framework for the injection of hydrogen in the existing gas grid and has made Government grants available in the context of the Hydrogen IPCEI.
Germany	**Goal? Under consideration** Projects identified under the Hydrogen IPCEI include establishing a pure hydrogen grid network of approximately 1,200 km (a so called “starter network”). In addition, Government funded research is exploring different hydrogen transport options as part of the TransHyDE project including high-pressure vessels, existing gas pipelines, ammonia-bound transport and liquid organic hydrogen carriers. A new regulatory framework for the development of pure hydrogen grids has been adopted.
Italy	**Goal? Under consideration** To date, the IRRP provides for a €300 million investment in the railway sector, which includes the development of high-capacity storage systems with the possibility of using metal hydrides or liquids, and a €160 million investment to improve knowledge of hydrogen-related technology for the production, storage and distribution.

The Netherlands	**Goal? Yes – four caverns for hydrogen storage to be developed before 2030 (the first as early as 2026)** In addition to hydrogen storage, the Government has decided that part of the gas network will be used for the transport and distribution of hydrogen, next to newly built hydrogen infrastructure. HyNetwork Services (**HNS**), a wholly-owned subsidiary of the national gas TSO Gasunie, is responsible for developing the infrastructure (in three phases). HyStock, another subsidiary of Gasunie, has been appointed as the operator of the hydrogen storage caverns mentioned above. Preparations for the national hydrogen backbone have started and a budget of €750 million has been reserved. Extra funding has been budgeted in the proposed Temporary Law on the Climate Fund. The Netherlands has the ambition of becoming a hydrogen hub. The national hydrogen backbone will connect regional backbones with large clusters of industrial consumers, port facilities, storage facilities and grids, import terminals and neighbouring countries. International co-operation has been intensified.
Portugal	**Goal? Yes – for gas grid blending:** • 2025: 1% - 5% • 2030: 10% - 15% • 2040: 40% - 50% • 2050: 75% - 80% The PT H2 Plan includes a tentative plan for auctions of production rights to inject hydrogen into the existing gas grids. The new Gas Distribution Grids' Regulation provides a regulatory framework for the operation of gas grids using 100% natural gas or 100% renewable-source and low carbon gases (such as biomethane and low carbon hydrogen). Support is available under the Environmental Fund (which supports projects that contribute to environmental public policies) and the Supporting Innovation Fund (which supports technological development and investments into renewable energy and efficient energy use) which may cover storage and distribution costs. Where storage and distribution costs are necessary for the production of green hydrogen, these costs are covered by the Scheme of Incentives to Support the Production of Green Hydrogen and other Renewable Gases.

Spain	**Goal? No** The Spanish Government is considering development and innovation in relation to hydrogen storage (both liquid and gas), distribution and direct supply to consumers or other users (such as road transport vehicles) through hydrogen re-fuelling stations. The Spanish Government has introduced several legal amendments intended to facilitate the injection of renewable gases into the existing natural gas network and distribution facilities, and to boost the development of hydrogen pipelines for the exclusive supply to a consumer and for the connection of new renewable gas production facilities to the Spanish gas network. The Spanish Hydrogen Roadmap also aims to review the technical rules applicable to natural gas infrastructure to allow a higher proportion of blending of hydrogen within the gas system. Support will be initially focused on small-scale storage and distribution facilities as green hydrogen production will be primarily located within areas with industry or transport.
UK	**Goal? Under consideration** A number of pilot projects are underway to explore hydrogen infrastructure requirements (e.g. Project Union, H21 and Future Grid). The cost of small scale hydrogen transport and storage infrastructure may be recovered by production projects under the IDHRS operating support regime proposed. Large-scale hydrogen storage requirements are also under review. New business models for hydrogen transportation and storage will be developed by 2025, to be in place by 2030. A Government consultation was published in 2022 seeking stakeholder views on high-level design options for these business models. Decisions on blending up to 20% hydrogen into the natural gas grid will be taken by the end of 2023.
EU	**Goal? No** The revision of the Trans-European Network for Energy Regulation (**TEN-E Regulation**) entered into force on 23 June 2022, setting guidelines for cross border energy networks. It includes a new focus on hydrogen networks (new and repurposed) and ensures that these are included in ENTSO-G's ten-year network development plans. The revision also includes hydrogen infrastructure within the categories eligible for support, principally through PCIs that are eligible for financing from the Connecting Europe Facility for 2021-2027. As part of the REPowerEU Plan, the European Commission announced plans to support the development of three major hydrogen import corridors via the Mediterranean, the North Sea area and, as soon as conditions allow, with Ukraine. The Iberian Peninsula was also highlighted as having potential in the long term as a production hub and import point from North Africa. An infrastructure needs assessment is expected to conclude in 2023. The European Commission's proposal for the Net-Zero Industry Act published on 16 March 2023 also acknowledges the need for EU Member States to "accelerate permitting and consider regulatory sandboxes and prioritise access to funding" to support the REPowerEU's objective of doubling the number of Hydrogen Valleys in the EU.

END USES: HYDROGEN USES ACROSS ALL SECTORS OF THE EUROPEAN ECONOMY

Most countries have focused on using hydrogen across a number of sectors, most commonly industry, transport heat and power. Despite the high-level similarities, the strategies of each country diverge in terms of specific industries and the level of maturity that is expected to be achieved from the hydrogen infrastructure by 2030.

FIGURE 2: CURRENT PRIMARY SECTORAL FOCUS FOR LOW CARBON HYDROGEN USAGE BY JURISDICTION

France	Germany	Italy	The Netherlands	Portugal	Spain	UK
Industry	Industry	Industry	Industry	Industry	Industry	Industry
Transport	Transport	Transport	Transport	Transport	Transport	Transport
		Heat	Ports		Power	Heat
			Built environment			Power

The focus on particular sectors is driven largely by each country's economy. For example: Germany has a strong focus on the chemicals and steel industries, the Netherlands is developing hydrogen hubs, France and Italy are researching the use of hydrogen in rail transport that has not been electrified, and the UK is considering plans to blend hydrogen into its already extensive gas network. Each of these sectors present their own challenges in relation to incorporating hydrogen into the energy mix and countries are adopting various levels of ambition (whether that be demonstration projects or a full-scale rollout).

Below, we highlight some of the commonalities and areas of divergence in national approaches to hydrogen use cases in the jurisdictions reviewed. For further details of measures applicable in each country, please see the relevant country annex.

Industry

Italy, the Netherlands, Portugal, Spain, France and the UK are promoting the development of industrial clusters, siting low carbon hydrogen production close to end users. Both the Netherlands and the UK are also supporting blue hydrogen production, and so these industrial clusters will also be connected to a CO2 transport and storage network. The number of industrial clusters may increase following the implementation of the European Commission's REPowerEU Plan, which envisages funding to double the number of so called 'hydrogen valleys'.

Stimulation of demand in industry is particularly supported via the Hydrogen IPCEI. In France, sites such as an ArcelorMittal steel factory in Dunkerque or a Vicat cement site, will be used to trial the adoption of low carbon hydrogen. Similarly in Germany, 16 of the German projects under the Hydrogen IPCEI are focused on low carbon steel production and hydrogen transformation in the chemical industry.

The REPowerEU Plan and the EU Hydrogen Strategy envisage innovation funding and the roll-out of carbon CfD to support hydrogen fuel-switching in industrial processes. The carbon CfD would pay the difference between the CO2 strike price and the actual CO2 price under the EU Emissions Trading System, bridging the cost gap compared to conventional hydrogen production.

Germany and Portugal are currently considering specific industrial sub-sector support and market intervention. For example, in Germany the introduction of a demand quota for green steel is being discussed.

The implementation of RED III by EU member states may result in further ambition for hydrogen in industrial applications in order to meet the target of at least 42% of hydrogen used in industry to come from RFNBOs by 2030, and 60% by 2035.

Transport

Due to the target of 14% of renewable transport fuels in consumption by 2030 under RED II, all countries (including the UK due to historic EU membership) are stimulating the adoption of renewable transport fuels, with many having adopted a sub-target for transport RFNBOs (including electrolytic green hydrogen). Some jurisdictions propose to exceed the RED II requirements. For example, Germany and France have set their national targets at the higher level of 25% and 15% respectively by 2030.

RED III, once formally adopted, will set a binding combined sub-target for EU member states of 5.5% for advanced biofuels and RFNBOs in the share of renewable energy supplied to the transport sector by 2030, with a minimum of 1% for RFNBOs. Following political agreement, it is also expected that RED III will also amend RED II to provide for a greenhouse gas intensity reduction target

of at least 14.5% by 2030 compared to a baseline, or alternatively (to be decided by each EU member state), a target of at least 29% of renewables within the final consumption of energy in the transport sector by 2030. Fuel suppliers may be required to demonstrate compliance with this obligation by the surrender of tradable credits.

As noted in the section on Standards, the EU Renewable Hydrogen Delegated Act establishes the criteria for electricity used in green hydrogen production for the hydrogen to be classified as a 'renewable transport fuel' and counted towards these targets by EU member states. A separate GHG Savings Threshold Delegated Act establishes a methodology for assessing greenhouse gas emissions savings from liquid and gaseous transport RFNBOs and savings from recycled carbon fuels.

The use of low carbon hydrogen is envisaged in all jurisdictions in road transport, particularly for heavy goods vehicles, with measures focused on the development of fuel cell technology, vehicles and re-fuelling stations underway. Support for projects is expected to be available via the Hydrogen IPCEI as well as via certificate trading, which is already in place in the UK and may be established pursuant to RED III (as noted above).

Hydrogen will play a role in other transport sub-sectors, although the extent of that role is overall less clear. Initiatives are underway in many countries to trial hydrogen in aviation, maritime and rail. For example, the Netherlands has negotiated an aviation sector commitment to reach 14% blending of sustainable aviation fuels (SAF) by 2030 and 100% by 2050 (although this is still in draft form) whilst France and Italy have launched initiatives focused on using low carbon hydrogen in the rail sector, where electrification is not feasible.

Heat in buildings

The Netherlands and the UK have the greatest focus on hydrogen in the heating sector of the countries reviewed. However, the ambition here is longer-term, and the focus in the next decade will be on understanding the viability of hydrogen as a heating fuel through a variety of demonstration projects.

Power

The potential role of low carbon hydrogen in the power sector has been acknowledged within the hydrogen strategies of the Netherlands, Spain and the UK. It has potential to provide valuable system flexibility services either as firm, dispatchable generation or by acting as long-duration storage. However, the contribution of hydrogen in the power sector is still being explored in most jurisdictions (although the UK is widely expected to consult on a business model later in 2023). As a result, many jurisdictions will be trialling power-related pilot schemes during the 2020s and exploring the implications of hydrogen blending. This use case is likely to scale up however in the 2030s.

Agriculture

Despite the potential for hydrogen to contribute to low carbon ammonia production and agricultural transport vehicles, agriculture is a sector omitted from many countries' strategies. The use of low carbon hydrogen in agriculture forms part of the Netherlands' Hydrogen strategy, and support schemes for pilot projects have been launched for the sector, however no concrete targets are set out in the Dutch National Hydrogen Programme (NWP). For information regarding fuel switching in transport (including agricultural vehicles), please refer to the Transport section above.

GLOSSARY

ACM	The Netherlands Authority for Consumers and Markets
BESS	British Energy Security Strategy (published April 2022)
BMWK	The German Federal Ministry for Economic Affairs and Climate Action
CCS	Carbon Capture and Storage
CCUS	Carbon Capture, Usage and Storage
CfD	Contract for Difference
Climate and Resilience Law	French law n°2021-1104 dated 22 August 2021
DESNZ	The UK Government Department for Energy Security and Net Zero (formerly the Department for Business, Energy & Industrial Strategy (BEIS))
Directive 2009/73/EC	Directive 2009/73/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC
EC Regulation 715/2009	Regulation (EC) No 715/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the natural gas transmission networks and repealing Regulation (EC) No 1775/2005
Energy Climate Law	French law n°2019-1147 dated 8 November 2019 relating to energy and climate.
Energy Taxation Directive	Council Directive 2003/96/EC of 27 October 2003 restructuring the Union framework for the taxation of energy products and electricity
ERSE	Portuguese Energy Services Regulator
EU	European Union
EU Hydrogen Strategy	Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: A hydrogen strategy for a climate-neutral Europe (COM/2020/301 final), 8 July 2020

EU Energy System Integration Strategy	Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Powering a climate-neutral economy: An EU Strategy for Energy System Integration (COM/2020/299 final), 8 July 2020
Fit for 55 Package	Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions 'Fit for 55': delivering the EU's 2030 Climate Target on the way to climate neutrality (COM(2021) 550 final) and related legislative proposals
FSR	EU Foreign Subsidies Regulation 2022/2560 of the European Parliament and of the Council of 14 December 2022 on foreign subsidies distorting the internal market
GHG Savings Threshold Delegated Act	Commission Delegated Regulation (EU) of 10.2.2023 supplementing RED II by establishing a minimum threshold for greenhouse gas emissions savings of recycled carbon fuels and by specifying a methodology for assessing greenhouse gas emissions savings from liquid and gaseous transport RFNBOs and from recycled carbon fuels
HAR	The UK electrolytic hydrogen allocation rounds to award support under the new IDHRS scheme to green hydrogen production projects
HINTCO	The Hydrogen Intermediary Company GmbH
HNS	HyNetwork Services, a wholly-owned subsidiary of Gasunie, appointed by the Government of the Netherlands as the developer of hydrogen infrastructure
HPF	Hydrogen production facility
Hydrogen and Decarbonised Gas Package	The European Commission's proposals of December 2021 for recasting (amongst other things) the Third Energy Package on natural gas
Hydrogen IPCEI	Important projects of common European interest for hydrogen, being projects which may represent a very important contribution to economic growth, jobs and competitiveness for the EU industry and economy
Hydrogen National Strategy	The National Strategy, dated March 2020, for the development of carbon-free hydrogen in France
Hydrogen Ordinance	The French ordinance n°2021-167 dated 17 February 2021 relating to hydrogen
IDHRS	The UK Industrial Decarbonisation and Hydrogen Revenue Support scheme in the UK

IEA	The International Energy Agency
IRRP	The Italian National Recovery and Resilience Plan (*Piano Nazionale di Ripresa e Resilienza*)
LCHA	Low Carbon Hydrogen Agreement
LCHS	Low Carbon Hydrogen Standard
Mt	Million tonnes
NWP	The Dutch National Hydrogen Programme (*Nationaal Waterstof Programma*)
PERTE ERHA	Strategic Projects for the Recovery and Economic Transformation of Renewable Energies, Renewable Hydrogen and Storage (*Proyectos Estratégicos para la Recuperación y Transformación Económica de Energías Renovables, Hidrógeno Renovable y Almacenamiento*), approved by the Spanish Government on 14 December 2021
PNEC 2030	The Portuguese National Plan for Energy and Climate 2020-2030
PPA	Power purchase agreement
Preliminary Guidelines	The Preliminary Guidelines on the National Strategy for the Development and Use of Hydrogen, issued in 2021 by the Italian Ministry of Economic Development
PRRP	Portuguese National Recovery and Resilience Plan (*Plano de Recuperação e Resiliência*) approved by the Portuguese Government
PT H2 Plan	The Portuguese National Hydrogen Plan, enacted by Council of Ministers' Resolution 63/2020, of 14 August 2020
RED II	Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources
RED III	The revision of RED II as part of the Fit for 55 Package, the status of which at the time of writing is the provisional agreement dated 30 March 2023 between the European Parliament and the Council on the revision of energy targets under RED II
RGF	Renewable generation facility
Renewable Hydrogen Delegated Act	Commission Delegated Regulation (EU) of 10.2.2023 supplementing RED II by establishing an EU methodology setting out detailed rules for the production of liquid and gaseous transport RFNBOs

REPowerEU	Regulation (EU) 2023/435 of the European Parliament and of the Council of 27 February 2023 amending Regulation (EU) 2021/241 as regards REPowerEU chapters on recovery and resilience plans and amending Regulations (EU) No 1303/2013, (EU) 2021/1060 and (EU) 2021/1755, and Directive 2003/87/EC
RFNBO	Renewable fuel of non-biological origin such as renewable hydrogen and hydrogen-based synthetic fuels
RTFO	The UK Renewable Transport Fuel Obligation established pursuant to the Renewable Transport Fuel Obligations Order 2007, as amended, a quota scheme coupled with tradable certificates for renewable transport fuels
SAF	Sustainable aviation fuels
SMR	Steam Methane Reformation
Spanish Hydrogen Roadmap	The Spanish Hydrogen Roadmap: a commitment to renewable hydrogen (*Hoja de Ruta del Hidrógeno: una apuesta por el hidrógeno emovable*), published in October 2020
Spanish RTR Plan	The Recovery, Transformation and Resilience Plan (*Plan de Recuperación, Transformación y Resiliencia*) approved by the Spanish Government in the context of Regulation (EU) 2021/241 of the European Parliament and of the Council of 12 February 2021 establishing the Recovery and Resilience Facility
TEN-E Regulation	The Trans-European Network for Energy Regulation (EU) No 347/2013 of the European Parliament and of the Council of 17 April 2013 on guidelines for trans-European energy infrastructure
TEN-T Regulation	Trans-European Network for Transport Regulation (EU) No 1315/2013 of the European Parliament and of the Council of 11 December 2013 on EU guidelines for the development of the trans-European transport network
Third Energy Package	Directive 2009/73/EC and EC Regulation 715/2009

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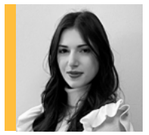

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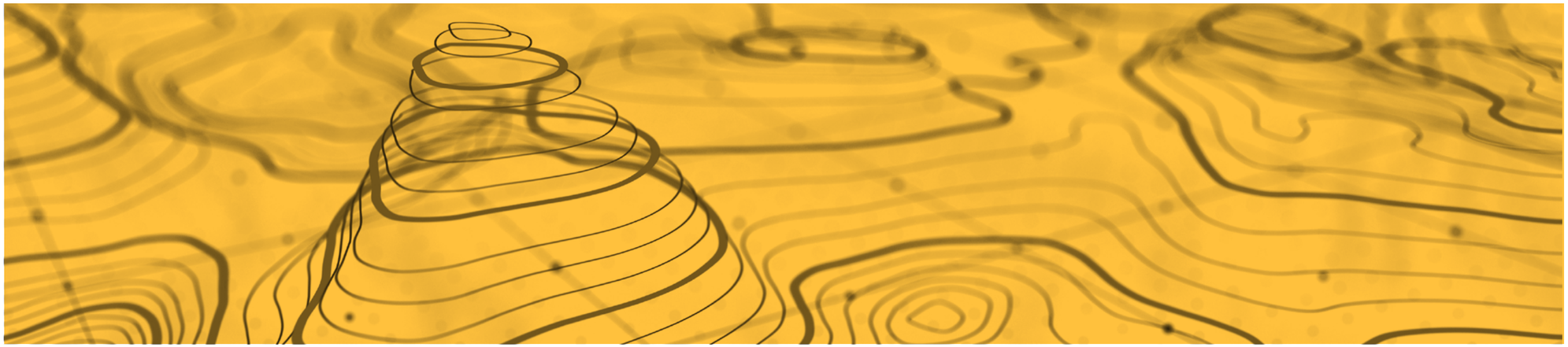
COUNTRY ANNEX



EU

Key developments in the EU in the last 12 months

- The adoption and publication of the Renewable Hydrogen Delegated Act and the GHG Savings Threshold Delegated Act requirements and methodology to qualify hydrogen as renewable (for further information, please see the section on EU wide standards , and the section on Methodologies for defining green hydrogen).
- The provisional political agreement of the Council and European Parliament on the increase of renewable energy targets in different sectors (subject to formal adoption in RED III), including renewable hydrogen as one of the main drivers for targets in transport and industry (for further information, please see the section on Industry and the section on Transport).
- The introduction of the European Hydrogen Bank to support renewable hydrogen production and reduce the cost gap between renewable hydrogen and fossil fuels for early projects (for further information, please see the section on Hydrogen support below).

Strategy and policy overview

The EU is aiming to develop its hydrogen industry in a step-by-step strategic approach as described in the EU Hydrogen Strategy. This plan establishes the following timeline for green hydrogen targets:

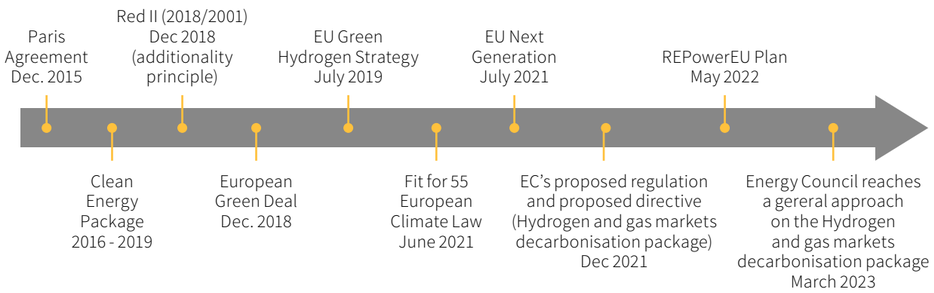
- Present – 2024: At least 6GW of installed capacity in electrolysers and production of up to 1Mt of green hydrogen.
- 2025 – 2030: At least 40GW of installed capacity in electrolysers and production of up to 10Mt of green hydrogen.
- 2030 – onwards: green hydrogen technologies will be fully implemented in all hard-to-decarbonise sectors.

The EU Hydrogen Strategy is one of the measures approved in connection with the European Green Deal, with the objective of delivering the EU climate targets:

- to reduce its net greenhouse gas emissions by 55% in 2030 (with regards to 1990 levels); and
- to achieve climate neutrality by 2050.

In December 2021, the European Commission adopted two legislative proposals (a proposed directive and a proposed regulation) referred to as the Hydrogen and gas markets decarbonisation package. The Energy Council reached a general approach on both proposals on 28 March 2023. Once agreement is reached with the European Parliament, and the legal acts are formally adopted, the Third Energy Package on natural gas will be recast to, among other objectives, support the development and integration of green hydrogen projects. In particular, this will provide a regulation for the decarbonisation of the gas and hydrogen markets and establish an internal market for hydrogen on similar terms to those applicable to the natural gas internal market.

The EU Hydrogen Strategy was further supplemented in 2022 by the European Commission's REPowerEU Plan, which envisages 10Mt of domestic green hydrogen production and 10Mt of green hydrogen imports. The measures within the REPowerEU Plan are expected to be fully implemented by 2030 in order to accelerate the EU's energy transition and energy independence from Russia.



Hydrogen Standard?

Progress has been made at the EU level to define the requirements which must be met for hydrogen produced to qualify as "renewable" and "low carbon" but the debate is not over yet. We outline the main measures in play below. More detail in relation to renewable hydrogen is provided in the following section.

In relation to "low carbon" hydrogen, the proposal for an EU directive on common rules for the internal markets in renewable and natural gases and in hydrogen (COM/2021/803 final) of 15 December 2021, part of the Hydrogen and Decarbonised Gas Package, defines this as "hydrogen the energy content of which is derived from non-renewable sources, which meets a greenhouse gas emission reduction threshold of 70%". This greenhouse gas reduction threshold (i.e., 70%) is aligned with the threshold set out under the GHG Savings Threshold Delegated Act for recycled carbon fuel and is intended to apply both to hydrogen produced in the EU and to imports. Based on the current draft of the proposal for an EU directive referred to above, the European Commission is expected to adopt by 31 December 2024 a delegated act to specify the methodology for assessing greenhouse gas emission savings from low carbon fuels. Depending on the methodology adopted by the European Commission, hydrogen produced from nuclear electricity, known as pink hydrogen, may be qualified as low-carbon hydrogen. The Hydrogen and Decarbonised Gas Package is currently subject to negotiation between the EU institutions.

Separately the Climate Delegated Act (2021/2139 of 4 June 2021) approved by the European Commission in the context of the EU Taxonomy Regulation – intended to provide investors with tools to assess which economic activities should be deemed as "sustainable" – also provides greenhouse gas thresholds in connection with hydrogen production and other hydrogen-related activities.

It is expected that further work will be undertaken to align and streamline the different definitions of low carbon and green hydrogen amongst EU member states. In the meantime, the industry must navigate the patchwork of requirements applicable in the relevant jurisdiction and monitor how the rules introduced at the EU level are transposed into EU law by member states. This is especially relevant to the requirements of RED II and the Renewable Hydrogen Delegated Act (see further below). For first movers making early investments according to national requirements, there may be a risk if more stringent standards are introduced without appropriate transition or grandfathering provisions.

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Renewable hydrogen

The main EU rules establishing the standards and methodology for what constitutes "renewable" hydrogen are: RED II, the Renewable Hydrogen Delegated Act and the GHG Savings Threshold Delegated Act. These Delegated Acts were adopted by the European Commission pursuant to article 27.3 RED II on 10 February 2023 and were published in the Official Journal on 20 June 2023, following the expiry of the requisite period for objection by the European Parliament and the Council.

In July 2021, in the context of the Fit for 55 Package to update the EU's commitments to align with the EU climate target for 2030, the European Commission proposed a revision to RED II, to be known as RED III, that would extend its provisions on the calculation and qualification of RFNBOs (including green hydrogen) produced from electricity regardless of their end use.

Following significant debate, an EU-wide position on what constitutes renewable hydrogen is emerging. Article 27 of RED II currently outlines the requirements for RFNBOs to count towards the target for a minimum share of renewable energy within the transport sector (although these requirements are expected to apply more widely to all RFNBOs regardless of their end-use). RED II provides that only hydrogen produced using electricity obtained via a direct connection to a renewable generation facility (**RGF**) may count as renewable transport fuel unless it can be demonstrated that the grid-derived electricity is from purely renewable sources and is claimed only once and only in one end use sector.

As a result, hydrogen production facilities (**HPFs**) will need to consider these requirements carefully in order to ensure the marketability (and in some cases access to support) for their projects.

The Renewable Hydrogen Delegated Act has clarified the RED II rules. These are complex, but a high-level summary is provided in the table below.

The Renewable Hydrogen Delegated Act provides that hydrogen producers may structure their renewable electricity input using a mix of electricity obtained via a direct connection and electricity taken from the grid, provided they are able to evidence compliance with the relevant requirements to regard such different sources of electricity as fully renewable under the delegated act. If the renewable hydrogen is produced outside the EU, hydrogen producers will be entitled to make use of international voluntary schemes validated by the European Commission to provide evidence of compliance with relevant requirements within the EU.

Several principles underpin a number of the options under the Renewable Hydrogen Delegated Act:

1. **Additionality –**
   The RGF came into operation not earlier than 36 months before the HPF, subject to exceptions for first movers (see below)
2. **Temporal correlation –**
   The hydrogen is required to be produced during the same hour as the renewable electricity was generated (or charged into a storage unit), subject to exceptions for first movers (see below)
3. **Geographical correlation –**
   The RGF(s) is/are located in the same bidding zone as the HPF, or in an interconnected bidding zone if certain requirements are met

TABLE 6: OVERVIEW OF THE RENEWABLE HYDROGEN DELEGATED ACT REQUIREMENTS

Electricity input	Requirements to count the electricity as fully renewable	Special rules for first movers
Via direct connection	**Article 3:** • The RGF is connected to the HPF via a direct line, or is located within the same installation • Additionality • The RGF is not connected to the grid, or if connected, a smart metering system is installed to evidence that no electricity has been taken from the grid	N/A
Via the grid	**Article 4(1):** The HPF is located in a bidding zone with average proportion of renewable electricity exceeding 90% in the previous calendar year and its production does not exceed a specific maximum number of hours for that bidding zone	N/A
	Article 4(3): The HPF takes electricity from the grid during an imbalance settlement period reducing the need for any curtailments from RGFs	N/A
	Article 4(2): • The HPF is located in a bidding zone where the emission intensity of electricity is lower than 18g CO_2 eq/MJ • The HPF should have one or more PPAs directly or via intermediaries • Geographic correlation • Temporal correlation	• Temporal correlation: Before 1 January 2030, hydrogen will be required to be produced during the same calendar month as the renewable electricity was generated (or charged into a storage unit)
	Article 4(4): • The HPF must have one or more PPAs directly or via intermediaries, or be taking power from its own offsite installation • Temporal correlation • Additionality • No operating or investment aid received by the RGF • Geographical correlation • The RGF(s) within the scope of the PPA(s) must generate an amount of electricity that is at least equal to the amount of electricity claimed to be consumed by the HPF	• Temporal correlation: Before 1 January 2030, hydrogen will be required to be produced during the same calendar month as the renewable electricity was generated (or charged into a storage unit) • The additionality requirements will not apply until 1 January 2038 to HPFs that come into operation before 1 January 2028 • No operating or investment aid received by the RGF. However, for HPFs that come into operation before 1 January 2028, this requirement will only apply from 1 January 2038

With regards to guarantees of origin, article 19 of RED II includes provisions relating to the establishment of a guarantee of origin scheme for the purposes of demonstrating to end consumers the share of energy from renewable sources in a supplier's energy mix. Guarantees of origin with respect to renewable electricity have been established in many countries (including the UK) for a number of years. As mentioned above, some EU member states, such as France and Spain, are however now extending these rules to cover renewable gases, including green hydrogen. RED II also provides for mutual recognition of guarantees of origin, as between EU member states.

Hydrogen support

Support is available under different programmes included in the Hydrogen Public Funding Compass (e.g. NextGeneration EU, Horizon Europe, Innovation Fund, InvestEU) to promote the development of green and low-carbon hydrogen projects at different stages of the value chain across the EU. In addition, financing support may also be obtained from the EU country funds, which are funding programmes available to each EU country where the relevant hydrogen project may be deployed.

In March 2023, the European Commission unveiled its plans to set up the European Hydrogen Bank, which aims to support renewable hydrogen production within the EU and reduce the cost gap between renewable hydrogen and fossil fuels for early projects. While the Commission plans to hold consultations to enhance the structure, operations and institutional framework of the European Hydrogen Bank, it intends to implement critical aspects of its functioning by the end of 2023.

The European Hydrogen Bank

The European Hydrogen Bank proposal is based on four pillars, two of which consist of financing mechanisms.

Pillar 1 (Domestic Market Creation): One of its essential aspects is the establishment of an auction system that awards subsidies to EU producers in the form of a fixed-premium scheme per kg of hydrogen produced for a maximum of 10 years. The first pilot auctions are currently being designed and are expected to be launched in autumn 2023, with €800 million in backing under the Innovation Fund.

Pillar 2 (Imports to the EU): A second auction is proposed to be established for imports to the EU and could take the form of a fixed green premium hydrogen auction for which suppliers from third countries or EU off-takers contracting with third country producers can apply. By using the same design as for EU-based production, this second auction could allow for timely and cost-effective implementation, benefiting from operational and institutional synergies with the domestic auction.

The third and fourth pillars aim to enhance transparency and coordination as well as streamlining existing financial instruments.

Renewable hydrogen projects may also fall within the scope of the IPCEI, which address market failures or other important systematic failures. Production of green hydrogen, and storage and distribution projects have both been declared as IPCEIs. In that regard, the European Commission has already approved two IPCEIs:

- IPCEI Hy2Tech which aims at developing innovative technologies for the hydrogen value chain to decarbonise industrial processes and the mobility sector, with a focus on the end-user; and
- IPCEI Hy2Use to support the construction of hydrogen-related infrastructure and the development of innovative and more sustainable technologies for the integration of hydrogen into the industrial sector (and complementing IPCEI Hy2Tech).

The REPowerEU Plan and the EU Hydrogen Strategy envisage innovation funding and the roll-out of carbon CfDs to support hydrogen fuel-switching in industrial processes. The carbon CfD would pay the difference between the CO2 strike price and the actual CO2 price under the EU Emissions Trading System, bridging the cost gap compared to conventional hydrogen production.

Separately, investors in hydrogen projects and ventures across the value chain will be closely monitoring the implementation of the FSR. The FSR is expected to impact acquisitions (including joint ventures) involving a financial contribution by a non-EU country, where the EU-based target company, one of the merging parties or the joint venture generates an EU turnover of at least €500 million, and where the parties to the transaction received from the non-EU countries combined aggregate foreign financial contributions of more than €50 million in the preceding three years. It will also impact bids in public procurements involving a financial contribution by a non-EU country, where the estimated contract value is at least €250 million and the bid involves a foreign financial contribution of at least €4 million per third country. Given the breadth of what may be counted as "foreign financial contributions", including state-funded R&D grants or tax incentives, companies and investors active in EU hydrogen projects may find themselves unwittingly within the ambit of the FSR.

Storage and transport

The revision of the TEN-E Regulation was proposed by the European Commission on 15 December 2020, and the revised Regulation entered into force on 23 June 2022, providing a framework for greater coordination of hydrogen infrastructure between EU member states. The TEN-E Regulation, inter alia, sets guidelines for cross border energy networks. In relation to hydrogen, the revision includes a new focus on hydrogen networks (new and repurposed) and ensures that these are included in ENTSO-G's ten-year network development plans. The revision also includes hydrogen infrastructure within the categories eligible for support, principally through PCIs that are eligible for financing from the Connecting Europe Facility for 2021-2027. The selection process began with the first cross-regional meeting held in October 2022, and the first list of PCIs and PMIs adopted under the new rules is expected in autumn 2023. Such PCIs and PMIs will be granted by EU Member States with a special status and will benefit from fast track permitting procedures.

The H2MeD project

The Portuguese, Spanish, French and German Governments have put forward the H2MeD project which aims to build the first major green hydrogen corridor in the EU. The project will link renewable gas production and storage facilities in the Iberian Peninsula with Marseille (France) in order to transport hydrogen from the Iberian Peninsula to Central Europe. Spain aims to transport 2Mt of green hydrogen per year, representing 10% of the total consumption of the EU. It is envisaged that it will be funded mainly through EU funds and completion of its construction is aimed for 2030. The sponsor countries have submitted an application requesting that H2MeD is declared a Hydrogen IPCEI.

As part of the REPowerEU Plan, the European Commission announced plans to facilitate the import of up to 10Mt of renewable hydrogen, by supporting the development of three major hydrogen import corridors via the Mediterranean, the North Sea area and, as soon as conditions allow, with Ukraine. The Iberian Peninsula was also highlighted as having potential in the long term as a production hub and import point from North Africa. An infrastructure needs assessment was expected to conclude in 2023.

The European Commission's proposal for the Net-Zero Industry Act published on 16 March 2023 also acknowledges the need for EU Member States to "accelerate permitting and consider regulatory sandboxes and prioritise access to funding" to support the REPowerEU's objective of doubling the number of Hydrogen Valleys in the EU.

Sector specific measures

The EU Hydrogen Strategy and the EU Strategy for Energy System Integration aim to promote the use of green hydrogen to decarbonise sectors that are hard to electrify (such as the transport sector and heavy industries) and as an alternative to electricity storage in the provision of flexibility services to electricity markets.

Transport

As part of REPowerEU, the EU wishes to accelerate the transition towards zero-emission vehicles combining electrification and fossil-free hydrogen to replace fossil fuels. As part of the revision of the Trans-European Network for Transport Regulation (**TEN-T Regulation**) it is proposed that member states will need to roll out hydrogen refuelling infrastructure along the trans-European transport core network (every 200 km) and in urban nodes by 2031.

RED II includes an obligation for transport fuel suppliers to ensure that the quota of renewable energy consumed is at least equal to 14% of the total energy consumed in the transport sector by 2030. There is also a mandate for member states to ensure that greenhouse gas emissions savings due to the use of liquid and gaseous RFNBOs in the transport sector are at least 70% from 1 January. Green hydrogen is expected to have a key role in the process of decarbonising the transport sector and so enabling the EU to achieve this goal.

RED III

A revised version of RED II, RED III, is in the process of being approved and these targets are expected to be updated and increased. In March 2023, the Commission, European Parliament, and the Council reached provisional agreement on RED III, setting targets for industry, transport, buildings, heating and cooling which imply the use of hydrogen. Industry must procure at least 42% of its hydrogen from RFNBOs by 2030, and 60% by 2035. As for transport, the agreement sets a binding combined sub-target of 5.5% for advanced biofuels and RFNBOs (mostly renewable hydrogen and hydrogen-based synthetic fuels) in the share of renewable energies supplied to the transport sector, with a minimum of 1% for RFNBOs.

With this provisional agreement, France has obtained a consensus with regards to nuclear power in the achievement of these targets, which may be seen as an implicit recognition of the use of nuclear power in low carbon hydrogen production. In relation to industry, the provisional agreement states that member states may obtain a 20% reduction of the RFNBOs target if they meet their national contribution to the EU renewable target and the share of hydrogen produced from fossil fuels is not more than 23% in 2030 and 20% in 2035. Member States with a low-carbon energy mix, such as France, are expected to benefit from this mechanism.

FRANCE

Key developments in France in the last 12 months

- The Government has announced that the French National Strategy for the development of carbon-free hydrogen in France published in September 2020 (the **Hydrogen National Strategy**) will be revised in June 2023, in particular to encourage the decarbonisation of major industrial sites by promoting the mass-production of carbon-free hydrogen (for further information, please see the section on Policy overview below).
- The Government is consulting certain public authorities on a draft implementing decree related to the public support scheme for the production of renewable and low-carbon hydrogen by water electrolysis (for further information, please see the section on Production below).
- Adoption on 10 March 2023 of the Law n°2023-175 relating to the acceleration of the deployment of renewable energies, which aims to simplify relevant administrative procedures to facilitate the delivery of carbon-free hydrogen projects in France (for further information, please see the section on Policy overview below).

Policy overview

The law n°2019-1147 dated 8 November 2019 relating to energy and climate (the **Energy Climate Law**) aims for renewable and low-carbon hydrogen (as defined below) to reach 20% to 40% of total hydrogen and industrial hydrogen consumption by 2030.

The Hydrogen National Strategy aims for 6.5GW of carbon-free hydrogen to be produced by water electrolysis by 2030. According to the Hydrogen National Strategy, €7 billion will be invested to meet these objectives by 2030. In November 2021, an additional €1.9 billion of financing for the Hydrogen National Strategy was announced in the context of the France 2030 investment plan.

The Hydrogen National Strategy will be revised in June 2023, to encourage the decarbonisation of major industrial sites by promoting the mass-production of carbon-free hydrogen.

The Hydrogen Ordinance established:

- a new and clarified hydrogen taxonomy
- a public support scheme for the production of Renewable and Low-carbon Hydrogen by water electrolysis in the form of financial operating support or a mix of operating support and financial support for investment
- guarantees of origin to certify the renewable or low-carbon nature of hydrogen, and
- the framework within which the operators of the natural gas grid must operate in the event of the injection of renewable energy into these systems.

The Law n°2023-175 relating to the acceleration of the deployment of renewable energies, adopted on 10 March 2023, has simplified relevant administrative procedures to facilitate the delivery of carbon-free hydrogen projects in France.

According to a provisional agreement dated 19 June 2023, France may benefit from a flexibility mechanism which has achieved consensus under proposals for RED III. This would enable it to obtain a 20% reduction on the RFNBOs target if its national contribution to the EU renewable target is met and the share of hydrogen produced from fossil fuels is not more than 23% in 2030 and 20% in 2035 (Article 22b). Member States with a low-carbon energy mix, such as France, will benefit from this mechanism. As for transport, France may choose to invoke a 14.5% reduction in greenhouse gas intensity by 2030 rather than a 29% share of renewable energy within the final consumption of energy in the transport sector (Article 25).

Key regulatory reforms

The main areas of focus for regulatory reforms are electrolysis sector development, industrial decarbonisation, clean mobility development, R&D, skills development, hydrogen taxonomy, guarantees of origin, the use of the natural gas grid, and the public support scheme for green hydrogen.

Hydrogen Standard?

France is developing a hydrogen standard to be applied at the point of production to all production methods that meet the required emissions threshold.

Renewable hydrogen is defined as hydrogen:

- produced exclusively using renewable energy sources
- produced by electrolysis (which most production will be overwhelmingly – if not exclusively – in practice) or using another technology allowing direct recovery (such as pyrogasification or thermolysis of biomass, steam reforming of biogas), and
- where the production process does not emit per kilogram of hydrogen produced a quantity of CO2 emissions greater than or equal to a certain threshold (still to be defined pending the adoption of a specific decree).

Low-carbon hydrogen is defined as hydrogen where the production process generates emissions less than or equal to the same threshold, but which is not produced solely using renewable energy sources.

Meeting the standard is an eligibility requirement for projects and businesses seeking to benefit from the public support scheme.

Hydrogen imports and exports

France has not adopted specific regulations on the import or export of hydrogen. Upon adoption of the National Strategy for the development of carbon-free hydrogen, France has decided to invest in domestic hydrogen production, to ensure national energy sovereignty and reduce France's dependence on fossil fuel imports. However, thanks to this strategy, the Government believes that the French hydrogen industry could have capacity to export in the coming years.

Production

The Hydrogen National Strategy aims for 6.5GW of carbon-free hydrogen produced by water electrolysis by 2030.

The revised Hydrogen National Strategy is likely to promote competition within carbon-free hydrogen production between the major industrial platforms in France. According to the announcements made by the Government, measures will be adopted to support large electrolysers through long-term contracts with electricity suppliers and/or public support. For this purpose, an aid package of €4 billion will be allocated (in addition to the initial aid package of €9 billion).

The Hydrogen Ordinance established a public support scheme for the production of renewable and low-carbon hydrogen by water electrolysis in the form of financial operating support or a mix of operating support and financial support for investment. The Government is consulting on a draft implementing decree with certain public authorities. While the draft decree has not been made public, an opinion issued by the "*Commission de Régulation de l'Energie*" indicates that its provisions will define the competitive bidding procedure for the selection of hydrogen projects eligible for public support. The terms of the financial support will be specified in each call for tenders.

In the context of the Hydrogen IPCEI, among the 15 projects selected in France, 10 projects have been approved by the European Commission. A significant number of these projects focus on the mass production of carbon-free hydrogen. The projects also focus on: the decarbonisation of industrial sites through the use of carbon-free hydrogen, the construction of key equipment gigafactories (such as electrolysers, fuel cells and storage tanks) and R&D.

Storage and transport

A number of regulations and Government initiatives focus on storage and distribution.

The French law n°2021-1104 dated 22 August 2021 (the **Climate and Resilience Law**) establishes the framework for calls for tenders relating to the development of hydrogen storage (Article 85 of the Climate and Resilience Law).

The Climate and Resilience Law authorised the Government to make an ordinance relating to the regulation of the underground storage of hydrogen (Article 81 of the Climate and Resilience Law).

A call for tenders regarding technological building blocks and hydrogen demonstrators will allocate €350 million until 2023 for projects developing or improving the distribution of hydrogen.

In the context of the Hydrogen IPCEI, projects selected by France focus on the construction of gigafactories to produce key equipment for the storage and distribution of hydrogen, such as fuel cells and storage tanks.

The Hydrogen Ordinance provides a framework for the injection of hydrogen into the existing gas grid, and states that if hydrogen is injected within the existing gas grid, gas grid operators must implement the necessary measures to ensure the proper functioning and balancing of the grid, the continuity of the natural gas transmission and delivery service, and the safety of people and property (Article 2 of the Hydrogen Ordinance).

Sector specific measures

The Hydrogen National Strategy identifies several priorities:

Electrolysis

As previously mentioned, the Hydrogen National Strategy aims for France to reach 6.5GW of carbon-free hydrogen produced by water electrolysis by 2030. In this context, France wants to develop large capacity projects related to electrolysis technology in order to reach the industrial scale needed to achieve profitability.

As mentioned above, the public support scheme for the production of hydrogen will only be available for the production of hydrogen by water electrolysis, and several

projects selected by France in the context the Hydrogen IPCEI focus on the production of hydrogen through electrolysis and the construction of electrolyser gigafactories.

Industry

The Hydrogen National Strategy also aims to replace carbon-intensive hydrogen by renewable or low-carbon hydrogen in order to decarbonise certain industrial processes and products, in high carbon-emitting sectors such as steel, cement and petrochemicals. France supports several projects designed to decarbonise certain industrial sites through the Hydrogen IPCEI, such as an ArcelorMittal steel factory in Dunkerque or a Vicat cement site.

The revised Hydrogen National Strategy is likely to promote the decarbonisation of the French industry. The objective of the French Government is to support the implementation of “hydrogen hubs” for major French industrial platforms to mutualise the production of carbon-free hydrogen in large-scale production centres.

Mobility

The Hydrogen National Strategy made the development of clean mobility through the use of carbon-free hydrogen, in particular for heavy vehicles, one of its priorities. Hydrogen technologies also have the potential to provide an alternative to storage capacity in addition to electric batteries. Hydrogen has application in high engine power or long-distance vehicles, especially for captive fleets that travel long distances in light traffic flows, light commercial vehicles, lorries, buses, waste collection vehicles, and in regional or inter-regional trains in non-electrified areas of track.

The French Government believes that investing in this sector is essential because it is a very dynamic market, which needs alternative technological solutions that provide greater autonomy than batteries. It also represents a major economic opportunity with an estimated annual turnover of €100 billion, and supports 225,000 jobs in the automotive manufacturing and equipment supply sectors. The state mainly supports the sector through the Hydrogen IPCEI by selecting projects relating to fuel cells for mobility, hydrogen vehicles or hydrogen trains.

R&D and skills development

The Hydrogen National Plan identified R&D and skills development as one of its three main priorities. R&D is supported through the Hydrogen IPCEI but also through a strong public framework and, in particular, the priority research programme on hydrogen applications that promotes upstream research and prepares the next generation of hydrogen technologies (batteries, tanks and electrolysers) with a budget of €65 million. Skills development is also encouraged in order to support the development of hydrogen uses within French territory through the creation and conversion of jobs, as well as training courses.

GERMANY

Key developments in Germany in the last 12 months

- A recast of the National Hydrogen Strategy is under preparation and expected to be published in June/July 2023 (for further information, please see the section on Policy overview below).
- Germany rescinded its initial green hydrogen standard and replaced it by a framework standard that will be further specified in accordance with requirements of EU law (for further information, please see the section on Hydrogen standard below).
- During the hydrogen ramp-up phase, Germany will support the import of blue and turquoise hydrogen to account for the growing demand and limited domestic production capacity (for further information, please see the section on Hydrogen imports and exports below).
- BMWK published a bill on the planning and approval process for a hydrogen core grid to be operative by 31 December 2032 at the latest (for further information, please see the section on Key regulatory reforms below).

Policy overview

Initially, Germany aimed for 5GW of electrolyser capacity by 2030 as outlined in the National Hydrogen Strategy adopted by the Federal Government on 10 June 2020. Currently, the Federal Government is preparing to recast the National Hydrogen Strategy in June/July 2023 to raise the electrolyser capacity target to 10GW by 2030. However, none of these targets have legally binding effect.

Germany's hydrogen policy is, on one hand, based on the direct funding of research and specific projects and, on the other hand, shaping supportive market conditions by establishing a regulatory framework for hydrogen. A major part of the available funding (€8 billion) was

awarded to 62 IPCEI projects in Germany, covering the entire hydrogen value chain from production to transport and use of hydrogen. The European Commission approved 41 IPCEI hydrogen projects across the EU (the so called 'technology wave'), including four initial German projects, in July 2022. Further projects (the so called 'industry wave') were approved in the autumn of 2022. However, the industry has been critical of the pace of state aid approval, which delays project decisions significantly. With regards to market conditions, the legislative focus to date has been on reducing production costs of green hydrogen as well as implementing pure hydrogen network regulation. Recently, legislators have implemented an initial regulatory framework for the offshore production and transport of hydrogen, including offshore electrolysis and hydrogen pipelines.

Currently, an advisory group (H2 Compass) is identifying research and development needs, which will culminate in the Federal Government's roadmap for the further development of the German hydrogen market. Notably, the framework has so far focused on large-scale projects and companies, but recent developments, such as the H2 innovation funding programme founded by the Federal State of North Rhine-Westphalia, illustrate that small and medium enterprises are also able to participate in the transition to hydrogen.

Key regulatory reforms

Although the regulatory framework is still fragmented, several basic regulations are already in place: licensing of onshore and, since 1 January 2023, offshore hydrogen production installations, basic elements of a green hydrogen standard, partial exemption / reduction of electricity taxes for hydrogen production, and voluntary opt-in regulation for pure hydrogen grids covering unbundling rules, network access and high return on equity rates (9% for new assets, 7.73% for old assets). The overall framework will be revised in accordance with upcoming EU legislation. In May 2023, BMWK published a bill on the planning and approval process for a hydrogen core grid to be operative by 31 December 2032 at the latest. The purpose of the bill is to enable a fast ramp-up of the German hydrogen market. It will require gas TSOs to submit an application for a hydrogen core grid within three weeks after the law enters into force and requires the regulator to approve the application within two months if all statutory requirements are met. The hydrogen core grid will qualify for an opt-in within the existing hydrogen grid regulation.

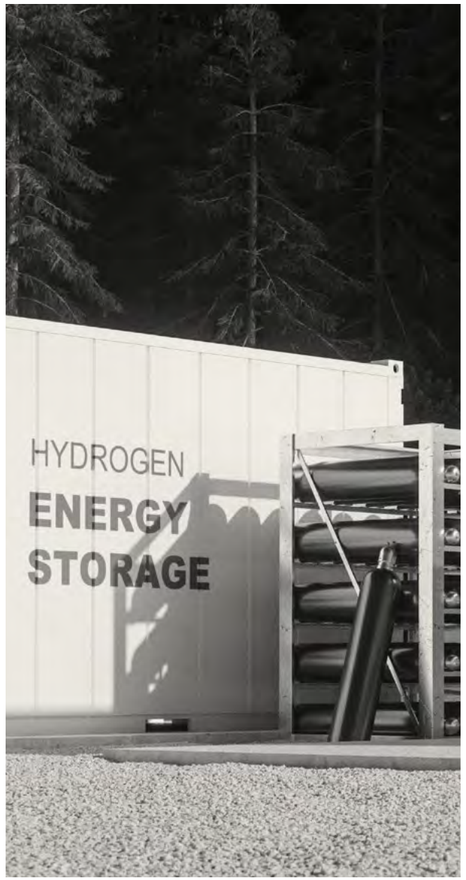
Further reforms are under discussion. However, both the level of ambition of the German targets and the speed of implementation has been criticised by the industry. Currently a CfD scheme to incentivise the carbon to hydrogen transition in industry is being prepared at the federal level. A green steel demand quota has also been discussed, but no specific legislative steps have been taken.

The recast of the National Hydrogen Strategy aims to further simplify and accelerate permit procedures and harmonise infrastructure planning and transport methods.

Hydrogen Standard?

After introducing a green hydrogen standard in 2021 for the purpose of exempting the production of green hydrogen from electricity taxation, the German legislator rescinded the standard with effect as of 31 December 2022.

Currently, the law only provides for a framework definition of green hydrogen, which requires that the hydrogen is produced in an electrochemical process, from solely non-funded renewable electricity. A new ordinance will provide further details on the new green hydrogen standard, aligned with the EU definition, once the EU standard has been adopted. The new ordinance is likely to regulate: (i) the start of the operation of the green HPF; (ii) the timeframe for the production of electricity and hydrogen; (iii) geographical requirements regarding the proximity of electricity and hydrogen production and any exceptions; (iv) alternative requirements for pilot periods; and (v) verification requirements.



Production

The regulatory framework for hydrogen production in Germany consists of permit requirements and operational support. Usually, a permit under emissions control law is required for the construction and operation of an onshore electrolyser. By contrast, offshore electrolysers require a planning approval. The allocation of offshore areas and funding for offshore hydrogen production follow separate award procedures.

Support in Germany is focused on green hydrogen by way of electrolysis. The German projects under the Hydrogen IPCEI alone aim to contribute more than 2GW to the overall capacity target of 10GW by 2030. An additional funding programme, known as Hydrogen Technologies 2030, aims to accelerate research activities regarding the mass manufacturing of electrolysers (H2Giga) as well as the offshore production of hydrogen (H2Mare).

Another project, H2 Global, provides funding of approximately €900 million for non-EU production projects importing hydrogen to Germany (Germany will not be able to meet its future hydrogen demand with domestic production alone). At least for an interim phase, these funds will also be available to offset the difference between the price of foreign production and the domestic sale price, each price being established based on an auction mechanism. The first of these contracts are expected in Q3 2023.

The production of green hydrogen is exempt from paying grid charges, electricity tax, and levies on the electricity price. However, for domestic production, there is currently no mitigation of offtake risks, such as an offtake obligation by grid operators at a guaranteed price, as this has been long standing practice since the ramp-up of electricity production from renewable energy sources.

Hydrogen imports and exports

According to an unofficial draft version of the recast National Hydrogen Strategy, Germany will – for an interim period – support the import of blue and turquoise hydrogen to account for the growing demand and limited domestic production capacity. Blue or turquoise hydrogen shall not exceed a threshold of 25g CO2 eq/MJ. By 2030, around 70% of overall hydrogen demand of 95 to 130 TWh is expected to be imported. The Federal Government is in the process of setting up a separate hydrogen import strategy, which is expected to address (amongst other things) supply via European pipelines, a diverse international supply structure and certification standards.

In addition, the Government concluded bilateral agreements on hydrogen cooperation, such as the treaty with Norway in March 2023 setting up a commission to assess the need for

additional transport infrastructure and the Canada-Germany hydrogen alliance of August 2022 set to start supply of Canadian hydrogen in 2025.

Storage and transport

The unofficial draft of the recast National Hydrogen Strategy aims to have a hydrogen starter network of 1,700 km by 2027. The German natural gas transmission system operators, however, forecast the need for 3,000 km by 2027 and 7,600 to 8,500 km by 3032. Part of the funded IPCEI projects also cover the establishment of a pure hydrogen grid infrastructure of approximately 1,200 km. A separate paper on fast and cost efficient H2 infrastructure development also integrating the ongoing IPCEI projects shall be published during summer of 2023. In addition, the German Government is funding research activities that explore hydrogen transport with a view to import conditions. The related project, TransHyDE, focuses on hydrogen transport in high-pressure vessels, in existing gas pipelines, bound in ammonia, and by means of liquid organic hydrogen carriers.

Sector specific measures

Within the industry sector, 16 of the German projects under the Hydrogen IPCEI focus on low carbon steel production or hydrogen transformation in the chemical industry. In addition, the funding programme Decarbonisation of the Industry, which started in January 2021, incentivises the transition to green hydrogen. Another funding programme for climate protection contracts incentivises low greenhouse gas processes based on the concept of CfDs and auction procedures are planned to start in 2023. The CfD scheme will have a particular focus on the steel industry but will also be available for the cement and glass industries to balance the additional cost of climate friendly production methods.

In addition, the introduction of a demand quota for green steel is also being discussed. The Federal Government's import strategy will also have to address how to source the demand that is created by these sector transitions.

Interestingly, the German Government began funding research activities for fuel cell technology as early as 2006. In addition to multiple smaller initiatives, 12 projects under the Hydrogen IPCEI focus on developing fuel cell technology, hydrogen vehicles and hydrogen refuelling stations. The funding focuses on areas where electrification is not a viable option (such as bus, train, air, sea and heavy transport). Besides direct funding, further market incentives can be expected as a result of the EU greenhouse gas reduction ratio for renewable transport fuels. Germany has set a target of 25% by 2030, exceeding the requirement under RED II.

In contrast to the chemical industry, the steel industry and certain areas of the transport sector, the German Government only sees limited potential for the use of hydrogen in the heating market.

ITALY

Key developments in Italy in the last 12 months

- The adoption of law decree no. 13/2023 providing a fast-track process for all green hydrogen production projects (for further information, please see the section on Key regulatory reforms below).
- The award of public grants for railway sector covering the production, transport and storage of green hydrogen as well as the construction of refuelling stations and the procurement of trains (for further information, please see the section on Rail below).
- The allocation of public grants for the hydrogen valleys (for further information, please see the section on Hydrogen valleys below).

Policy overview

In 2021, the Italian Ministry of Economic Development issued the Preliminary Guidelines, which establish a primary role for hydrogen by calling for a "growth in the energy mix from the current <2% to 13–14% by 2050, with an estimated underlying electrolysis capacity of [500GW]" at the European level. This is because "hydrogen is in an exclusive position to contribute to national environmental objectives [...] especially if produced from renewable energy sources through electrolysis". As stated in the Preliminary Guidelines, a detailed Italian hydrogen strategy was expected to be published in 2021; however, it is still under discussion and has not yet been published.

Italy is aiming for 5GW of low carbon hydrogen capacity by 2030 as outlined in the Preliminary Guidelines. Italy plans to support a variety of production methods, including green and blue hydrogen. There is currently no definitive policy goal beyond 2030. However, the Preliminary Guidelines suggest that Italy could require up to 20% of overall energy demand to be met by hydrogen in 2050, and forecast that the long-term Italian strategy, once approved, will also set the Italian targets for 2050.

Key regulatory reforms

The legislative decree no. 199/2021 simplified the authorisation process for the construction and operation of electrolysers for hydrogen production. In addition, two key reforms have been made in relation to:

1. technical norms (such as production safety, transport, and storage of hydrogen): the Italian Government has adopted an initial set of standards that promote the development of infrastructure for the production and transportation of hydrogen. In particular, law decree n. 13/2023, as converted into law n. 41/2023, implemented Mission 2 of the IRRP, providing a fast track process for all green hydrogen production projects, which will now be prioritised from an environmental perspective by the competent national authorities. In addition, it established the Central Committee for Technical Safety of Energy Transition as an advisory body for technical safety issues with respect to hydrogen plants.
2. measures to incentivise production and consumption: in September 2022 the Minister of Environment and Energy Security established the eligibility criteria for incentives relating to the production of electrolytic green hydrogen.

Furthermore, the Government has already expressed its intention to promote hydrogen as part of the proposal to the EU Commission for the first update of the Italian National Energy and Climate Plan to be submitted by 30 June 2023 pursuant to Article 14 of EU Regulation 2018/1999.

Hydrogen Standard?

Italy has not (yet) formulated its own standard but is in favour of regulating this at the EU (or even international) level.

Production

According to the Preliminary Guidelines, to implement the low-carbon hydrogen strategy in Italy and to meet the hydrogen demand target, it is estimated that up to €10 billion of investment will be required between 2020 and 2030 (net of the investments in renewable projects). This amount includes a specific allocation for hydrogen production investments of around €5-7 billion. Additional resources will also be allocated to hydrogen research (€1 billion).

The Italian National Energy and Climate Plan also provides for the promotion of the production and use of hydrogen generated from renewable electricity. At the time of writing, support is available under the IRRP, which allocates – among the €23 billion funding to promote and develop the green transition – a dedicated amount to support hydrogen production. In particular, the IRRP allocates:

- €500 million for the redevelopment of brownfield sites for the production of hydrogen to be used for local transportation and industry; and

- €450 million for the start-up of a large industrial plant for the production of electrolysers with approximately 1GW of electrolysis capacity by 2026 and the development of further technologies needed to support hydrogen end-use (e.g. fuel cells for trucks).

In addition to the above, the IRRP supports research and promotes all necessary legislative reforms to facilitate the production (as well as use, transport, and distribution) of hydrogen with a dedicated amount of €160 million.

Hydrogen imports and exports

Regarding hydrogen imports and exports, Italy could play a central role due to its strategic geographical position. The network of connections with Africa, also through existing pipelines, allows Italy to be the European infrastructure hub for the importation and, consequently, the exportation of hydrogen to European countries. However, there is currently no specific legislative framework regulating the importation and exportation of hydrogen in Italy. Industry experts are nevertheless flagging a need to implement specific legislation, including providing specific measures for importation via sea.

Storage and transport

According to the Preliminary Guidelines, investments in hydrogen distribution and consumption facilities are expected to be around €2 to 3 billion. To date, the IRRP provides for:

- a €300 million investment in the railway sector, which encompasses the development of high-pressure electrolysers as well as high-capacity storage systems with the possibility of using metal hydrides or liquids; and
- a €160 million investment to improve knowledge of hydrogen-related technology for production, storage and distribution in order to increase competition and to gradually reduce costs.

Sector specific measures

Pending approval of a detailed hydrogen strategy, the Preliminary Guidelines identify sectors where green hydrogen is expected to become competitive in the short term, such as transport (in particular, trucks), rail and industry (specifically where hydrogen is already used as a raw material, e.g. in the chemical and oil refining sectors). Support for specific sectors is currently available under the IRRP as set out below.

Transportation

The IRRP allocates €230 million to increase the use of hydrogen in road transport, promoting the creation of truck and car hydrogen re-fuelling stations, reaching at least 5-7% of the internal market by 2030. The development of 36 refuelling stations is expected by 2026, giving priority to strategic areas for heavy goods vehicles (e.g. along highways, close to ports and near logistics terminals). In March 2023, the Ministry of Infrastructure and Transport published a list of 36 projects awarded public grants for the construction of hydrogen refuelling stations. These will supplement two hydrogen vehicle refuelling stations currently existing in Italy.

The new EU Alternative Fuels Infrastructure Regulation, agreed in March 2023, further increases this ambition and provides that Italy will develop approximately 70 hydrogen refuelling stations by 2030 (half of which will be supported by the IRRP) in order to implement hydrogen refuelling infrastructure, serving both cars and trucks, in key city junctions and every 200 km.

The IRRP also allocates €3.6 billion to reduce private car use by at least 10% in favour of public transport by building 231km of new subway, tramway, trolleybus (*filovie*) and funicular networks. To accomplish this, hydrogen-powered public transport will be promoted.

Rail

The IRRP allocates €300 million for the conversion to hydrogen of non-electrified railway lines in regions characterised by high passenger traffic with high usage of diesel trains. The most advanced projects envisage this being done in an integrated manner including the production and distribution of hydrogen and the procurement of hydrogen trains. This investment covers the entire value chain: from production of the green hydrogen, its transport and storage, to the construction of refuelling stations and the procurement of trains. 10 hydrogen rail-refuelling stations are to be completed by 30 June 2026.

In March 2023, the Ministry of Infrastructure and Transport awarded:

- €276 million for the construction of renewable hydrogen production, storage and refuelling facilities; and
- €24 million for the acquisition of hydrogen trains.

The beneficiaries include several Italian regions and the operators managing railway infrastructure.

Hard-to-abate sectors

The IRRP allocates €2 billion for the transition towards zero emission green hydrogen in industries that are energy-intensive and hard-to-abate, such as steel mills and petroleum refining, as well as the chemical, concrete, glass and paper sectors. The grants will be allocated to a range of innovative projects selected by the Minister of Environment and Energy Security through a tender process.

In March 2023, applications opened for project proposals for hydrogen production in certain eligible, hard-to-abate sectors eligible for €1 billion in grants, split as follows:

- €450 million for the financing of industrial research and experimental development research projects for the use of low-carbon hydrogen, including projects related to storage systems; and
- €550 million for the financing of investment projects for using low-carbon hydrogen in industrial processes (e.g. projects aimed to replace methane or fossil fuels in industrial processes through the low-carbon hydrogen).

Hydrogen valleys

The IRRP allocates €500 million for the redevelopment of brownfield sites for the production of hydrogen to be used for local transportation and industry:

- €450 million is earmarked for the regional implementation of projects intended to achieve targets related to the investment; and
- €50 million is earmarked for the so-called 'Flag Projects' (*Progetti bandiera*).

In this regard, the IRRP aims to create 10 hydrogen valleys (industrial areas where the economy is based partly on hydrogen) in order to promote, at the local level, the production and use of hydrogen in industry and transport. To minimise costs in the first phase, brownfield sites already connected to the electrical grid will be used to install electrolysers for hydrogen production using excess renewable electricity or dedicated renewable electricity production in the area.

All 20 Italian regions have awarded their lists of eligible projects grant funding from the IRRP to support the production of renewable hydrogen in brownfield sites, completing the tender process started by the Minister of Environment and Energy Security in January 2022.

In April 2023, the EU Commission approved Italy's €450 million programme to support the production of renewable hydrogen on brownfield sites, in accordance with the EU Green Deal. The IRRP funds will be provided in the form of direct grants to finance investment costs; with a maximum amount of aid per project set at €20 million. The EU Commission has stated that the amount of the grant will be determined through an open, fair, transparent, and non-discriminatory tender process.

THE NETHERLANDS

Key developments in the Netherlands in the last 12 months

- Hydrogen infrastructure has moved to the top of the agenda – important decisions as to where and how have been taken (for further information, please see the section on Storage and transport below).
- Clear policy decisions have been made for intensifying offshore hydrogen production (Wadden Islands) and the formal decision-making process has started (for further information, please see the section on Production below).
- By publishing the National Programme for Sustainable Industry, the Dutch Government has made clear decisions for the long-term stimulation of hydrogen.
- Memoranda of Understanding have been signed to stimulate co-operation and import/export facilities with a number of countries both inside and outside of the EU (for further information, please see the section on Hydrogen imports and exports below).

Policy overview

The Dutch Government's Hydrogen Strategy (March 2020 and updated in December 2022 and Spring 2023) aims to scale up electrolysis to approximately 500MW by 2025, 4GW by 2030, and 8GW by 2032. As a result of cross-sector cooperation, the NWP 2022 to 2025 has been developed which provides further detail. The NWP forms part of the National Climate Agreement. For blue hydrogen, the NWP aims for 1.5-1.8Mt of production by 2030. Hydrogen is seen as indispensable amongst the gas energy carriers that will be needed to provide at least 30% of Dutch energy consumption in order to achieve a climate-neutral energy supply and economy by 2050. In 2023, the Government expects to subsidise around 1GW of electrolysis capacity.

Key regulatory reforms

A number of general reforms will have implications for the hydrogen market in the Netherlands:

- on 1 January 2024, the Dutch Environment and Planning Act (*Omgevingswet*) will enter into force, and
- a draft Energy Act was submitted to Parliament in June 2023. The proposal aims to replace the current Gas Act and Electricity Act 1998, implement new European regulations and directives on gas and electricity, and give substance to agreements made in the Climate Accord of 2019. Hydrogen has not yet been integrated in the draft. However, due to the gas and electricity reforms at the EU level, in which hydrogen is taken into account, the Energy Act tries to reform the gas market to be as policy-neutral as possible. Further amendment of the Energy Act may be necessary in the future. The draft Energy Act, however, already facilitates the injection of other gases (such as biogas and hydrogen) into the gas system and clarifies which activities may be performed in the context of ancillary activities with other energy carriers.

In relation to hydrogen specifically:

- in autumn 2022 two *hydrogen safety guidelines* for the built environment were published on behalf of the Ministry of Economic Affairs. These guidelines should provide interpretation and frameworks in situations where the current legal regime is lacking or insufficient. There is a *generic guideline* for dealing with hydrogen safety risks in the energy transition and an *additional safety guideline* for the four hydrogen pilots for heating homes in the built environment
- as a consequence of RED III the Government has announced it will develop a support scheme aimed at the use of hydrogen in transport (including heavy vehicles), and
- a number of other reforms are under consideration but have not yet been enacted including in relation to taxation, a blending obligation for aviation (by making use of hydrogen), market regulation and further implementation of RED II and III and its delegated acts.

Hydrogen Standard?

In relation to the definition of what constitutes renewable hydrogen in the EU, the Netherlands is in favour of the proposed standard for renewable hydrogen as is stipulated in the delegated acts under RED. The Government has announced that until 2030, the focus will be on hydrogen production from additional renewable resources. The Netherlands is, however, also in favour of EU standards for low carbon hydrogen using other production methods, such as from nuclear energy, separate from and complementary to the agreement on renewable hydrogen in the RED. The Netherlands is of the opinion that after renewable hydrogen, low-carbon hydrogen can make an important contribution to making energy-intensive industries more sustainable and should therefore also be stimulated.

The Netherlands is also considering the question of the quality of hydrogen produced. A public consultation was held on hydrogen quality (minimum hydrogen purity of 98 mol%), in which both the EU and the German proposals were considered. The Dutch Government will, in the short-term, set national criteria so that the hydrogen market can take off and the infrastructure can be developed and commissioned. In the longer term, the Dutch Government is in favour of an integrated hydrogen market and therefore is expected to adopt uniform national hydrogen quality criteria.

Under the Dutch support schemes, such as SDE++, green hydrogen production is eligible subject to certain conditions including that the hydrogen is produced by a plant that produces hydrogen by electrolysis with a nominal capacity of at least 500 kW, and has a connection to the electricity grid or has a direct connection to an installation that produces renewable electricity (wind or solar). For transition purposes, blue hydrogen (using CCS) is also eligible under SDE++.

Production

Hydrogen production in the Netherlands is focused on green and blue hydrogen, using large-scale electrolysers linked to wind or solar energy facilities, on land and offshore, or using production plants with CCS in the coastal regions. In December 2022, the Government announced that the Netherlands is on track to achieve its ambition of 500MW of domestic electrolysis capacity by 2025. In 2023, the Government expects to subsidise around 1GW of electrolysis capacity. Currently, the Netherlands has 2MW of electrolyser capacity but by 2025 is aiming to develop 50 - 100MW of electrolysis capacity with a reserved budget of €250 million.

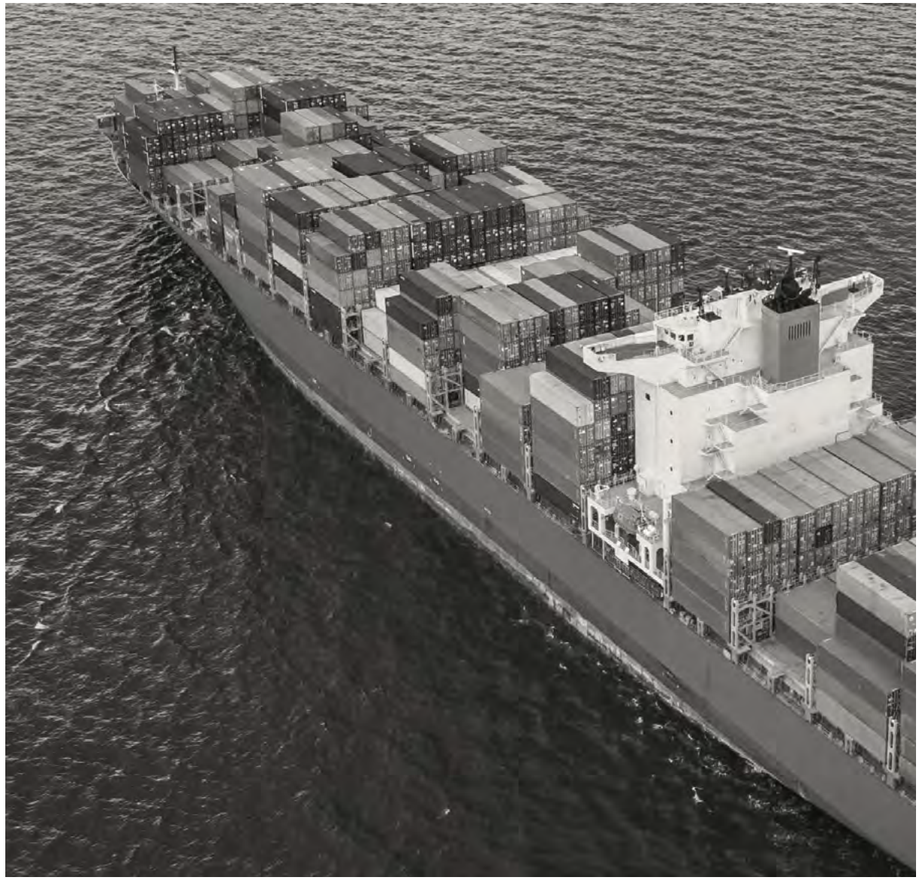
The Government's priority continues to be to reduce the production costs of clean hydrogen by upscaling production plants in so-called 'regional hydrogen clusters' (Port of Rotterdam area, Zeeland/Flanders and in the North of the Netherlands). Different support schemes are being introduced to facilitate this development such as GroenvermogenNL (> 100MW electrolysers), SDE++ and the temporary scaling-up support scheme for green hydrogen via electrolyser (< 50MW electrolysers), and the IPCEI. In addition, the Climate Fund sets aside €15 billion for scaling up renewable energy carriers, including hydrogen, on the basis of the Temporary Law on Climate Fund which has been submitted to Parliament. In May 2023, the Government started a public consultation on a new temporary support scheme under the EU Temporary Crisis and Transition Framework to support the building of new production lines and/or plant environments for hydrogen electrolysis production (or components thereof).

As for green hydrogen produced through electrolysis, the Government decided that the production of hydrogen and operation of electrolyser facilities should be reserved for private/commercial market parties and should not be open to transmission and distribution system operators (TSOs and DSOs) (unless

only temporarily and if necessary). Precise locations of electrolysers have been chosen by the Government in close consultation with the industry. Key factors in determining the location are the proximity to gas infrastructure, space for the electrolysers and the space for and capacity of electricity infrastructure.

Offshore hydrogen production is an important part of the hydrogen production strategy. By 2030 pilot projects using electrolysis at sea will be developed to gain experience with a view to scaling up after 2030. The intention is to have around 500MW of electrolysis capacity operational in the wind energy area north of the Wadden Islands by 2031. In addition, required offshore hydrogen infrastructure is being mapped including landfall locations. Scaling up depends on several preconditions, including the availability of renewable electricity (especially offshore), hydrogen infrastructure (such as a national transmission grid and import terminals), certification and safety aspects.

Stimulating the production of blue hydrogen (e.g. the Porthos Project in the Port of Rotterdam area) will contribute to the emissions reductions needed by 2030 and also support the accelerated development of green hydrogen.



The SDE++ support scheme, with a total budget for 2023 of €8 billion, provides operating support for hydrogen production projects in the Netherlands.

Overview of the SDE ++	SDE++ support scheme subsidizes the 'unprofitable component' in order to render a technology competitive. The 'unprofitable component' is the difference between the 'base rate' and the market value of the output generated by the technology in question (the 'corrective amount'). The base rate is fixed for the entire subsidy period but the corrective amount is set annually. The base rate differs per technology and is calculated by Netherlands Environmental Assessment Agency (Planbureau voor de Leefomgeving, PBL), commissioned by the Ministry of Economic Affairs. The base rate is the cost price of the technology: the calculation is based on a reference installation where the majority of projects are profitable. The unprofitable component decreases when the market value rises, reducing the amount of the subsidy received. Subsidies are granted for periods of 12 or 15 years. The duration of the subsidy depends on the technology used (see below).	
	New build	**Retro-fit**
Electrolytic H_2	As of 2020: supported a minimum of 0.5MW hydrogen production capacity Subsidy period: 15 years Electrolysis directly linked to the grid or to wind / solar (green hydrogen)	Not applicable.
H_2 production using CCS	As of 2022 the capture of CO2 emissions originating from the production of hydrogen from industrial waste gases is eligible for subsidy (both new-build and retrofit). Subsidy period: 15 years	

Apart from support schemes, the fiscal aspects of hydrogen are important to facilitate further development. Tax reliefs are available to companies for the purchase of, or investment in, hydrogen-powered vehicles, small scale production of hydrogen (for own use), equipment for hydrogen transport, and equipment for the electrification of processes in the chemical industry.

Currently, an energy tax has been levied on the electricity and mineral resources necessary for hydrogen production but not on hydrogen itself. Clarity on future taxation is, however, important for business cases (e.g. double taxation of resource and end product should be avoided).

Hydrogen imports and exports

Import targets have been set in the Netherlands: by 2025 0.1 – 0.2Mt and by 2035: 1.5 – 3Mt H2 equivalent. In March 2023, the Netherlands reached agreement with Germany to take part in H2Global as well as to start developing a common vision on hydrogen import policies, to work together more closely on hydrogen infrastructure, such as a synchronised coupling of both hydrogen grids, and co-operation in cross-border hydrogen corridors. The first two interconnections are expected to be ready by 2027. The Netherlands is aiming to be a hydrogen hub by making use of its favourable location, ports, extensive gas grid and storage capacities.

Currently, two import terminals are being developed (Rotterdam and Noordzeekanaalgebied). The Netherlands is also in favour of the European Commission's Hydrogen Bank initiative. Memoranda of Understanding with several countries inside and outside Europe are being concluded to safeguard its import opportunities. Example countries include Australia, Oman, Canada, Chili, Namibia, Portugal, Spain, Uruguay and the United Arab Emirates. The focus is mostly on green hydrogen.

Storage and transport

The aim of 4GW of electrolysis requires hydrogen storage of approximately 3-5 caverns according to the NWP. The ambition is to develop four sites before 2030 (the first already in 2026) with a budget of €35 million set aside for this purpose. The procedures to create these new caverns for hydrogen storage are pending. Six existing caverns, currently in use for natural gas storage, will also be repurposed to allow them to also be used for hydrogen storage. HyStock, a subsidiary of Gasunie, has been appointed as the operator of the hydrogen storage caverns. The possibility of hydrogen storage in depleted gas fields also needs to be researched further.

The Government has also appointed HNS, a wholly-owned subsidiary of Gasunie, as the developer of hydrogen infrastructure, consisting of a national hydrogen backbone and of regional industrial networks. The infrastructure will become available in three phases and will be completed by 2030, utilising repurposed natural gas infrastructure as well as new-build infrastructure. The hydrogen network will connect five industrial clusters to each other, to neighbouring countries and to hydrogen storage and import locations. HNS has concluded several Expressions of Interest with industry partners. The Government has, however, declared that it will proactively be building infrastructure as it believes that supply (in this case of energy infrastructure) will create its own demand since it will give the industry clusters a major competitive advantage to attract new business. Preparations for the national hydrogen backbone have started and a budget of €750 million has been reserved in 2022. Furthermore, the Temporary Law on Climate fund (*Tijdelijke Wet Klimaatfonds*) which was submitted to Parliament, allocates approximately €4 billion of additional funding for energy infrastructure, including hydrogen infrastructure.

Sector specific measures

The NWP contains a detailed gaps analysis of RED III (as described in the section on Policy overview above) with specific goals per sector. The EU targets agreed under RED III will need to be implemented nationally and may not yet be reflected below.

Ports and industrial clusters

The Government is in favour of the sector-specific RFNBO targets under RED III as they are a necessary instrument to ensure that parties in the Netherlands make efforts to achieve this goal. Implementation of targets for industry by January 2026 is under consideration. In addition, the Government sees an important role for subsidies to kickstart the market and to prevent industrial activity and emissions from relocating.

Currently industry uses about 0.8Mt/year of hydrogen which is estimated to increase to approximately 2.5 kilotonnes by 2030. In the short term (by 2025), the first uses for 'low carbon' hydrogen are in ammonia production, methanol production, petrochemicals, refining and steelmaking furnaces. In the longer term, ports and industrial clusters will accelerate their efforts in developing blue hydrogen by means of studies, business cases and investments, with grey hydrogen being replaced by blue hydrogen. Most of these projects will be local either producing hydrogen by capturing CO2 emissions from existing hydrogen production within the five industrial clusters (as showcased by the Porthos Project and H-Vision in the Port of Rotterdam) or by accelerating offshore wind energy production and new build electrolysers to produce green hydrogen. The availability of a hydrogen infrastructure in the near future, however, will be key for hydrogen to become a success.

Power

The aim is to convert natural gas plants into hydrogen plants to provide sustainable, flexible generating capacity. Currently the technology necessary for hydrogen fired-generation is being developed but should be commercialised before 2030. Scaling up demonstration projects is feasible. If the supply of zero-carbon hydrogen can be scaled up in time, this would help achieve CO2 reductions in the electricity sector in the long term. At a local and regional level, initiatives are currently being undertaken to combine local generation with the production, use and storage of hydrogen. Important factors for successful scale up include the availability of CO2-neutral hydrogen and a sufficient hydrogen network.

Transport

On the basis of the NWP, the Netherlands has the ambition to deploy 50 refuelling stations, 15,000 fuel cell vehicles and 3,000 heavy-duty vehicles by 2025, which is expected to increase the number of fuel cell vehicles to 300,000 by 2030. For aviation, the Netherlands is firmly committed to a European blending obligation and will even pursue a national obligation as of 2023 if progress is delayed at the European level. The negotiated (draft) Sustainable Aviation Agreement with the sector included a commitment to reach 14% blending of sustainable fuels by 2030 and 100% by 2050. This consists largely of synthetic fuels requiring the sufficient availability of (blue or green) hydrogen.

Built environment

Unlike the UK, where large-scale projects such as the H21 project have started, the Netherlands has started four smaller scale pilot projects in the 2020-2025 period (in Lochem (12 homes by the start of 2022),

Wagenborgen (50 to 60 homes by the start 2023), Stad aan't Haringvliet (600 homes by the start of 2023) and Hoogeveen (200 homes: existing and newly built by the start of 2025)). In this period, the main focus will be on researching how hydrogen can be an alternative for natural gas. In the period 2025-2030, more and larger-scale projects will follow, taking into account the lessons learned from, for example, H21, and the projects targeted up to 2025. After 2030 application at a larger scale is foreseen. Safety Guidelines have been issued for these pilot projects. During this first period, hydrogen will be added to the guidelines for municipalities on sustainability and the phasing out of natural gas in the built environment. An amendment of the current Gas Act and Environmental Act is necessary for the phasing out of natural gas, with an online consultation held on this subject at the end of 2021/beginning of 2022. In anticipation of new legislation, the Netherlands Authority for Consumers and Markets (**ACM**) has drafted a Temporary Framework for Hydrogen Pilots on the basis of which the regulator takes a tolerance decision per pilot project. Conditions set by the ACM include that households may decide for themselves whether to participate in a pilot project, there should be clarity on the costs for households, there should be no difference for consumers between heating with hydrogen or natural gas, and there should always be a sufficient supply of hydrogen.

Agricultural sector

As part of the Hydrogen Strategy and support schemes, pilot projects using hydrogen have started in the agricultural sector. However, no concrete targets are specified in the NWP. Since many farms are already generating sustainable energy from solar, wind and biomass sources, this locally produced energy can also be used for hydrogen production for use in heavy transport, such as tractors and other agricultural equipment, and in trucks in the agro-logistics sector.

PORTUGAL

Key developments in Portugal in the last 12 months

- The launch of the first hydrogen supply auction, which is expected to begin by June 2023 (for further information, please see the section on Storage and transport below).
- The implementation of legislative measures applicable to licensing procedures for hydrogen production projects (for further information, please see the section on Key regulatory reforms below).

Policy overview

The Portuguese Government's current macro policy for the energy and gas sectors is set out in the National Plan for Energy and Climate 2020-2030 (**PNEC 2030**). The PNEC 2030 is designed with the goal of achieving carbon neutrality by 2050. Decree-Law 84/2022, of 9 December, has also set targets for the consumption of energy from renewable sources (including green hydrogen), in line with RED II.

Aligned with the PNEC 2030, the Portuguese Government approved the PT H2 Plan. According to the PT H2 Plan, by 2030 Portugal expects to achieve the following goals:

- 10% to 15% injection of green hydrogen into natural gas networks
- 2% to 5% of green hydrogen in the industrial sector's energy consumption
- 1% to 5% of green hydrogen in the road transport sector's energy consumption
- 3% to 5% green hydrogen in the national shipping sector's energy consumption
- 1.5% to 2% of green hydrogen in the energy final consumption
- 2GW to 2.5GW of installed capacity in electrolysers, and
- Setting up 50 to 100 hydrogen refuelling stations.

Key regulatory reforms

Reforms are mainly underway through Decree-Law 62/2020, of 28 August, which approved a new legal framework applicable to the gas sector allowing for the production and grid blending of renewable gases, and established the Regulation on the Natural Gas Distribution Grid issued by the Portuguese Energy Services Regulator (**ERSE**).

The main areas of focus for reform are:

- the regulatory framework for green hydrogen production
- hydrogen blending into the gas grid
- the obligation on suppliers to incorporate green hydrogen in their supplies
- the extension of guarantees of origin to renewable gases, including green hydrogen, and
- the streamlining and simplification of licensing procedures applicable to hydrogen production projects as well as the establishment of projects exempted from such licencing procedures (particularly with regard to construction and environmental licensing procedures).

Hydrogen Standard?

Portugal is not developing its own standard and will use the EU standard. However, while the EU standard is still pending, the Portuguese authorities have outlined requirements to be met by sponsors of hydrogen production facilities in order to apply for public incentives under the Scheme of Incentives to Support the Production of Green Hydrogen and other Renewable Gases. These include that the project demonstrates it does “no significant harm”.

Production

The PT H2 Plan sets forth various national funding instruments applicable to production projects, amongst others. In particular, the PT H2 Plan foresees incentive measures such as:

- an initial, partial or total exemption for hydrogen projects from payment of the tariff for hydrogen projects to access the distribution or transmission gas grids
- operating support aimed at funding the difference between the energy source which will be replaced – natural gas – and the initial production cost of the hydrogen via a variable premium on the price of natural gas to match the price of green hydrogen, so that the additional cost of green hydrogen production is not reflected in the price paid by users
- implementation of a tax benefit mechanism or positive discrimination regarding the tax treatment of hydrogen production operators, and
- guarantees of origin in the hydrogen sector.

The Portuguese Government is in the midst of implementing measures in relation to grants or incentives for hydrogen production. The PRRP approved by the European Commission provides for investment of €185 million into the hydrogen and renewable gas sector available to various projects, including projects for the production of green hydrogen using electrolysis. Notices of any invitation to tender must comply with the rules set out in Regulation (EU) 2021/241 of the European Parliament and the Council of 12 February 2021 establishing the Recovery and Resilience Facility and are being published on the Portuguese Environmental Fund (Fundo Ambiental)’s website.

Aside from funding, from a regulatory framework perspective, the Portuguese Government is focusing on simplifying the licensing procedures of green hydrogen production projects, for example, by simplifying and exempting projects from environmental and construction licensing requirements.

In terms of guarantees of origin in the hydrogen sector, the applicable legal framework is now regulated in Decree-Law 84/2022, 9 December

Hydrogen imports and exports

At this stage, there are no concrete goals for hydrogen imports set by the Portuguese Government for the national consumption of green hydrogen. It is, however, the aim of the Portuguese Government for Portugal to become a green hydrogen import hub for the subsequent export and supply of Europe by land and sea. Alongside these aims, although the focus is primarily on internal consumption, the Portuguese Government is also aiming for the export of national production and currently expects for the country to start exporting hydrogen by 2026.

Storage and transport

The following indicative targets for blending hydrogen into the gas distribution grids are set out in the PT H2 Plan:

- 2025: 1% - 5%
- 2030: 10% - 15%
- 2040: 40% - 50%
- 2050: 75% - 80%

In order to try to achieve these goals, the PT H2 Plan includes a tentative plan for auctions of production rights to be held to inject hydrogen into the existing gas grids. The amount of hydrogen to be auctioned is set so that the share of hydrogen in the gas grids grows steadily until it reaches the 15% target in 2030.

In line with the promotion of renewable gas production, the first hydrogen supply auction is set to be launched by the Portuguese Government during the second semester of 2023. According to Ministerial Order no. 15/2023, of 4 January, the auction will entail the acquisition of green hydrogen by the Wholesale Last Resort Supplier from producers for injection into the national gas grids. However, it is currently not expected to include the granting of grid access rights. Producers will be allowed to auction a total quantity of up to 120GWh/year with a base price of €127/MWh. The hydrogen will be acquired via contracts with a 10-year term, which provide that the associated guarantees of origin must be delivered together with the hydrogen and the costs resulting from the grid access tariffs due to supply injection into the grid will be borne by the Wholesale Last Resort Supplier.

On 19 January 2022 ERSE approved the new Gas Distribution Grids' Regulation, which authorises and regulates the operation of gas grids using 100% natural gas or 100% gas of renewable origin and low carbon content, such as biomethane or hydrogen. A maximum share of hydrogen content in the national gas distribution grid of 20% by volume is permissible, although this limit may alter depending on the place of consumption or the group of users.

In March 2023, the first injection of green hydrogen into the Portuguese gas grids took place on a trial basis. This pilot project currently entails a blend of 2% of hydrogen with natural gas, used to supply 82 end-consumers, including commercial, residential and industrial consumers.

Sector specific measures

The PT H2 Plan identifies many specific targets and measures to be implemented by 2030 in sectors such as industry, transport and water.

Industry

The PT H2 Plan establishes a target of 2 - 5% of green hydrogen in the industrial sector's energy consumption by 2030. To achieve this, the PT H2 Plan sets out measures to regulate the installation of hydrogen production, storage and supply in industrial installations, and to implement industrial scale pilot projects for the introduction of hydrogen in the various industry sub-sectors (such as refining, chemicals, metallurgy, cement and glass).

The PT H2 Plan also aims to use hydrogen to decarbonise an industry sub-sector representing a strategic opportunity for Portugal, which will be selected on the basis of its importance in the national economy and its impact in terms of greenhouse gases emission reductions. For example, were the chemical industry to be selected, this would allow Portugal to become a leading country in green ammonia production, and to substitute imports with national production.

Currently, there are hydrogen projects being developed by private players aimed at decarbonising their industrial operations. For example, the H2Enable Project entails green hydrogen production for the decarbonisation of a chemicals plant as well as for injection into the gas grids. This project has been awarded the status of an IPCEI and is estimated to require investment of €142 million.

The Sines Project

The PT H2 Plan envisages the implementation of the Sines Project, an industrial-scale project under development for the production of green hydrogen, which is expected to have a total electrolyser capacity of at least 1GW by 2030. The objective is for the project to be a green hydrogen hub for national consumption and, ultimately, hydrogen exports. It is also envisaged that the project will include a manufacturing facility for the production of electrolysers, which, in the first phase, will meet demand generated by this project, and in the second phase will supply equipment for other national and international projects. There are several hydrogen projects currently envisaged to be implemented by various players in the Sines Industrial Logistic Zone amounting to an investment of approximately €5,382 million in total.

Transport

The PT H2 Plan establishes a target of 1 - 5% of green hydrogen in the transport sector's energy consumption by 2030, with the aim of decarbonizing the transport sector, in particular, road transport (heavy freight, urban logistics and passenger vehicles).

Various measures are set out to achieve this, such as regulation for the roll-out of hydrogen vehicle refuelling stations, green hydrogen supply infrastructure, and the procurement of hydrogen-powered vehicles by the public sector and public transport companies, among others.

Water

The PT H2 Plan also promotes the implementation of measures to encourage synergies between the water and energy sectors, in order to incorporate the use of both domestic and industrial wastewater in green hydrogen production. This solution is expected to foster the use of, and attribute economic value to, wastewater, an almost unused resource.

SPAIN

Key developments in Spain in the last 12 months

- The introduction of rules on permitting and connection of hydrogen projects to natural gas pipelines or direct customers (for further information, please see the section on Storage and distribution below).
- The implementation of the system of guarantees of origin for renewable gases by the Spanish issuing authority (for further information, please see the section on Hydrogen standard below).
- The partial awarding by Spanish authorities of the initial €1.5 billion budget of funding available for green hydrogen projects through programmes "H2 Pioneers" (around €150 million awarded) and "H2 Value Chain" (around €144 million awarded) (for further information, please see the section on Production below).

Targets and policy overview

The Spanish Hydrogen Roadmap comprises a list of 60 measures to be adopted across a range of issues, such as the regulatory framework, market integration and research, development and innovation activities, in order to promote the deployment of green hydrogen activities and infrastructure within Spanish territory. However, it does not outline any specific measures in connection with other types of low carbon hydrogen (such as blue hydrogen).

By 2030, Spain expects:

- to deploy 4GW of electrolysis capacity;
- at least 25% of hydrogen used in the industry sector to be renewable;
- to deploy 100 to 150 hydrogen refuelling stations and 5,000 to 7,500 road transport vehicles powered by hydrogen; and
- to make €8.9 billion in investments for the construction and commissioning of green hydrogen production facilities and related electricity generation projects, for industrial transformation to use hydrogen and for other transport applications (including, amongst other things, trains and heavy transport vehicles powered by hydrogen).

Key regulatory reforms

Reforms are mainly being implemented through Royal Decree-laws 6/2022, 14/2022 and 18/2022 although these reforms are in principle subject to the final outcome of the review of the Third Energy Package currently ongoing at the EU level.

The main areas of focus of the reforms are:

- the regulatory framework applicable to the development and construction of green hydrogen production projects in Spain (in particular with regards to the formalities for the access and connection of such projects to the Spanish gas network and the permits and licences required in connection with applicable gas sector regulations and environmental laws), including new rules to integrate renewable gases (including green hydrogen) within the Spanish guarantees of origin scheme;
- the regulatory framework for green hydrogen facilities and infrastructure isolated from the gas network (*canalizaciones aisladas*); and
- the specific regime applicable to direct connections from green hydrogen production facilities to the Spanish gas network (*líneas directas*).

Hydrogen Standard?

Spain is not developing its own standard and will use the EU standard. However, while the EU standard is pending, Spanish authorities have outlined the requirements to be met by sponsors of hydrogen

production facilities in order to apply for public subsidies under the Spanish RTR Plan. These include that the electricity used by a hydrogen producer must be of renewable origin, and that the supply of electricity to the hydrogen producer must be through a direct connection or provided under long-term PPAs with the electricity sourced from newly commissioned generation projects.

In addition, implementing article 19 of RED II, the Spanish Government has established the legal framework of the guarantee of origin system in connection with renewable gases (including green hydrogen) by virtue of Royal Decree 376/2022 and Order TED/1026/2022 which temporarily appointed Enagás GTS as the issuing authority and manager of the guarantee of origin system.

Currently, only producers that use renewable sources to produce gases (e.g. green hydrogen) will be eligible to be registered in this system and to receive guarantees of origin, for their renewable gas production.

Production

Hydrogen production in Spain is currently classified as a chemical industry activity, regardless of the renewable or non-renewable origin of the hydrogen produced. This classification as a "chemical industry" entails certain regulatory restrictions (especially in terms of environmental and land use rules), although one of the main targets of the Spanish Hydrogen Roadmap is reducing the regulatory burden for green hydrogen production facilities.

Public support will be available under the PERTE ERHA scheme. The PERTE ERHA scheme provides for public support to green hydrogen projects of up to €1.5 billion and, although this scheme will be also applicable to the development of hydrogen storage, distribution and supply activities, it is expected that a large part of these funds will be for green hydrogen production activities. The PERTE ERHA funds will be awarded from 2023 to 2026 through the programmes "H2 Pioneers" and "H2 Value Chain", which comprise other specific incentive sub-programmes including the following (note applications are now closed):

- **Programme H2 Pioneers:** €150 million in grants and public subsidies for innovation in the hydrogen value chain, with a special focus on the development of manufacture capacity of hydrogen equipment. The entire budget, consisting of €150 million, has already been allocated according to information available on the Spanish Government's website.
- **Programme H2 Value Chain**
  - **Incentive Programme 1:** €30 million in grants and public subsidies for integrated projects that combine, in an aggregated manner, the production, distribution and use of hydrogen in the same territorial location. According to the Spanish Government's website, €11.9 million has already been awarded.
  - **Incentive Programme 3:** €100 million in grants and public subsidies for large-scale hydrogen production through electrolysis (open to projects with electrolysis capacity higher than 20MW). A final proposal awarding the entire budget, consisting of €100 million, has already been published on the Spanish Government's website.
  - **Incentive Programme 4:** €40 million in grants and public subsidies for innovation in the hydrogen value chain, with a special focus on research, development and innovation activities. A final proposal, awarding approximately €32.4 million, has been published on the Spanish Government's website.

Hydrogen imports and exports

Spain is aiming to be one of the leading producers and exporters of green hydrogen in Europe. One of the main projects to realise such potential is the so-called H2MeD project (for further

information, please see the EU annex), which will include an upgrade of existing natural gas networks in Spain to allow direct connection between the two main projected axes of H2MeD. These comprise of the pipelines: (i) CelZa, between Portugal and Spain; and (ii) Bar-Mar, between Spain and France. However, there are alternatives to this Mediterranean corridor being developed, such as the hydrogen maritime corridor of Cepsa and Port of Rotterdam, which connects the Ports of Algeciras to Rotterdam and is expected to be operational by 2027. In addition, the Spanish and EU authorities recognise that a potential connection with North of Africa through the Iberian Peninsula could be considered if countries such as Morocco and Algeria develop sufficient production capacity to export green hydrogen that is compliant with EU standards.

Storage and distribution

As described in the PERTE ERHA, support will be focused on small-scale storage and distribution facilities as green hydrogen production will be primarily located within areas with industry or transport potential to integrate hydrogen consumption in the medium-term. The Spanish Hydrogen Roadmap identifies, amongst other things, the following areas as potential hydrogen clusters: A Coruña, Huelva, Vizcaya, Puertollano, Madrid, Barcelona, Valencia and Asturias.

Recently approved regulations have introduced several measures to facilitate the deployment of pipelines to connect green hydrogen production projects to the Spanish gas network or to direct customers, such as the removal of certain permits relating to the construction works, rules on access and connection of hydrogen projects to existing gas networks, and the granting of expropriation rights over plots affected by the connection pipelines.

The Spanish Hydrogen Roadmap also targets the review of the technical rules applicable to natural gas infrastructure in order to allow a higher proportion of blending of hydrogen within the gas system (currently limited to 5% blending). An example is Project HIGGS (Hydrogen in Gas Grids) whereby several partners and institutions are analysing the impact of hydrogen blending in existing natural gas infrastructure, as well as the improvements and modifications required in such facilities to allow a higher level of hydrogen blending.

Sector specific measures

Transport

The Spanish Hydrogen Roadmap sets out ambitious goals with regards to the role of green hydrogen within the transport sector (e.g. the development of a fleet of at least 150 to 200 renewable hydrogen fuel cells buses by 2030).

The potential production of synthetic fuels or other types of energy carriers from green hydrogen (whether for road and maritime transport, shipping and aviation, or for the industrial and construction sectors) is highlighted by the Spanish Hydrogen Roadmap and is being developed through different alternatives and technologies:

- Road: Pursuant to data provided by the Directorate General of Traffic (*Dirección General de Tráfico*), more than a dozen hydrogen fuel cell vehicles are being developed as part of public and private research projects in Spain. Similarly, with regards to heavy-duty vehicle transport, several projects have been launched to study the feasibility of renewable hydrogen as fuel for industrial vehicles (such as buses, trucks). Among these projects is a public tender launched by Transports Metropolitans de Barcelona for the purchase of eight hydrogen fuel cell buses in 2020. As of March 2023, 11 green hydrogen fuelling stations are in operation

in Spain. Naturgy, the largest natural gas supplier, aims to have up to 38 hydrogen fuelling stations developed by 2025.

- Rail: Renfe (the Spanish railway company) has launched a project to develop locomotives powered by hydrogen fuel cells jointly with Enagás and the National Hydrogen Centre (*Centro Nacional de Hidrógeno*), with funding support from the EU.
- Maritime: There are several ongoing initiatives studying the use of green hydrogen in machinery used in ports and cargo terminals. Notably, the H2Ports initiative is dedicated to the development of a pilot project in the port of Valencia to incorporate hydrogen in port logistics operations in order to reduce their environmental impact. H2Ports has received funding from the Fuel Cells and Hydrogen Joint Undertaking.

Industry

According to data provided by the Spanish Government in the Spanish Hydrogen Roadmap, annual hydrogen consumption in Spain is around 500,000 tonnes (mostly grey hydrogen), the majority of which is used in the production of industrial products and fertiliser such as ammonia and in refineries for the removal of impurities from crude oil. Iberdrola has developed the largest green hydrogen project in Europe in Puertollano (Ciudad Real) consisting of a 100MW solar photovoltaic plant and a 20MW green hydrogen generation facility which is meant to supply a nearby ammonia production plant. Another project, the so-called "Cluster Puerta de Europa" aims to integrate up to 600MW of electrolysers by 2030 and is supported by more than 80 companies.

Power

The Spanish Hydrogen Roadmap highlights the key role of green hydrogen in power generation and as long duration storage – allowing better management of the electricity system by absorbing the renewable electricity that is not consumed at the time it is produced.

Hydrogen clusters

The Green Hysland Project, a green hydrogen project developed in the Balearic Islands, has been selected by the Fuel Cell and Hydrogen Joint Undertaking to be awarded with an EU grant amounting to €10 million (the second largest grant awarded by that authority to a green hydrogen project). The Green Hysland Project will be the first flagship project in southern Europe and will create a "green hydrogen ecosystem" in the Balearic Islands. The Green Hysland Project will generate, distribute and use at least 300 tonnes of renewable hydrogen per year in Mallorca, produced from solar energy. The green hydrogen produced by the Green Hysland Project will have multiple uses, prioritising the direct consumption of renewable hydrogen, for example, in the generation of heat and power for commercial and public buildings, the supply of auxiliary energy to ferries and port operations and the creation of a refuelling station. In addition, the possibility of injecting part of this green hydrogen into the island's gas pipeline network through a guarantee of origin system will be assessed, which will allow for the decarbonisation of the gas supply.

In addition, the other hydrogen projects worth highlighting are:

- the so-called "Basque Hydrogen Corridor", intended to promote the development of renewable hydrogen projects throughout the whole value chain in the Basque Country
- HyVal, which aims to develop up to 2GW of electrolysis capacity by 2030 to produce green hydrogen in Castellon (Valencian community) and
- the Andalusian Green Hydrogen Valley, emerging as the largest green hydrogen project in Europe (with a total capacity of 2GW of electrolysis), located in Palos de la Frontera (Huelva) and San Roque (Cadiz), and projecting an investment of up to €3 billion.

UK

Key developments in the UK in the last 12 months

- The introduction of the Energy Bill to Parliament, including enabling powers to support hydrogen production under the IDHRS (for further information, please see the section on Key regulatory reforms below).
- The first low carbon hydrogen production projects were shortlisted to receive support under the IDHRS and will now move forwards to negotiations or due diligence. In addition, fifteen applicants were awarded support totalling £37.9 million under the Net Zero Hydrogen Fund (for further information, please see the section on Production below).
- The launch of a consultation on hydrogen transportation and storage business models (for further information, please see the section on Transport and storage below).

Policy overview

The UK is aiming for 10GW of low carbon hydrogen capacity by 2030, with at least half of this coming from electrolytic hydrogen, as set out in the British Energy Security Strategy published April 2022 (BESS), doubling the ambition of the UK Hydrogen Strategy (originally published August 2021 and updated in December 2022). The UK plans to support a variety of production methods including blue and green hydrogen, but perhaps also biomass gasification with CCUS. There is currently no policy goal beyond 2030, however, the Hydrogen Strategy suggests the UK could require between 7-20GW of production capacity in 2035 and 15-60GW in 2050. A pipeline of UK projects has been identified potentially providing up to 20GW of hydrogen production through to 2037.

The Scottish Government also published a Hydrogen Policy Statement in December 2020, aiming for 5GW by 2030 and at least 25GW by 2045 in Scotland alone. It published its Hydrogen Action Plan in December 2022.

Key regulatory reforms

IIn the UK, a number of proposals are progressing including:

- recognition of hydrogen in the draft overarching National Planning Statement for energy
- implementation of an offshore hydrogen regulatory regime (pipelines and storage), and
- the passage of the Energy Bill through the UK Parliamentary process. This includes primary legislation required to implement the new IDHRS scheme and for hydrogen heating trials as well as the economic licensing regime for carbon dioxide transport and storage networks needed for blue hydrogen production.

Wider reforms, for example to gas network and storage rules, planning, health and safety, licensing, permitting, and wider environmental regulations, are also likely to be required as policy develops. The UK has established a Hydrogen Regulators' Forum to determine current and future non-economic regulatory responsibilities across the hydrogen value chain.

Hydrogen Standard?

Low Carbon Hydrogen Standard

The Department for Energy Security and Net Zero (DESNZ) has published an LCHS. Low carbon hydrogen projects and businesses seeking government grants or revenue support from the Net Zero Hydrogen Fund or under the hydrogen business model are required to comply with the standard in order to secure that support. The standard will be a single 'low carbon label', applied at the point of production to all production methods that meet the required emissions threshold of 20g CO_2e/MJ(Lower Heating Value). Although the standard will be reviewed periodically (and has already been updated in 2023), the level of the standard will be grandfathered so any future

changes would not apply retrospectively to contracts for support that had already been awarded.

The standard will apply to UK production pathways only at this stage but the UK Government is consulting on the development of the standard into a certification/guarantee of origin scheme to be in place by 2025.

The Renewable Transport Fuel Obligation

The RTFO obliges all suppliers of relevant transport fuels that supply at least 450,000 litres of fuel per year to ensure and prove that a proportion of the fuel they supply comes from renewable sources. The UK Department for Transport administers the scheme and has published supplementary guidance in relation to RFNBOs. This includes requirements for additionality, temporal correlation, evidence of a PPA, absence of grid constraints as well as taking account of losses in grid transportation and retirement of any applicable guarantees of origin. The requirements are summarised in the table below. However, the electricity used in production of the RFNBO is permitted to receive support under the CfD regime for renewables.

UK Green Taxonomy

Like the EU, the UK is developing a green taxonomy. The UK Government will also be consulting on including the standard in the UK Green Taxonomy to support investment in low carbon hydrogen.

TABLE 7: SUMMARY OF CONDITIONS AND EVIDENCE REQUIREMENTS FOR RFNBOS UNDER THE RTFO PUBLISHED BY THE DEPARTMENT OF TRANSPORT, 2022

Case	New generation capacity / additionality	Temporal correlation	PPA	Grid losses	Grid congestion
Direct line, no grid connection	✓	✕	✕	✕	✕
Direct line, grid connection	✓	✕	✕	✕	✕
Additional capacity via electricity grid	✓	✓	✓	✓	✓
Curtailment and wastage	✕	✓	✓	✓	✓

Production

Support will be available under the new IDHRS scheme for new build low carbon hydrogen production projects and for the retrofitting of existing hydrogen production capacity with carbon capture capability. The Government will be providing up to £140 million to establish the scheme, including up to £100 million to award contracts of up to 250MW of electrolytic hydrogen production capacity in 2023 with further allocation in 2024 to achieve 1GW by 2025. In addition, a range of innovation funding and co-funding is being made available.

Although being developed in parallel, the level of support, terms and timing for award under the IDHRS differ, depending on the technology used and whether the project is a new build or retrofit project. Draft terms have now been published. A summary of the support is set out in the table:

	New build	**Retro-fit**
H_2 production using CCS	Bilateral CfD with a counterparty known as an LCHA, under which producers are paid the difference between a reference price and a strike price. Until a hydrogen market benchmark develops, the reference price will be the higher of the natural gas price and the 'achieved sales price' negotiated by the producer. A contractual price discovery mechanism is proposed to incentivise higher sales prices. Allocated under the CCUS cluster sequencing programme, the first LCHAs are expected to be awarded in 2024.	Industrial carbon capture scheme will provide the plant with revenue support to cover capex plus a return, carbon transport and storage fees, and opex. The capex payment is a negotiated amount per tonne of CO2, repaid over 5 years (but can be extended). The opex payment is structured as a CfD: the reference price is intended to imitate the avoided costs of carbon (based on the historical growth in carbon prices) and producers are paid the difference per tonne of CO2 captured to a negotiated strike price, reflecting expected opex (indexed, except for energy prices). Allocated under the CCUS cluster sequencing programme, expected to be awarded in 2024.
Electrolytic H_2	Bilateral CfD (known as the LCHA as described above). Allocated under electrolytic allocation process. Hydrogen allocation round (**HAR**) 1 opened in July 2022, with projects totalling 250MW in total expected to be awarded contracts by December 2023. HAR 2 will be launched in Q4 2023 for award of up to 750MW of capacity in early 2025.	Not applicable.

In April 2023 the UK Government announced that two blue hydrogen production projects had been selected to progress to negotiations with the UK Government as part of the CCUS Track 1, phase 2 cluster sequencing process. Twenty electrolytic hydrogen production projects totalling 408MW were selected under HAR1 to move forwards to the due diligence phase. The UK Government is consulting on a move to price-based competitive allocation for electrolytic and other non-CCUS technologies following HAR2.

Some production projects will not require business model support, for example due to revenue from the RTFO scheme (see below) or displacement of a more expensive fuel such as diesel. Grant funding is also available via the £240 million Net Zero Hydrogen Fund and under other fuel-switching grant schemes. In March 2023, fifteen applicants for strand 1 (devex) and strand 2 (devex and capex) were awarded support totalling £37.9 million.

There is also up to £18 billion financial capacity available from UK Infrastructure Bank (a UK Government-owned policy bank) for all sectors including hydrogen, which has been identified as an investment opportunity in the bank's first strategic plan.

Hydrogen imports and exports

The UK Government is exploring opportunities to export hydrogen, including from the UK to continental Europe, and expects there to be opportunity for the UK to both import and export low carbon hydrogen, although this will depend on domestic demand.

The Government committed in the BESS to launching a hydrogen certification scheme by 2025. DESNZ published a consultation on the LCHS in February 2023, in which it sets out that the certification scheme will aim to enable both the hydrogen and the low carbon attributes of hydrogen to be exported, through compatibility with a range of international certification schemes, allowing exporters to demonstrate their emissions credentials internationally. It also aims to certify the emissions of imported hydrogen, seeking to demonstrate compliance with the UK's LCHS.

Storage and transport

A variety of joint Government and industry research, development and testing projects are underway, designed to help determine the safety, feasibility, costs and benefits of converting the existing gas grid to carry 100% hydrogen. An example is Project Union whereby National Grid is considering the development of a hydrogen 'backbone' to link industrial clusters in the UK.

The Government plans to develop new business models for transportation and storage by 2025, to be in place by 2030. The Government published a consultation in 2022 seeking stakeholder views on high-level design options for these business models, with the outcome expected later in 2023. The hydrogen transport and storage business models are expected to need an external subsidy mechanism and so the Government is seeking powers to introduce a hydrogen levy (although a decision in relation to this has yet to be taken and this is subject to significant Parliamentary debate). The Government also expects that a regulated asset base model will be required to support the development of hydrogen pipelines, to be implemented via gas transporter licences under the Gas Act 1986, and has included provisions in the Energy Bill to enable the allocation of this.

The need for large-scale hydrogen storage is also subject to further review by the UK Government. A Call for Evidence on facilitating the deployment of large-scale and long-duration electricity storage sought evidence in relation to power-

hydrogen-power as a technology option, with the Government committing to take forward the design of a business model to enable investment by 2024 (although no commitment to a particular technology was made).

Funding is available under the UK Research and Innovation Hydrogen storage and distribution supply chain innovation competition to support development of hydrogen storage and distribution systems and encouraging the commercialisation and adoption of hydrogen storage and distribution innovation in the UK.

Work is also underway to consider blending of up to 20% of hydrogen by volume into the existing gas distribution network (which could generate carbon-savings of up to 6-7% on current Great Britain grid gas consumption), and up to 2% into the gas transmission network, with a decision expected by the end of 2023.

Sector specific measures

The UK Government plans to publish a Hydrogen Sector Development Action Plan in 2022.

Transport

A consultation on a low carbon fuel strategy for transport was concluded in 2022 and the strategy is expected to be published later this year.

Existing support for green hydrogen production is available under the RTFO scheme. Under the RTFO, transport fuel suppliers have an obligation to provide a volume of sustainable renewable fuel which is calculated as a proportion of the overall volume of fuel they supply for road transport and non-road mobile machinery. A sub-target was introduced in January 2019 for 'development fuels', including RFNBOs such as green hydrogen. Compliance is evidenced via a certificate trading regime.

Spring 2023 guidance enhanced the flexibility of the RTFO for electrolytic hydrogen, allowing suppliers to blend additional and non-additional renewable energy in order to reach the greenhouse gases threshold and qualify for support.

The UK Government has also provided £20 million grant funding to support large-scale trials and demonstrations of hydrogen use across multiple transport modes, in the Tees Valley Hydrogen Hub.

In relation to aviation, in July 2022 the UK Government published its Jet Zero strategy, committing to reaching net zero by 2040 for UK domestic flights and by 2050 for international aviation. The strategy includes plans to increase the uptake of SAF (produced using low carbon hydrogen as a feedstock or as a process input). The UK is aiming for five commercial SAF plants to be under construction by 2025 and has £180 million of new funding available between 2022-2025 to support the commercialisation of SAF plants and fuel testing in the UK. From 2025, a SAF mandate (currently under consultation) will replace the RTFO in supporting the development of SAF. The Government is consulting on the design of mechanisms to accelerate the growth of SAF (both domestic production and imports), including proposals for additional support for power-to-liquid production technology, with legislation expected to be prepared for 2025. The Department for Transport's Jet Zero Council, in its delivery plan, sets out the intention to define a UK certification programme for hydrogen powered large commercial air transport by 2024.

Industry

The UK's Industrial Decarbonisation Strategy aims to create four low carbon industrial clusters by 2030 which will involve a mix of blue and green hydrogen production projects together with the development of CO2 transport and

storage networks. Two clusters have been identified for delivery by the mid-2020s as part of a CCUS competition known as Track 1: HyNet (in the North West of England) and the East Coast Cluster (in Humber and Teesside). In April 2023 the Government also launched Track 2 of the CCUS cluster sequencing process to establish two further CCUS clusters for delivery by 2030 and called for expressions of interest from further CO2 transport and storage networks. The Acorn (in Scotland) and Viking (in Humber) systems are however acknowledged to be well placed to deliver the UK Government's objectives.

In April 2023 the UK Government announced that two blue hydrogen production projects had been selected to progress to negotiations with Government to connect to the HyNet and the East Coast Clusters as part of the CCUS Track 1, phase 2 cluster sequencing process. The UK Government intends to launch a further process within 2023 to enable expansion of Hynet and the East Coast Cluster by identifying further capture projects to connect to these clusters.

Hydrogen also features strongly in the Government's policy for industrial fuel switching, alongside electricity and bioenergy. A £315 million Industrial Energy Transformation Fund supports the deployment of fuel switching technologies, with various innovation programmes for hydrogen end-use funded through the £1 billion Net Zero Innovation Portfolio.

The British Standards Institute is working to develop a publicly available specification for hydrogen-ready industrial boilers, supporting faster and cheaper fuel switching to hydrogen.

Heat

As part of the UK Hydrogen Strategy, Government is supporting industry to deliver a 100% hydrogen heating neighbourhood trial by 2024 and a village trial by 2025, with powers being taken in the Energy Bill to achieve this. However, a strategic decision on the role of hydrogen for heating is not expected to be taken until 2026. In addition, the outcome of a consultation on proposals to mandate that from 2026 all newly-installed gas boilers are 'hydrogen-ready' is outstanding.

Power

The potential for hydrogen to be used directly in power generation or as long duration storage (so called power-hydrogen-power projects where the hydrogen is produced by electrolysis) is acknowledged in the UK's Hydrogen Strategy. The UK Government intends to consult in 2023 on the need and potential design options for market intervention to support hydrogen to power.

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