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Special report

## The EU's industrial policy on renewable hydrogen

Legal framework has been mostly adopted – time for a reality check



EUROPEAN  
COURT  
OF AUDITORS

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# Executive summary

I The EU is committed to becoming climate neutral by 2050, meaning that all sectors that emit greenhouse gases are called on to decarbonise. The Commission saw renewable hydrogen as one way to decarbonise hard-to-electrify industries in particular. It published an [EU Hydrogen Strategy](#) in mid-2020 and updated it with its [REPowerEU plan](#) in 2022. The Commission also set the course for creating a renewable hydrogen market in the EU through setting targets for hydrogen production and import. It also recognised that low-carbon hydrogen could play a role in the transition towards climate neutrality.

II For the 2021-2027 period, total EU funding for hydrogen-related projects is currently estimated at €18.8 billion. This financial support is allocated through multiple programmes. Two major funding sources are the Recovery and Resilience Facility and the Innovation Fund.

III We decided to carry out an audit on how effective the Commission has been in creating the right conditions for the emerging renewable and low-carbon hydrogen markets, given the significant implications of this transition for the future of key EU industries. To this end, we assessed whether the EU is on track for achieving its targets and whether it has adopted the necessary legal acts to effectively provide timely support for the hydrogen market. We also assessed whether the EU has a comprehensive set of funding programmes to allow the hydrogen value chain to develop across the EU. Lastly, we assessed whether the Commission has appropriately coordinated market creation between its own services, with member states and with industry.

IV Overall, we conclude that the Commission was partially successful in creating the necessary conditions for the emerging hydrogen market and the hydrogen value chain in the EU. We are calling for a reality check now as nearly 4 years have passed since the publication of the Hydrogen Strategy and first lessons can be drawn.

V The Commission did not undertake robust analyses before setting the EU's renewable hydrogen **production and import targets**. These were not broken down into binding targets for member states and not all member states set their own targets. When they did so, these national targets were not necessarily aligned with the Commission's targets. In fact, the EU targets turned out to be overly ambitious: based on the available information from member states and industry, the EU is unlikely to meet them by 2030. The Commission did not set any EU targets for low-carbon hydrogen.

**VI** The renewable hydrogen **legal framework** is now mostly complete, while for low-carbon hydrogen some acts still need to be proposed and adopted. However, the renewable hydrogen production rules, which are key for market development, were set by a directive and supplemented by a delegated act without prior assessment of their impact (for example on production cost). Agreeing on the renewable hydrogen rules took time and many investment decisions were deferred during this period. In 2023, the EU adopted measures to increase the cost competitiveness of renewable and low-carbon hydrogen, but the effect of these measures will not be immediate and certain aspects were not included.

**VII** Work on standardisation and certification is still required. Progress in market development will depend on several factors, including whether member states will (i) meet the demand targets which in turn depends on progress made by industry, and (ii) manage to reduce permitting timelines for renewable hydrogen and renewable energy projects.

**VIII** Investment needs are huge, but the Commission does not have a complete overview of these **needs or the public funding** available. Industry is faced by a set of different EU funding programmes with different rules, making it difficult to determine the best-suited programme for a given project. There is still no guarantee that the EU's hydrogen production potential can be fully harnessed. So far, those member states with a high share of hard-to-decarbonise industry are more advanced in terms of planned projects (either at an advanced or in the feasibility study stage).

**IX** The Commission took steps to **coordinate** the ramp-up of the hydrogen value chain, but has not yet used the existing fora to discuss important strategic issues, such as how best to move forwards without creating new strategic dependencies.

**X** We recommend that the Commission:

- (1) following a reality check, make strategic choices on the way ahead without creating new strategic dependencies;
- (2) set out an EU roadmap and monitor progress;
- (3) obtain reliable national funding data and assess the appropriateness of EU funding arrangements accordingly;
- (4) monitor the permitting process in the member states;
- (5) take a clear decision on support and coordination actions with and for the hydrogen industry.

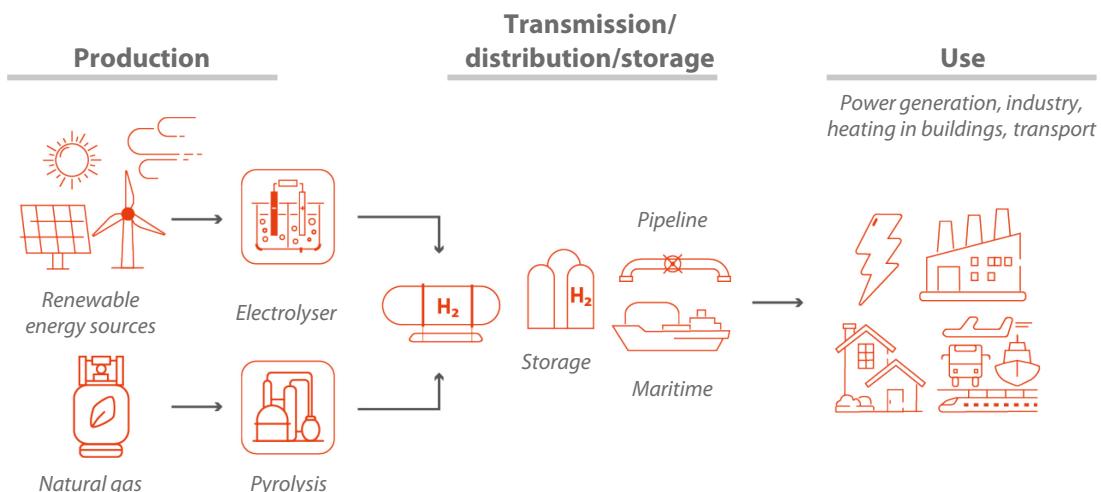
# Introduction

## Hydrogen explained

**01** Hydrogen is a chemical element, which is a gas under standard conditions. There are also different hydrogen derivatives, such as ammonia and synthetic electrofuels (such as e-methane or e-methanol).

**02** The hydrogen value chain as illustrated in *Figure 1* covers three phases: (1) production, (2) transmission, distribution and storage, and (3) use.

**Figure 1 – Hydrogen value chain**



Source: ECA.

**03** Hydrogen can be produced in different ways, using different energy sources and production technologies, as detailed in *Table 1*.

**Table 1 – Examples of different ways to produce hydrogen (not exhaustive)**

Energy source	Process/Technology
Renewable electricity	Electrolysis: water is split into hydrogen and oxygen
Nuclear energy	Electrolysis
Natural gas	Steam-methane reforming
	Steam-methane reforming with carbon capture and permanent storage of this carbon to reduce emissions

**04** According to the [Commission](#), 96 % of the hydrogen used in Europe in 2022 was produced using natural gas, resulting in significant amounts of CO<sub>2</sub> emissions. In the same year, hydrogen accounted for less than 2 % of Europe's energy consumption and the largest share of demand for hydrogen came from refineries.

## Renewable hydrogen as one way to decarbonise

**05** The EU is committed to becoming climate neutral by 2050, i.e. achieving net zero greenhouse gas emissions. This goal was enshrined in EU legislation through the European Climate Law<sup>1</sup>, which was adopted in 2021. The Law also set an intermediate target of reducing net emissions by 55 % by 2030, compared with 1990 levels.

**06** To achieve this target, all greenhouse gas emitting sectors therefore need to decarbonise. In 2020, the sectors with the highest carbon emissions were: (i) transport (including international aviation and shipping), (ii) energy supply, (iii) industry and (iv) agriculture<sup>2</sup>.

**07** **Renewable hydrogen** (i.e. hydrogen produced either using renewable electricity or biomass) is one tool for decarbonisation. This is because producing renewable hydrogen creates minimal carbon emissions, while using it creates zero carbon emissions. Apart from renewable hydrogen, **low-carbon hydrogen** is another way to reduce carbon emissions, particularly during the transitional period between now and when we aim to reach climate neutrality. The EU legislators defined<sup>3</sup> low-carbon hydrogen as that derived from non-renewable sources and which produces at least 70 % fewer greenhouse gas emissions than fossil fuels across its full lifecycle.

**08** In terms of using renewable hydrogen, EU legislation<sup>4</sup> suggests the following focus.

- It “can be used as feedstock or as a source of energy in industrial and chemical processes, in maritime transport, and in aviation”. It gives hard-to-decarbonise sectors (where either direct electrification is not technologically possible or is not a competitive option) the possibility to decarbonise. For example, in the following

<sup>1</sup> Regulation (EU) 2021/1119.

<sup>2</sup> Data published by [statista](#).

<sup>3</sup> 2024 directive on common rules for the internal markets for renewable gas, natural gas and hydrogen ([adopted](#), but not yet published as of the date our report was adopted).

<sup>4</sup> Renewable Energy Directive EU/2023/2413, recital 75.

sectors there are industrial and chemical processes which are hard-to-decarbonise and hard-to-electrify: steel production, petrochemicals, cement and fertilisers.

- It “can also be used for energy storage to balance, where necessary, the energy system”. This means it can balance a grid that has a high proportion of fluctuating energy generation from renewables.

**09** However, the use of renewable hydrogen comes with its own set of challenges. Some of these are listed below and detailed in *Box 1*.

- Current efficiency issues (i.e. energy losses) linked to electrolysis.
- The cost of production, which is not yet competitive because the production through electrolysis is still in its infancy.
- The need for renewable electricity and water.
- The infrastructure needs: ramping up the use of hydrogen requires transport and distribution infrastructure (which either has to be built or results from repurposing gas pipelines), and storage infrastructure.

### Box 1

#### Renewable hydrogen – challenges

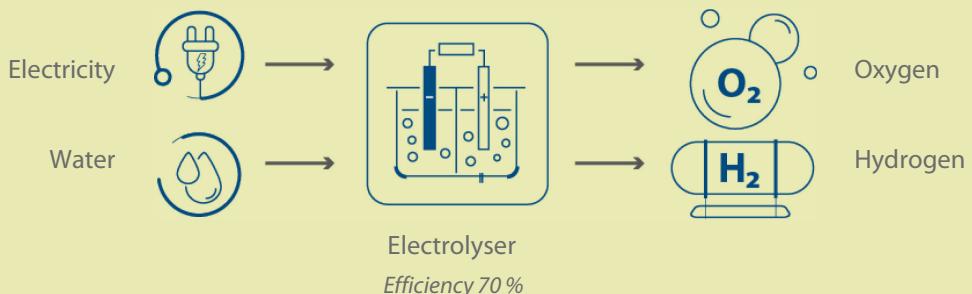
Producing renewable hydrogen using electrolysis is very **energy-intensive** because a certain amount of the electricity used is lost in the process. Therefore, it is often more cost-effective to use that electricity directly, rather than converting it into hydrogen. Reconverting the hydrogen to electricity leads to further energy losses.

- Converting electricity to renewable hydrogen (see *Figure 2*): an indicative assumption sometimes used for electrolyser efficiency is 70 %.<sup>5</sup> Efficiency varies depending on the technologies used.

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<sup>5</sup> See for example: European Electrolyser Summit, [Declaration 2022](#).

**Figure 2 – Producing hydrogen by electrolysis**



Source: ECA.

- Converting electricity to renewable hydrogen (gas) and reconverting hydrogen (gas) to electricity: according to various sources<sup>6</sup>, the efficiency ("round-trip") is estimated at below 50 %.

Based on 2022 data published by the International Energy Agency<sup>7</sup>, producing hydrogen by using natural gas was estimated to cost between \$1/kg and \$3/kg (2021), while producing renewable hydrogen was estimated to cost between \$3.4 and \$12/kg (2022). The **cost of renewable hydrogen** depends on the cost of renewable electricity and the cost of the electrolyser. The cost of electrolyzers is expected to decrease as their performance is expected to improve due to technological advancements and through the production scale-up leading to economies of scale.

It is not easy to produce renewable hydrogen simply anywhere, as it requires water and renewable energies. Research studies look at the water consumption by type of electrolyser and manufacturer. As a general rule of thumb, the **direct water consumption** to produce hydrogen through water electrolysis is estimated at 10 litres of ultrapure water for 1 kg of hydrogen<sup>8</sup>. The volumes of raw water, which are required to obtain ultrapure water, depend on the type of raw water (for example, sea or surface water).

Hydrogen has the highest **density** by mass of any fuel<sup>9</sup>. That is why it is an interesting option in terms of **energy storage**: large amounts of energy can be stored. However, it has a low energy density by volume at standard temperatures and pressures. This means that either large storage facilities are required, or the volume needs to be reduced. This can be done by compressing or liquefying the hydrogen, but these processes require energy.

<sup>6</sup> (1) Fraunhofer IWES, Prof. Dr Jürgen Schmid, *Speicherungsmöglichkeiten von Überschussenergie mit Wasserstoff oder Methan – ein Vergleich*; (2) S&P Global Market Intelligence, Tom DiChristopher, *Hydrogen technology faces efficiency disadvantage in power storage race*, 2021.

**10** In July 2020, the Commission published a communication outlining an EU Hydrogen Strategy<sup>10</sup> for the first time, setting the course for renewable hydrogen in the EU. The strategy focuses on obtaining, distributing and scaling up the use of renewable hydrogen, and sets non-binding quantifiable targets for the EU's production of renewable hydrogen. It also recognises that appropriate support will be needed for low-carbon hydrogen during a transitional phase.

**11** Since renewable hydrogen can contribute to reducing the import of fossil fuels from Russia (strategic independence), it has become even more significant in the wake of Russia's war of aggression against Ukraine. The Commission went on to issue its REPowerEU Communication<sup>11</sup> in 2022, which included more ambitious production targets compared with those in the Hydrogen Strategy. It also set import targets for the first time.

## Industrial policy challenges triggered by decarbonisation efforts

**12** Complying with the climate neutrality goal calls for industry to make enormous transformation efforts, which will require massive amounts of financing, where the bulk of this will have to come from the private sector (industry). At the same time, EU industry is already facing a number of additional challenges such as:

- volatile energy prices (wholesale gas and electricity prices rose to historic levels over 2022-2023), especially since the war of aggression against Ukraine which exposed the EU's dependence on energy imports (some member states were more affected than others);
- disruptions to and dependence on supply chains for certain raw materials.

These factors contribute to reducing the competitiveness of certain industries within the EU. A key challenge for EU policy makers is therefore to create the right conditions

<sup>7</sup> IEA (2023), *Global Hydrogen Review 2023*, IEA, Paris <https://www.iea.org/reports/global-hydrogen-review-2023>, Licence: CC BY 4.0, Figure 3.11.

<sup>8</sup> DVGW Deutscher Verein des Gas- und Wasserfachs e.V., *Genügend Wasserstoff für die Elektrolyse*, Februar 2023.

<sup>9</sup> Applied Sciences, 2019; 9(22):4842-1-4842-30; <https://hdl.handle.net/2440/123912>.

<sup>10</sup> COM(2020) 301.

<sup>11</sup> COM(2022) 230.

for decarbonisation, but at the same time to ensure that the EU's industries remain in the EU and can stay competitive.

**13** Other major economies such as the United States, Canada, Japan, China and India<sup>12</sup> already provide significant subsidies to support decarbonisation, including the production of renewable hydrogen. In addition, some countries also have less stringent rules on the carbon intensity of their products. Focusing more particularly on the United States, legal acts from 2021 and 2022 pave the way for significant public funding, including for renewable hydrogen. Implementing rules are still being adopted<sup>13</sup>, especially those for hydrogen production project developers who intend to apply for support in the form of a tax credit under the US Inflation Reduction Act. For more details, see *Annex I*.

**14** For specific industries in the EU, support from state resources is subject to state aid rules. Aside from public funding, the EU has adopted and implemented economy-wide market-based carbon pricing mechanisms (see *Box 2*) to reduce carbon emissions.

- Since 2005, under its [emissions trading system<sup>14</sup>](#) (ETS1), some operators in certain sectors of industry (e.g. power generation, the manufacturing industry and aviation) have to surrender allowances to compensate for their CO<sub>2</sub> emissions. The new emissions trading system<sup>15</sup> (ETS2) of 2023 addresses CO<sub>2</sub> emissions from fuel combustion in buildings, road transport and additional sectors (mainly small industry).
- On a global level, many countries do not yet have such emissions trading systems. As a result, the EU's emissions trading system can put industry in the EU at a competitive disadvantage. This could lead to carbon leakage.

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<sup>12</sup> A staff working document from the Commission ([SWD\(2023\) 68](#)) provides a short description of the support schemes in these countries.

<sup>13</sup> In December 2023, the US administration published [draft rules](#).

<sup>14</sup> See [special report 18/2020](#).

<sup>15</sup> Directive 2003/87/EC.

- o Carbon leakage occurs when companies based in the EU move carbon-intensive production abroad to countries where less stringent climate policies exist. Leakage can also occur when EU products are replaced with imports that are more carbon-intensive. Therefore, the EU has put in place an additional mechanism (the carbon border adjustment mechanism) to prevent carbon leakage.

## Box 2

### Carbon pricing mechanisms applicable in the EU

Under the emissions trading system, companies in sectors of industry other than power generation receive a share of cost-free allowances to protect them from carbon leakage as they compete on an international scale.

These free allowances will gradually be phased out as the EU's [carbon border adjustment mechanism](#) is phased in. The aim of this mechanism is twofold: firstly, to put a fair price on the carbon emitted through producing carbon-intensive goods that enter the EU, and secondly to encourage cleaner industrial production in non-EU countries.

The carbon border adjustment mechanism will initially apply to imports of certain goods and selected relevant input materials (known as precursors) with carbon-intensive production. This is also where there is the greatest risk of carbon leakage, namely in the cement, iron and steel, aluminium, fertiliser, electricity and hydrogen sectors.

The Commission [stated](#) that the transitional period of this mechanism (up to end-2025) will serve as a pilot to be able to finetune the methodology.

## Roles and responsibilities

**15** The roles of the Commission, member states and industry are detailed in *Figure 3*.

**Figure 3 – Roles and responsibilities**



### COMMISSION

#### Policy and strategic leadership

Direktorate-General (DG) ENER is responsible for energy policy and is the leading policy DG for hydrogen. DG GROW is responsible for industrial and internal market policy. DG COMP is responsible for setting the rules on state aid (a form of market intervention) and checks the application of these rules.

State aid rules have an effect on national industrial policies because member states decide on the level of financial support for industry at national level, including decarbonisation efforts.

#### Funding

Seven directorates-general are involved in managing the different EU funds.

The Innovation Fund, the Connecting Europe Facility and parts of Horizon Europe are managed by the Commission's [European Climate, Infrastructure and Environment Executive Agency \(CINEA\)](#).



### MEMBER STATES

- decide on their energy mix;
- establish their own national strategies for industry and energy (including hydrogen, its transport and its distribution);
- decide on their level of public support (state aid);
- implement some of the EU funds (such as those under cohesion policy);
- decide about countries from which to import energy, the countries to which they will export energy, and the EU and non-EU countries with which they will form energy partnerships.



### INDUSTRY

Industry, in particular the electrolyser manufacturing and user industries also take investment decisions on their route to climate neutrality. The Commission consults industry, for example in the context of the [Clean Hydrogen Alliance](#), which it launched to bring together industry, public authorities, civil society and other stakeholders. The aim is to discuss the large scale deployment of clean hydrogen technologies and the requirements for such a deployment.

Source: ECA.

## EU regulatory framework

**16** Since the publication of the Hydrogen Strategy in July 2020 (see paragraph [10](#)), a number of legal acts have been adopted. The most important of these, which relate to renewable and low-carbon hydrogen, are set out in [\*Figure 4\*](#).

## Figure 4 – Legal acts

### **RENEWABLE ENERGY DIRECTIVE (RED III)**

#### **Renewable Energy Directive EU/2023/2413; amendment of 2023**

The latest amendment of 18.10.2023 increases the share of renewable energy in the EU's overall energy consumption to 42.5 % by 2030, with an additional 2.5 % indicative top up. Moreover, it sets binding targets:

- for the use of renewable fuels of non-biological origin (mostly renewable hydrogen and hydrogen based synthetic fuels) in industry; and
- for the use of renewable fuels of non-biological origin in the transport sector.

### **RULES FOR RENEWABLE HYDROGEN (hereafter referred to as DELEGATED ACT)**

#### **Commission Delegated Regulation (EU) 2023/1184**

Establishes an EU methodology, setting out detailed rules for the production of renewable liquid and gaseous transport fuels of non-biological origin. For example, gaseous renewable hydrogen (which is produced by feeding renewables based electricity into an electrolyser) is included in this category. For details, see [Annex II](#).

### **METHODOLOGY TO ASSESS GREENHOUSE GAS EMISSION SAVINGS**

#### **Commission Delegated Regulation (EU) 2023/1185**

Establishes a minimum threshold for greenhouse gas emission savings from recycled carbon fuels. Also specifies a methodology to assess greenhouse gas emission savings from renewable liquid and gaseous transport fuels of non biological origin, and from recycled carbon fuels.

### **GAS PACKAGE**

#### **2024 directive and 2024 regulation (adopted, but not yet published)**

These legal acts seek to facilitate the entry and integration of renewable and low carbon gases into the energy system. This enables a shift away from natural gas in line with the EU's goal to achieve climate-neutrality by 2050. The Regulation establishes common internal market rules for renewable and natural gases and hydrogen.

### **ReFuelEU AVIATION**

#### **Regulation (EU) 2023/2405**

Aviation fuel suppliers will have to blend increasing amounts of sustainable aviation fuels with conventional fuels, starting with a 2 % minimum blend in 2025 and reaching 70 % in 2050. From 2030, 1.2 % of fuels must also be synthetic fuels, rising to 35 % in 2050. Sustainable aviation fuels include, for example, electric fuels produced from renewable hydrogen.

### **FuelEU MARITIME**

#### **Regulation (EU) 2023/1805**

The greenhouse gas intensity of energy used on board a ship should decrease gradually (by 2 % in 2025 to as much as 80 % by 2050). This would be achieved particularly through the uptake of renewable fuels of non-biological origin with a high potential for decarbonisation (including hydrogen).

### **TEN-E REGULATION**

#### **Trans-European Networks for Energy Regulation (EU) 2022/869**

Lays down guidelines for the timely development and interoperability of the priority corridors and areas of trans-European energy infrastructure

### **NET ZERO INDUSTRY ACT**

#### **Regulation (EU) 2024/1735**

The aim is to boost the industrial deployment of net-zero technologies needed to achieve the EU's climate goals. Among other measures, it eases conditions for investing in green technologies, by simplifying permit-granting procedures and supporting strategic projects.

*Source:* ECA.

## Audit scope and approach

**17** This report assesses the Commission's effectiveness in creating the conditions for the emerging market on renewable and low-carbon hydrogen. To this end, we examined whether:

- the EU is on track for achieving its hydrogen-related targets;
- the EU adopted the necessary legal acts to support the nascent market for renewable and low-carbon hydrogen effectively and in a timely manner;
- the EU has a comprehensive set of funding programmes to allow the hydrogen value chain to develop across the EU;
- the Commission appropriately coordinated market creation between its own services, with member states and with industry.

**18** We took the EU policy (Hydrogen Strategy and REPowerEU plan) on renewable and low-carbon hydrogen as starting point. Since the policy focused more on renewable than low-carbon hydrogen, our report does the same. For those sections of the report where low-carbon hydrogen was relevant, we have specifically referred to it. We excluded research-related aspects and regulations and support for the transport sector from the scope of our report. Our audit covers the period from July 2020 to the end of 2023.

**19** We analysed evidence from a range of sources as detailed in [Figure 5](#).

## Figure 5 – Evidence



### Documents

EU policy documents on hydrogen, the regulatory framework, information on the various EU funding schemes, national strategies, national energy and climate plans (on a sample basis) and reports on the hydrogen ecosystem published by research bodies, industry associations and academics.



### Data

Data from different sources (mainly the International Energy Agency and the European Commission), for example on projects announced, projects financed by EU funding programmes, funding allocated to hydrogen under the national resilience plans and authorised state aid.



### Four member states

For a sample of four member states (Germany, Spain, Netherlands, Poland, see [Annex III](#)), we looked at their hydrogen strategies, legislative and policy documents, funding support, etc.

*We judgementally sampled member states to include both frontrunners in renewable hydrogen and those that are progressing more slowly, those with different roles in the value chain (such as production, import and use), and member states with a significant number of companies in sectors deemed hard to decarbonise.*



### Seven projects

For a sample of seven projects (in the same four member states), we looked at project applications, state aid approval and grant approval (see [Annex IV](#)).

*We judgementally sampled projects to include (i) projects of important size, (ii) hydrogen production and use and (iii) projects that either received financing from the EU budget in the 2021-2027 period or for which state aid was authorised.*



### Interviews

Interviews with staff from Commission directorates-general, the European Climate, Infrastructure and Environment Executive Agency and with representatives from national ministries and bodies.

Interviews with industry associations at EU and national level, staff from the International Energy Agency and representatives from the Clean Hydrogen Alliance.

*Source:* ECA.

**20** This report forms part of our series of reports examining certain aspects related to industrial policy, namely a 2019 review on energy storage technologies (including hydrogen)<sup>16</sup> and a 2023 special report about the EU's industrial policy on batteries<sup>17</sup>. In addition, we are currently undertaking an audit on microchips and another on state aid rules<sup>18</sup>.

**21** We decided to carry out this audit because renewable hydrogen is seen as a way to support the EU's commitment to reaching carbon neutrality and because of the significant implications of the decarbonisation on the future of key EU industries. This report can feed into the Commission's reflections and decisions on its next steps in developing the emerging market for renewable hydrogen.

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<sup>16</sup> Review 04/2019.

<sup>17</sup> Special report 15/2023.

<sup>18</sup> See the ECA's 2024+ Work programme.

# Observations

## The Commission set unrealistic hydrogen production and import targets - the EU is not on track for achieving them

**22** To succeed in building a market for hydrogen and to enable the EU's hard-to-decarbonise industry to remain in the EU and stay competitive, it is essential that member states and industry move in the same direction in terms of developing production capacity and use their strengths to their own and the EU's advantage. As previously mentioned, the Commission set the course at EU level using hydrogen targets (see paragraphs [10-11](#)). Targets should be based on robust assumptions and should be ambitious, but realistic.

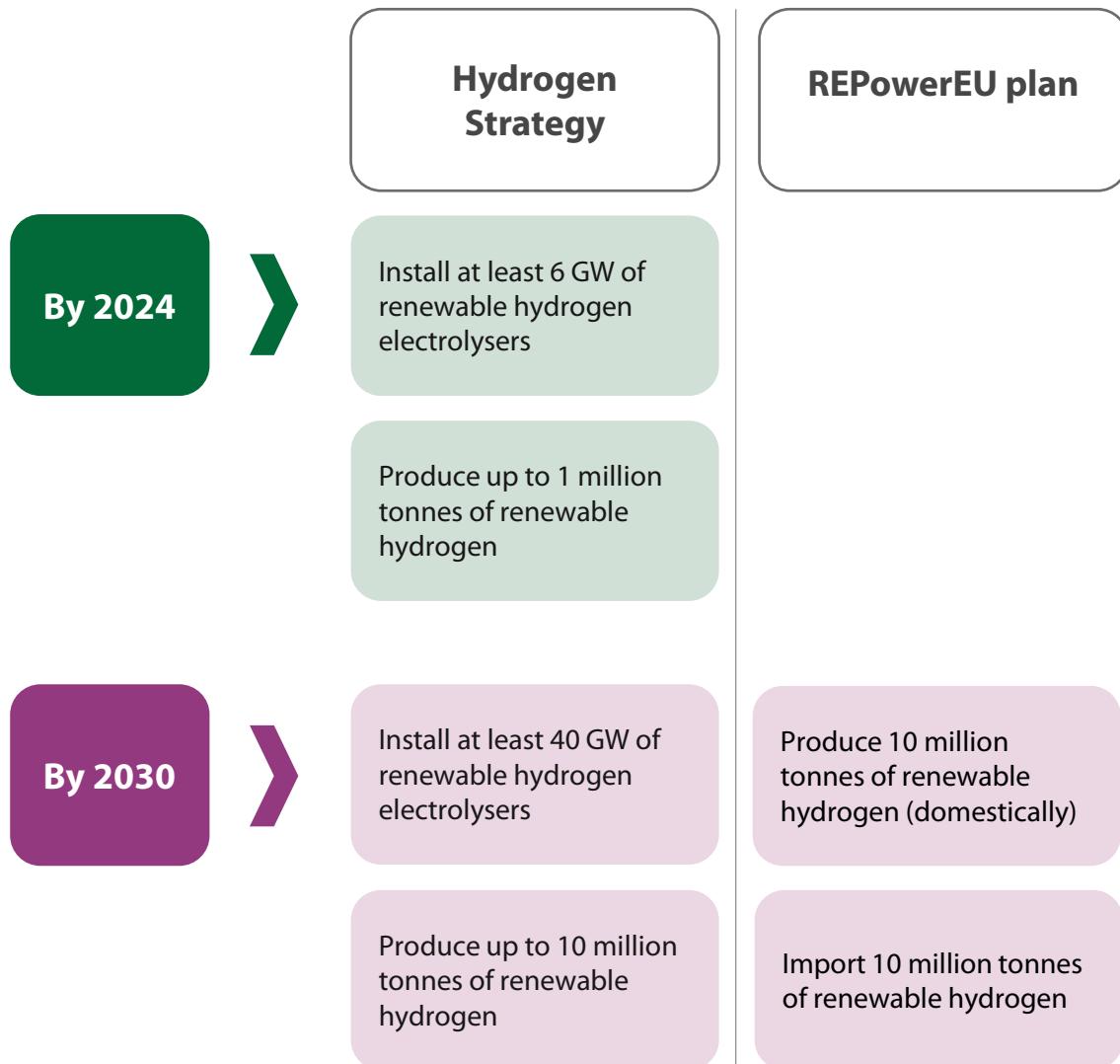
**23** We assessed whether:

- the Commission had defined clear targets based on a robust rationale;
- member states' objectives were aligned with the EU's targets;
- industry in the EU is implementing sufficiently large projects in enough time to meet the EU 2030 targets.

## The Commission set capacity targets without recourse to robust analyses

**24** The Commission announced the targets (see [Figure 6](#)) for producing and importing renewable hydrogen in its communications which are non-binding for member states. It did not set targets for low-carbon hydrogen.

**Figure 6 – Targets set by the Commission for producing and importing renewable hydrogen**



Source: ECA, based on Commission communications.

**25** We assessed how the hydrogen-related targets were determined and specified. For the Hydrogen Strategy and the REPowerEU plan, we found that the definitions were unclear, both in terms of the electrolyser capacity to be installed for the target production level (for 2024 and 2030), and in terms of imports (for 2030).

- It was not clear whether the capacity (in GW, unit of power) is measured in terms of renewable electricity input or in terms of hydrogen output. In fact, the difference between both (input and output) is determined by electrolyser efficiency, which falls short of 100 % because of energy losses (see *Box 1*).

- The estimates relating to renewable hydrogen production (in million tonnes, Mt) that can be achieved with electrolyzers with a total capacity of 40 GW varied in different Commission documents, as did the electrolyser capacity required to produce 10 Mt (see *Table 2*).
- For imports, the REPowerEU plan refers to 10 Mt of imported hydrogen. However, one Commission [document](#) indicates that imports are composed of 6 Mt of renewable hydrogen and approximately 4 Mt of ammonia, a hydrogen derivative (see paragraph [01](#)). It is not clear whether this figure refers to 4 Mt of hydrogen that should be imported (equivalent to around 25 Mt of ammonia) or 4 Mt of ammonia (equivalent to 0.6 Mt of hydrogen).

**Table 2 – Estimated production and required electrolyser capacity**

Electrolyser capacity	Production in Mt	Reference document
<b>Commission documents</b>		
<b>40 GW</b>	4.4	The Hydrogen Strategy refers to the “ <a href="#">2x40 GW Initiative</a> ”, i.e. that 40 GW would produce 4.4 Mt of hydrogen
<b>40 GW</b>	6.6	Commission staff working document accompanying the REPowerEU plan ( <a href="#">SWD(2022) 230</a> , page 9)
<b>40 GW</b>	5.6	Commission <a href="#">communication</a> on the European Hydrogen Bank
65-80 GW	<b>10</b>	Commission staff working document accompanying the REPowerEU plan ( <a href="#">SWD(2022) 230</a> , page 16)
80-100 GW output	<b>10</b>	Commission <a href="#">communication</a> on the European Hydrogen Bank
90-100 GW output	<b>10</b>	European Electrolyser Summit, 2022 <a href="#">Declaration</a> (co-signed by the Commission)
140 GW input		

Electrolyser capacity	Production in Mt	Reference document
<b>Other papers (for comparison)</b>		
192 GW	<b>10</b>	A. van Wijk, K. Westphal, J. F. Braun, <i>How to deliver on the EU Hydrogen Accelerator</i> , Brussels, May 2022
60-120 GW	<b>10</b>	M. de Vries, E. van den Toorn, N. Voulis, C. Jongsma, <i>Additionality of renewable electricity for green hydrogen production in the EU</i> , CE Delft, September 2022

**26** When the Commission set the 2020 and 2022 targets, it faced the following challenges.

- The definition of what is considered renewable hydrogen had not yet been adopted (i.e. by the Delegated Act<sup>19</sup>).
- The market is only in its infancy, so it was difficult to set an accurate target.
- Setting a target in terms of quantity (Mt) means that assumptions need to be made about electrolyser efficiency (see *Box 1*) and its capacity utilisation rate. This rate depends on the energy source (such as its availability): for example, an electrolyser that runs on energy from a stand-alone solar farm has a lower rate than an electrolyser that runs on electricity from the grid.

**27** Regarding the targets set by the Hydrogen Strategy, we analysed the Commission's underlying documents and found the following points.

- The initial production target (10 Mt) was mainly based on the EU's actual consumption of fossil-based hydrogen (i.e. produced using natural gas): 8-10 Mt in 2020, depending on the data source used. There is, however, no guarantee that this fossil-based hydrogen consumption will be fully replaced by renewable hydrogen.
- The initial electrolyser capacity target (40 GW) was advocated by a paper ("2x40 GW Initiative") issued by a hydrogen lobby (see *Table 2*).

**28** The updated targets (20 Mt for production plus import) were based on a Commission modelling exercise. Since in 2023 the EU adopted three legal acts (the

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<sup>19</sup> Commission Delegated Regulation (EU) 2023/1184.

Renewable Energy Directive<sup>20</sup>, the REFuelEU Aviation Regulation<sup>21</sup> and the FuelEU Maritime Regulation<sup>22</sup>), which set targets for the use of renewable fuels of non-biological origin (mostly renewable hydrogen and hydrogen based synthetic fuels) in industry and transport, we compared different estimates of the demand stimulated by these measures. We found that the demand expected to be stimulated will not even reach 10 Mt by 2030, let alone 20 Mt (see *Table 3*). Last but not least, a Commission modelling exercise conducted in 2023<sup>23</sup> concludes that the amounts of import of hydrogen will be relatively modest, at least until 2040 (i.e. below 10 Mt).

**Table 3 – Estimates of the demand for renewable hydrogen stimulated by new regulatory measures (by 2030)**

in Mt	Estimate of demand	Reference
3.8	Estimate of the demand stimulated by EU measures (1.4 Mt for industry, 1.8 Mt for transport) and by policies in force in member states (0.6 Mt)	International Energy Agency
5.6	Estimate of the demand stimulated by EU regulatory measures	Commission staff working document accompanying the REPowerEU plan ( <a href="#">SWD(2022) 230</a> )
6.3	Estimate of the demand stimulated by EU regulatory measures (and additional assumptions)	Hydrogen Europe, <i>Clean Hydrogen Monitor</i> , 2023
7.1	Consumption estimate based on plans announced by industrial buyers in Europe	
4.8-10.5	Estimate of the demand stimulated by EU regulatory measures	C. Robinson, C. Laurencin, <i>Back in the driving seat? Europe agrees on renewable hydrogen consumption targets</i> , <a href="#">S&amp;P Global Commodity Insights</a> , April 2023

<sup>20</sup> Directive EU/2023/2413.

<sup>21</sup> Regulation (EU) 2023/2405.

<sup>22</sup> Regulation (EU) 2023/1805.

<sup>23</sup> Impact assessment report, [SWD\(2024\) 63](#), Part 3, p. 28.

**29** The Commission considered the production and import targets to be more aspirational than compulsory. We take note that under the Renewable Energy Directive (RED III), the Commission will develop an EU strategy for imported and domestic hydrogen, based on newly introduced data reporting by member states. However, the Directive does not set a deadline for this new strategy.

**30** The Commission did not set a target for the cost of producing hydrogen; the Hydrogen Strategy simply mentions that renewable energy should be available at a competitive price. By comparison, the United States did set such a target, namely \$1 per kilo by 2031<sup>24</sup>.

### Member states have divergent ambitions which are not necessarily aligned with the EU targets

**31** There was no obligation for member states to create hydrogen strategies, but member states did have to establish national energy and climate plans (NECPs), outlining all policies and measures designed to meet the EU's climate objectives in general. Such policies can include promoting renewable hydrogen, for example.

**32** The first NECPs were due by the end of 2019, i.e. before the Commission set renewable hydrogen targets. Member states were required<sup>25</sup> to update these national plans: draft plans were due by mid-2023 and final plans by mid-2024. They were asked<sup>26</sup> to report on measures, initiatives and incentives that were either planned or had been undertaken to meet the EU targets for renewable hydrogen. Moreover, they should "reflect measures stemming from the REPowerEU plan". Member states were not specifically asked to provide national targets for renewable hydrogen.

**33** We analysed the targets included in the strategies of those member states with a strategy (18<sup>27</sup>). We also looked at the production and import targets of all 24 draft NECPs available as of 31.12.2023, as well as the demand support instruments for

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<sup>24</sup> U.S. National Clean Hydrogen Strategy and Roadmap, June 2023.

<sup>25</sup> Regulation (EU) 2018/1999.

<sup>26</sup> Commission Notice, 2022/C 495/02.

<sup>27</sup> This number includes Finland, which at the time of writing did not have a separate strategy, but did have a roadmap attached to its national energy and climate plan.

seven<sup>28</sup> of these drafts. We assessed the extent to which the strategies and NECPs converged towards a common EU ambition. The results of our analysis for certain aspects are shown in *Table 4*. Further details on the national strategies can be found in *Annex V*.

**Table 4 – Comparison of some of the aspects included in national hydrogen strategies and draft NECPs**

Aspect	National hydrogen strategies	Draft NECPs (2023)
<b>Production</b>	<p>The sum of the targets in terms of installed electrolyser capacity ranged from 34 GW to 39 GW (input), and relate to 13 member states.</p> <p>However, not all this capacity is necessarily linked to renewable hydrogen; some strategies also envisage low-carbon hydrogen.</p> <p>No member state set targets in terms of production (renewable hydrogen) in Mt.</p>	<p>The sum of the targets in terms of installed electrolyser capacity ranged from 46 GW to 50 GW (input), and relate to 16 member states<sup>1</sup>. This is some way off any estimate of the installed capacity required to produce 10 Mt (see <i>Table 2</i>).</p> <p>Moreover, not all of this capacity is necessarily linked to renewable hydrogen; some of the 24 plans also envisage low-carbon hydrogen.</p>
<b>Import</b>	Only Germany set import targets.	Of the 24 plans, only one (Germany) included import targets.
<b>Instruments to support demand</b>	With the exception of one strategy, none includes a clear set of instruments to support demand for renewable hydrogen.	With the exception of two plans (out of seven), the demand support measures are not clearly set out.

<sup>1</sup> Where member states had not yet provided the draft NECP but had included a target in their strategy, we took that target into account.

**34** While two member states (Germany and the Netherlands, the group of first movers) issued national hydrogen strategies around the same time as the Commission, 10 other member states produced their strategies after the Hydrogen Strategy, but before the REPowerEU plan. The remaining six took longer. No formal process was agreed between the Commission and the member states to ensure that targets and objectives as set in the national strategies would be aligned with those set by the

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<sup>28</sup> The seven drafts are those of our sampled member states, with the exception of Poland as it had not yet submitted its plan, plus Czechia, France, Italy and Romania.

Commission. The same is true for the draft NECPs. The Commission considers that the relevant regulation<sup>29</sup> does not provide for such an interaction with member states. In late 2023, the Commission president announced that the Commission will assess how member states plan to implement the national hydrogen commitments to provide a clear roadmap towards 2030 in each member state.

**35** Close to 80 % of the total envisaged electrolyser capacity is planned to be installed in five member states (Denmark, Germany, Spain, France and the Netherlands). They are mostly also among the most advanced member states in terms of projects that are operational, under construction, or for which final investment decisions have been taken (see *Annex VI*). Some ministry representatives we met consider that most of the measures between now and 2030 are “no-regret” measures, i.e. they are worth implementing whatever the actual market developments turn out to be.

**36** While certain member states have the potential to produce renewable hydrogen for export (within or outside the EU), we found that only very few include specific indications relating to the export of renewable hydrogen in their strategies.

**37** As at the end of December 2023, the Commission had reviewed 21 of the 24 draft NECPs submitted. In a communication<sup>30</sup>, it concluded that there “is still a large unexplored potential to further promote electrolyser capacity for renewable hydrogen and related products in demand sectors, including through international partnerships for hydrogen imports in line with the objectives of the REPowerEU plan”. On this basis, the Commission:

- asked all but seven member states to describe how they aim to promote hydrogen in industry and prepare the EU for trade in renewable hydrogen, but
- did not issue any recommendations to member states asking them to either set or increase national capacity targets. The Commission considers that it does not have the mandate to do so.

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<sup>29</sup> Regulation 2018/1999.

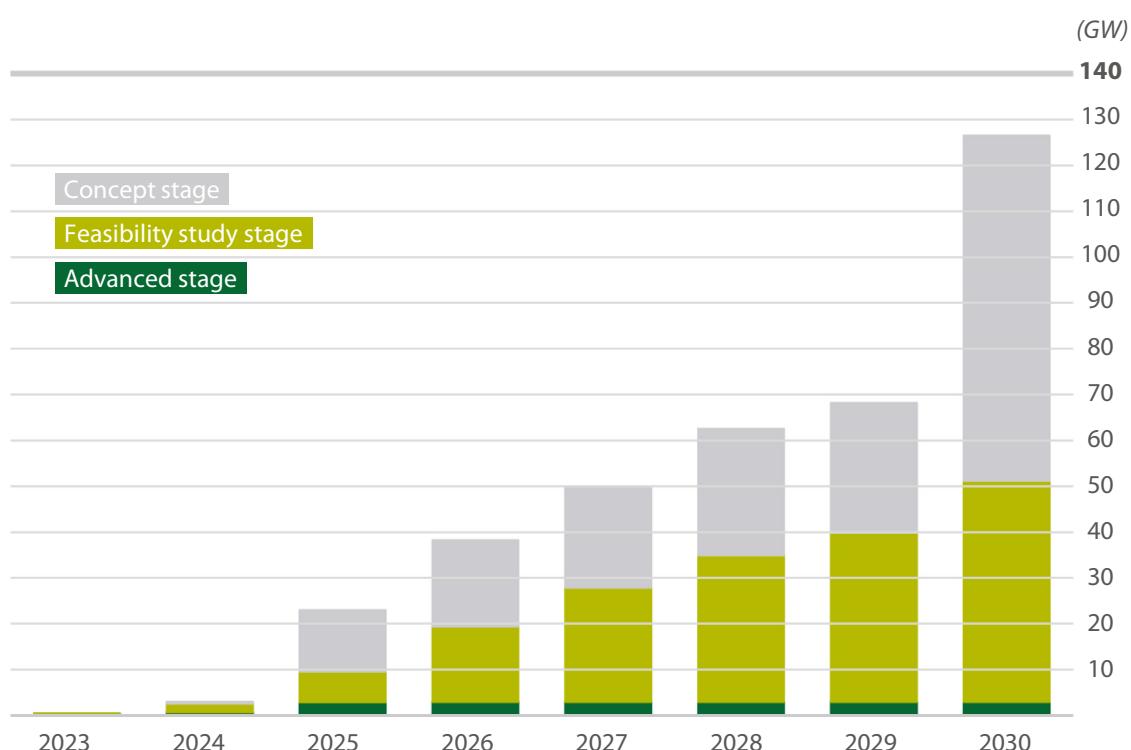
<sup>30</sup> COM(2023) 796.

## Achieving EU targets has been compromised by a bumpy start

**38** Based on data collected by the International Energy Agency (project announcements), we assessed whether a sufficient number of hydrogen production projects in an advanced stage exist to be able to meet the EU's production targets.

**39** We found that the production target of 10 Mt, which may require up to 140 GW<sup>31</sup> in terms of electrolyser capacity (input), is unlikely to be met as shown in *Figure 7*.

**Figure 7 – Electrolyser capacity of projects announced (cumulative, in GW) by stage and projected year of entry into operation (as of October 2023)**



Note: Advanced stage includes projects that are operational, or where the stage is “under construction”, or for which a final investment decision has been taken.

Source: ECA, based on data from the International Energy Agency.

<sup>31</sup> European Electrolyser Summit, 2022 Declaration (co-signed by the Commission).

**40** Moreover, these figures include projects for producing both renewable and low-carbon hydrogen. Therefore, the actual electrolyser capacity for renewable hydrogen projects alone is even lower. We also analysed data published by Hydrogen Europe in its [Clean Hydrogen Monitor 2023](#) and found that all renewable hydrogen projects considered to be in an advanced stage in Europe (i.e. including also non-EU countries) are projected to produce around 2.7 Mt by 2030. The situation in the four member states visited is shown in [Annex III](#).

**41** In fact, although there are many announcements about future projects to produce renewable hydrogen, project developers had only taken a few final investment decisions by the end of 2023. However, projects that are supposed to be operational in 2030 should make their investment decisions between 2025 and 2027 at the latest. This is because of the average project lead time<sup>32</sup>: it takes approximately 3-5 years for the final investment decision to be made and another 3-5 years for construction and commissioning before operations can start.

**42** The stakeholders we met indicated that the lack of rules defining renewable hydrogen did delay investment decisions. This was remedied when the Delegated Act was published in June 2023. In fact, the International Energy Agency noted<sup>33</sup> that the number of announced electrolyser projects had grown rapidly between 2022 and 2023.

**43** Representatives from ministries and industries in the four member states we visited listed additional reasons for project developers to defer investment decisions, some of which are linked to the fact that this is a nascent market (the “chicken and egg” problem, meaning supply is waiting for demand to develop and vice versa). These reasons include the following.

- The lack of standards and certification schemes.
- The difficulty in securing demand, i.e. buyers (offtakers) for the renewable hydrogen produced. This is due to uncertainties surrounding available quantities and price.
- The inflationary environment leading to significant increases in project construction costs and in electricity prices.

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<sup>32</sup> [International Journal of Hydrogen Energy](#), 2022.

<sup>33</sup> [Global Hydrogen Review](#), 2023.

- The difficulty in sourcing renewable energy (see paragraphs [54-61](#)).
- The lengthy permitting processes (see paragraphs [64-68](#)).
- The lack of funding sources (see paragraphs [83-97](#)).
- The lack of a transmission and distribution network (see paragraph [102](#)).

**44** Similarly, challenges also exist for the electrolyser manufacturing industry.

- Scaling up the production capacity of electrolyzers – in Europe, there are currently no electrolyzers above 20 MW, but the first orders for larger electrolyzers have been placed (see project examples in [Annex IV](#)).
- Component and raw materials value chains – delivery times may be long and dependent on certain countries outside the EU.
- Skilled labour – sufficient quantities required for increased demand are not necessarily available.
- A proposal (under the [Regulation](#) on the Registration, Evaluation, Authorisation and Restriction of Chemicals) to ban the use of per- and polyfluoroalkyl substances (mostly known by its abbreviation, PFAS) in different sectors, including the energy sector. The proposal provides that the Commission can grant a derogation for the energy sector. The legislative process is still ongoing. According to stakeholders, there is currently no available alternative to these substances, which are used in the industry's fundamental technologies (namely electrolyser membranes and fuel cells).

**45** Like the Commission, some ministry representatives in the four member states we visited explained that they see their country's 2030 production targets as aspirational rather than hard targets.

## The legal framework is mostly complete, but its overall impact on the market is as yet uncertain

**46** Many different aspects require regulation to establish a market for hydrogen. We therefore assessed whether:

- the legal acts shaping the nascent market were proposed in good time;
- the definition of the rules on renewable hydrogen production was based on an appropriate rationale;
- the legal acts include appropriate provisions to increase the cost competitiveness of renewable and low-carbon hydrogen;
- within its remit, the Commission took measures to speed up the permitting process;
- the Commission decided swiftly on the compatibility of state aid with EU law whenever member states pre-notified their intentions to provide support to industry.

**The Commission proposed most legal acts within a short period of time, but delays in adopting the rules for renewable hydrogen held up market development**

**47** Certainty regarding the legal framework is a key factor in establishing a new market. We therefore analysed the length of time required for the legislative process, to create the legal acts and shape the nascent market, i.e. from a Commission proposal, through to publication by the legislators.

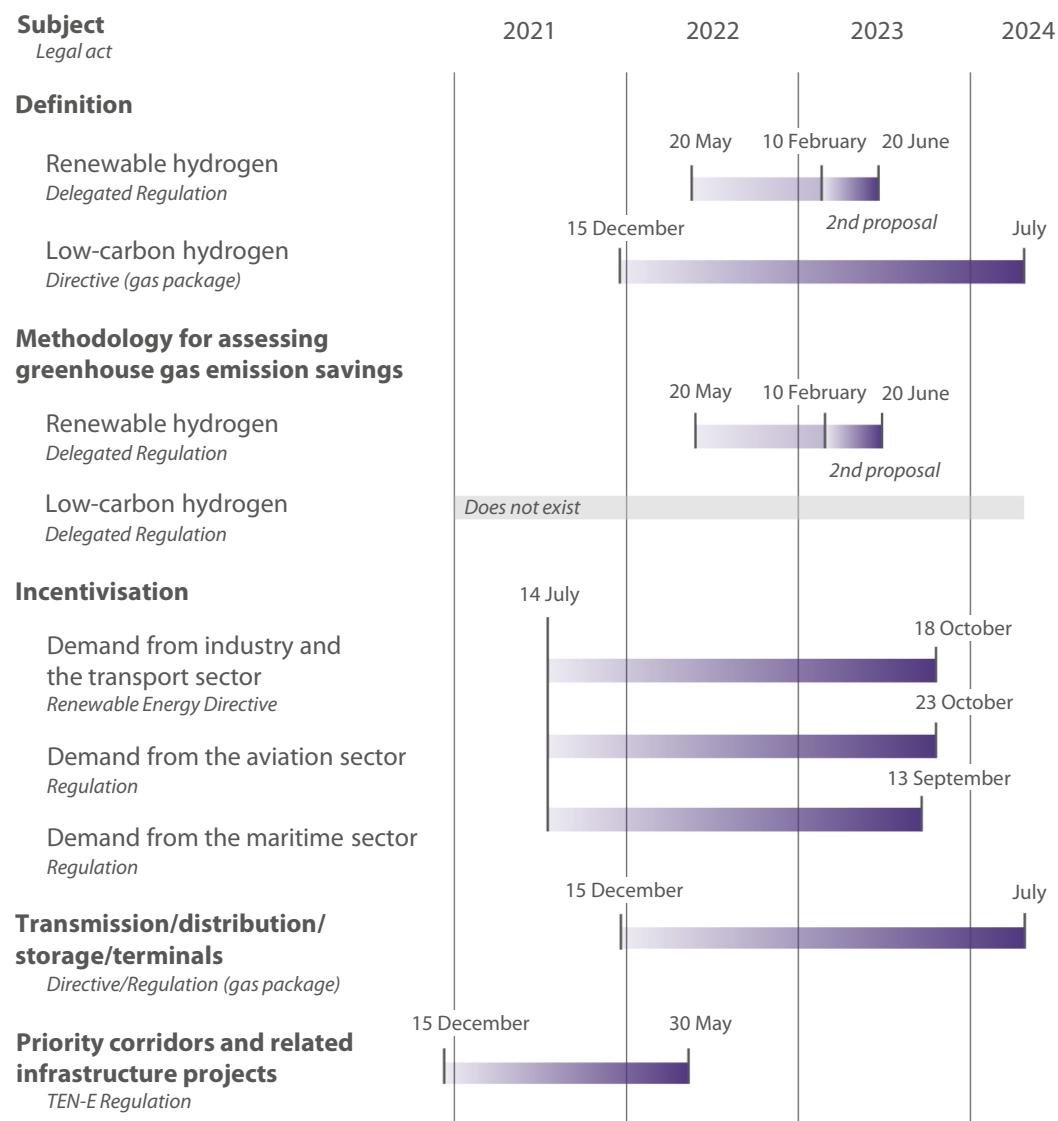
**48** The Commission proposed most of its legal acts within about a year of publishing the Hydrogen Strategy (see *Figure 8*). The only exception to this was a Directive<sup>34</sup> and a Regulation<sup>35</sup> (the “gas package”) which were proposed 17 months after the Hydrogen Strategy was published. The package was eventually adopted in May 2024. With this last adoption, the regulatory framework on renewable hydrogen is mostly complete. However, a great deal of work on standardisation and certification is still required.

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<sup>34</sup> 2024 directive ([adopted](#), but not yet published as of the date our report was adopted).

<sup>35</sup> 2024 regulation ([adopted](#), but not yet published as of the date our report was adopted).

**Figure 8 – Legal acts – duration of the legislative process**



*Note:* The Delegated Regulations on the definition of renewable hydrogen and on the methodology for assessing greenhouse gas emission savings (for renewable hydrogen) were due by December 2021.

*Source:* ECA.

**49** The gas package is intended to regulate elements such as planning (10-year network development plan at EU level and national development plans), access to dedicated hydrogen infrastructures, separating hydrogen production and transport activities and tariff setting (for more details, see [Annex VII](#)). The first 10-year network development plan and national plans specifically for renewable hydrogen are due by 2026.

**50** The Directive also defines low-carbon hydrogen, but:

- a delegated act still needs to be adopted (with a deadline of 12 months after the date on which the Directive enters into force) relating to the methodology for assessing greenhouse gas emissions savings from low-carbon fuels;
- implementing acts are due for network codes and guidelines.

Further details on low-carbon hydrogen, carbon capture and storage and carbon capture and utilisation are found in [Annex VIII](#).

**51** Under the TEN-E Regulation<sup>36</sup>, an EU-wide 10-year network development plan is the basis for selecting projects of common interest and projects of mutual interest. These are projects that are of cross-border relevance and that benefit from accelerated planning and permitting, among other things. This 2022 regulation already established that dedicated hydrogen-related projects (including renewable hydrogen) could apply and be selected as being of “common interest” from 2023 onwards. This was to ensure progress in developing the dedicated hydrogen network and while waiting for a legal base for a hydrogen-specific 10-year network development plan. The selection of projects was based on scenarios for a 10-year network development plan, which were established involving all relevant hydrogen market stakeholders. The list of projects of common and mutual interest was [published](#) in November 2023. It included 31 hydrogen network projects, 7 hydrogen storage projects, 10 reception facilities in ports and 17 electrolyser projects.

**52** In line with the Renewable Energy Directive<sup>37</sup>, two essential pieces of legislation were due by December 2021, namely the Delegated Regulation defining the rules for renewable hydrogen (i.e. the requirements to be met) (hereafter referred to as the Delegated Act) and the Delegated Regulation on the methodology to assess greenhouse gas emission savings. However, these acts were proposed in May 2022, with a 5-month delay. For both, a new version was proposed in February 2023 and following approval by the European Parliament and the Council they were published in June 2023. The time between the two proposals and the overall delay incurred is partially due to the fact that the hydrogen industry deemed the first proposal on the

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<sup>36</sup> Regulation (EU) 2022/869.

<sup>37</sup> Article 27 of the Renewable Energy Directive EU/2018/2001 (RED II) that came into force in December 2018.

definition of renewable hydrogen to be too strict and too much of a burden. Conflicting interests made the Delegated Act very controversial.

**53** According to stakeholders, the uncertainty created by the absence of this crucial Delegated Act was one of the main reasons that project developers were holding off before making their final investment decisions (see paragraph [43](#)).

**The adoption of the EU rules for renewable hydrogen provided certainty, but the Commission did not assess their effects on the market ramp-up**

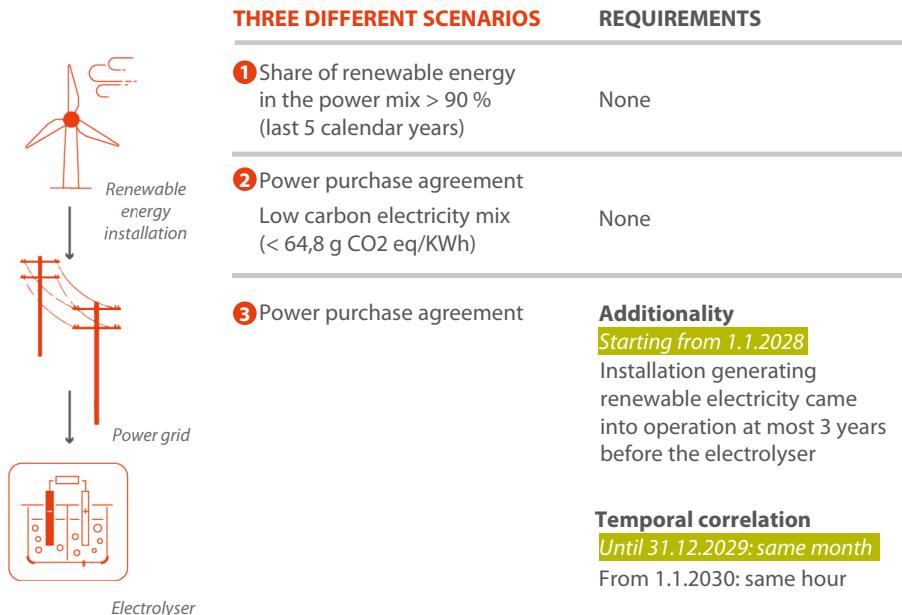
**54** The rules on renewable hydrogen production as set out by the Delegated Act are illustrated in [Figure 9](#).

**Figure 9 – Rules in the Delegated Act**

**Direct connection**



**Grid electricity**



**Temporal correlation**  
**Until 31.12.2029: same month**  
 From 1.1.2030: same hour

**Geographic correlation**

- same bidding zone; or
- interconnected bidding zone with equal or higher electricity price; or
- interconnected offshore bidding zone.

*Note:* Electrolysers can be directly connected and take grid electricity.

*Source:* ECA, based on the Delegated Act.

**55** The main rationale<sup>38</sup> behind the Delegated Act was to avoid creating incentives for increased fossil fuel-based electricity generation, by ensuring that the production of renewable hydrogen:

- incentivises the deployment of new renewable electricity generation capacity (additionality principle);
- takes place at times when renewable electricity is available, i.e. the generation of renewable electricity and its use for hydrogen production must occur within the same timeframe, e.g. hour or month (temporal correlation);
- takes place in locations where renewable electricity is available (geographic correlation).

**56** The Commission considers that allowing renewable hydrogen producers, connected to the grid, to operate indefinitely on a 24/7 basis would place a considerable burden on the electricity system, electricity consumers, taxpayers and the environment. However, for many industrial production processes, a constant flow of hydrogen is required (electrolyser output) while the supply of renewable energy fluctuates (electrolyser input). There are therefore trade-offs between the objective of achieving energy efficiency on the one hand, and incentivising the use of renewable hydrogen as a tool for decarbonisation in certain cases (such as hard-to-decarbonise industry) on the other.

**57** Considering the hydrogen production side, certain public studies<sup>39</sup> have estimated that the requirement relating to hourly temporal correlation (applicable from 2030 as set in the Delegated Act, see *Figure 9*), would increase the cost of renewable hydrogen. The extent of the increase varies because the studies were based on different models and assumptions: the increase ranges from moderate to between 25 % and 35 %. On the other hand, some of the studies estimated that a stricter temporal correlation leads to lower carbon emissions.

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<sup>38</sup> Recital 8 of [Commission Delegated Regulation \(EU\) 2023/1184](#).

<sup>39</sup> See for example the following studies: (i) Oliver Ruhnau, Johanna Schiele, *Flexible green hydrogen: The effect of relaxing simultaneity requirements on project design, economics, and power sector emissions*, Energy Policy, Volume 182, 2023, 113763, ISSN 0301-4215, <https://doi.org/10.1016/j.enpol.2023.113763>, (<https://www.sciencedirect.com/science/article/pii/S0301421523003488>), Licence: CC BY 4.0 DEED and (ii) *Grünstromkriterien der RED II – Auswirkungen auf Kosten und*

**58** As explained by the stakeholders we met, companies may either have to accept higher costs or slow down the hydrogen ramp-up phase to succeed in this balancing act. The following are examples.

- To ensure a constant flow of renewable hydrogen for offtakers, renewable hydrogen producers will have to build storage facilities or larger electrolyzers (although these assets may not be fully utilised at all times).
- Alternatively, companies may decide to pause their own planned hydrogen production projects (on their industrial sites) and instead wait until renewable hydrogen can be delivered through pipelines from elsewhere. This scenario is particularly likely for industrial companies located in areas with low potential for producing renewable electricity.

**59** While the stakeholders we visited welcomed the Delegated Act with its long-awaited legal certainty, they also considered it very complex and too strict for the ramp-up phase. For example:

- the 3-year window between the point when the installation that produces renewable energy becomes operational and the point when the electrolyser becomes operational is considered to be very short, given the many factors beyond the control of companies installing an electrolyser;
- companies located either in countries which are not very advanced in terms of producing renewable electricity, or in regions with limited potential for renewable electricity may be at a disadvantage, as renewable electricity complying with the additionality criterion may not be easily available;
- many developers of renewable hydrogen projects financed by the Innovation Fund confirmed that they have or have had problems in securing sufficient amounts of electricity from renewables, through power purchase agreements, which comply with the Delegated Act.

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*Verfügbarkeit grünen Wasserstoffs in Deutschland*, Frontier Economics, July 2021, (iii)  
 Johannes Brauer, Manuel Villavicencio, Johannes Trüby, *Green hydrogen – How grey can it be?*, European University Institute, Robert Schuman Centre for Advanced Studies, The Florence School of Regulation, RSC Working Paper 2022/44, (iv) Elisabeth Zeyen et al, 2024, Environ. Res. Lett. 19 024034, *Temporal regulation of renewable supply for electrolytic hydrogen*, DOI 10.1088/1748-9326/ad2239.

**60** Aware of these possible negative effects and to provide more flexibility, the Commission allowed for transitional measures, marked in green in [Figure 9](#) above. The transitional period after which the additionality rule will become applicable ends on 1.1.2028. The transitional period is therefore rather short. Indeed, most projects with plans to install electrolyzers have not yet started and, given the lead time (see paragraph [41](#)), they run the risk of not being able to benefit from this transitional period. We note that the draft rules with which hydrogen production project developers will have to comply to apply for support under the US Inflation Reduction Act (see paragraph [13](#)) are similar to those in the Delegated Act.

**61** The Commission did not carry out an impact assessment before proposing the Delegated Act on the rules for the production of renewable hydrogen (correlation and additionality) because this is not a legal requirement for a delegated act. The relevant article<sup>[40](#)</sup> of the Renewable Energy Directive (RED II), which the Delegated Act was designed to supplement, was added during the legislative process and was therefore not covered by the Commission's impact assessment of this directive. We note that the Delegated Act requires the Commission to assess the impact of these requirements by mid-2028.

### The impact of the EU regulatory framework on the cost competitiveness of renewable and low-carbon hydrogen remains to be seen

**62** We assessed whether the EU regulatory framework includes effective measures to improve the level playing field between producers of renewable and low-carbon hydrogen on the one hand, and producers of fossil-based hydrogen on the other.

**63** The EU has adopted some important regulatory measures, but their impact is not immediate and the extent of the impact remains to be seen.

- o Demand-boosting measures (see paragraph [28](#) and [Annex II](#)). The demand targets for the use of renewable hydrogen in industry and in the transport sector are to be met by 2030 and 2035. Five member states stated in a Council document<sup>[41](#)</sup> that the targets were either unrealistic or very difficult to achieve. The Commission has no enforcement means to ensure that the targets are respected, other than lengthy and time-consuming infringement procedures. We note that according to the Directive (RED III), the Commission must submit a report

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<sup>[40](#)</sup> Article 27 of the Renewable Energy Directive EU/2018/2001.

<sup>[41](#)</sup> Note 13188/23 ADD 1 REV 3 (October 2023).

by July 2028, assessing various elements including the EU's ability to achieve its targets for renewable fuels of non-biological origin.

- Carbon pricing through the [emissions trading system](#) and the [carbon border adjustment mechanism](#). The effect of the carbon border adjustment mechanism and the 2023 emissions trading system revision on the level playing field will only be felt from 2026 onwards. Moreover, the system does not cover all hydrogen derivatives as explained in [Box 3](#).

### Box 3

#### **The coverage of hydrogen by the emissions trading system and the carbon border adjustment mechanism**

Up until end-2023, only producers of fossil-based hydrogen in the EU were eligible to receive CO<sub>2</sub> allowances free of charge. From January 2024 onwards, EU producers with new installations producing hydrogen from electricity (including renewable electricity) are also entitled to receive CO<sub>2</sub> allowances free of charge. However, operators of existing fossil-based hydrogen installations wishing to transition to renewable hydrogen production will not be eligible for CO<sub>2</sub> allowances free of charge for this renewable hydrogen up until 2026. The producers that receive the CO<sub>2</sub> allowances receive the same amount of free allowances, but fossil-based hydrogen producers need to surrender them for the emissions they produce. Producers with zero emissions can, however, sell their free allowances and therefore create a revenue stream for themselves. Free allowances will be phased out between 2026 and end-2033.

The carbon border adjustment mechanism also applies to ammonia but does not yet apply to other hydrogen derivatives such as methanol and electrofuels or to liquid organic hydrogen carriers. This means that no price has yet been put on the carbon emitted when producing hydrogen derivatives (except ammonia) that enter the EU.

Moreover, the carbon border adjustment mechanism does not so far cover exports to non-EU countries. This is a cause for concern when such countries have either low carbon pricing or none at all. The potential shift in trade patterns towards more processed goods poses a risk of circumvention. To take steel as an example: while steel and iron ore are subject to the carbon border adjustment mechanism, finished goods which are produced using steel, such as cars, are not.

**The Commission took all possible measures to speed up permitting; uncertainty remains whether member states can follow suit**

**64** The stakeholders we met singled out the permitting process as one of the factors which leads to delays in project implementation. This problem has been recognised by the Commission and the ministries or stakeholders in all four of the member states we visited.

**65** In this early phase of the hydrogen ramp-up, delays in granting permits are a more pressing issue for installations that produce renewable electricity than for installations that produce renewable hydrogen using electricity from the grid through power purchase agreements. This is mainly because so far, many of the renewable hydrogen installations (i.e. electrolyzers) are built on existing industrial sites. This is the case for six of our seven sampled projects (see [Annex IV](#)).

**66** We therefore analysed whether the Commission had taken legislative measures to help resolve the issue. The Commission did in fact take a number of legislative steps intended to accelerate procedures for both renewable energy production and the production of hydrogen. However, we found that the duration of the permitting process that has to be respected by authorities in the member states varies between the different legal acts (see [Annex IX](#)). For example, a hydrogen production project (using an electrolyser) may fall under the rules of the TEN-E Regulation (with a permitting process duration of 18 months (excluding the time needed for the preparatory study phase), plus a possible 9-month extension), or the gas package Directive (with a duration of 24 months, plus a possible 12-month extension). The TEN-E Regulation also sets a timeline for the complete process including the preparatory phase (42 months). This is not the case for the gas package Directive. The Commission justifies these differences by the fact that projects falling under TEN-E should have a higher priority and should therefore be implemented even faster.

**67** Moreover, the organisational aspects of the permitting process fall fully within the member states' remit. The extent to which member states implement the requirements from the EU legal acts remains to be seen. The Commission's only enforcement tools are lengthy and time-consuming infringement procedures.

**68** The Commission's [guidance](#) document relating to the content of NECPs also asks member states to address the challenge of permitting. By end-2023, the Commission had reviewed 21 of the 24 plans submitted and recommended<sup>42</sup> the following: 14

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<sup>42</sup> COM/2023/796.

should describe more clearly how they plan to accelerate the permitting process, while all should detail their simplified procedures. Finally, we found that the Commission had not yet set up detailed monitoring of national permitting processes, for example through the European Semester. However, we note that for projects of common and mutual interest under the TEN-E Regulation, project promoters must submit annual reports which include information on progress with regard to the permitting process.

**Certain state aid rules were amended to facilitate subsidy-granting, but the actual provision and level of support depends on member states**

**69** As national subsidies can provide a financial advantage for specific operators, these subsidies must comply with EU rules on state aid:

- member states must notify new subsidy schemes or aid to an individual company to the Commission and can only implement them once the Commission has confirmed either that there is no aid, or that it is compatible with EU rules;
- in certain cases, concerning lower amounts of aid, no mandatory notification is required, in particular when aid is granted based on the General Block Exemption Regulation (GBER).

**70** The EU state aid framework sets out various sets of rules under which member states can notify the Commission of aid they intend to provide to an individual company or of aid schemes. The most important aspects for hydrogen-related projects are set out in [Table 5](#).

**Table 5 – State aid rules relevant for hydrogen projects**

Sets of rules	Short description
Important projects of common European interest (IPCEIs)	IPCEIs are large cross-border projects involving multiple member states to overcome important market or systemic failures.
Climate, Energy and Environmental Aid <a href="#">Guidelines</a> (CEEAG)	Framework to help member states provide the necessary support to reach the Green Deal objectives. The Guidelines were updated in early 2022. They explicitly refer to the fact that investments in renewable hydrogen are covered. Moreover, for the first time they include investments in decarbonising production processes.

Sets of rules	Short description
Temporary Crisis and Transition Framework (TCTF)	<p>Member states can adopt the support measures necessary for the transition to net zero industry, particularly schemes to speed up the rollout of renewable energy and energy storage, and schemes to decarbonise industrial production processes.</p> <p>The deadline for using the TCTF is short as aid must be granted by 31.12.2025.</p>
General Block Exemption Regulation (GBER)	Under this Regulation, unless otherwise specified, investment aid for environmental protection which does not exceed €30 million per undertaking per investment project is exempt from the requirement of notification and consequently from Commission approval.

**71** With the amendments to this toolbox that have been adopted over the last 2 years, the Commission aimed to ease the provision of state aid to support the green transition and other initiatives. This already resulted in the Commission declaring large amounts of aid as compatible with EU rules (see [Annex X](#) for details). Moreover, according to information from the Commission, since the adoption of the Delegated Act (see also paragraph [53](#)), member states (two in particular – Germany and the Netherlands) have opened discussions with the Commission about future schemes to support renewable hydrogen, envisaging aid of around €5 billion.

**72** We found that successive reviews of the different sets of rules (see [Figure 10](#)) led to confusion among some project developers. Due to the nature of certain projects, the Commission asked to move around 20 projects (partially already pre-notified to the Commission) out of the relevant IPCEI, so they could be assessed either under the CEEAG or the GBER.

**Figure 10 – Revision of different sets of rules – timeline**

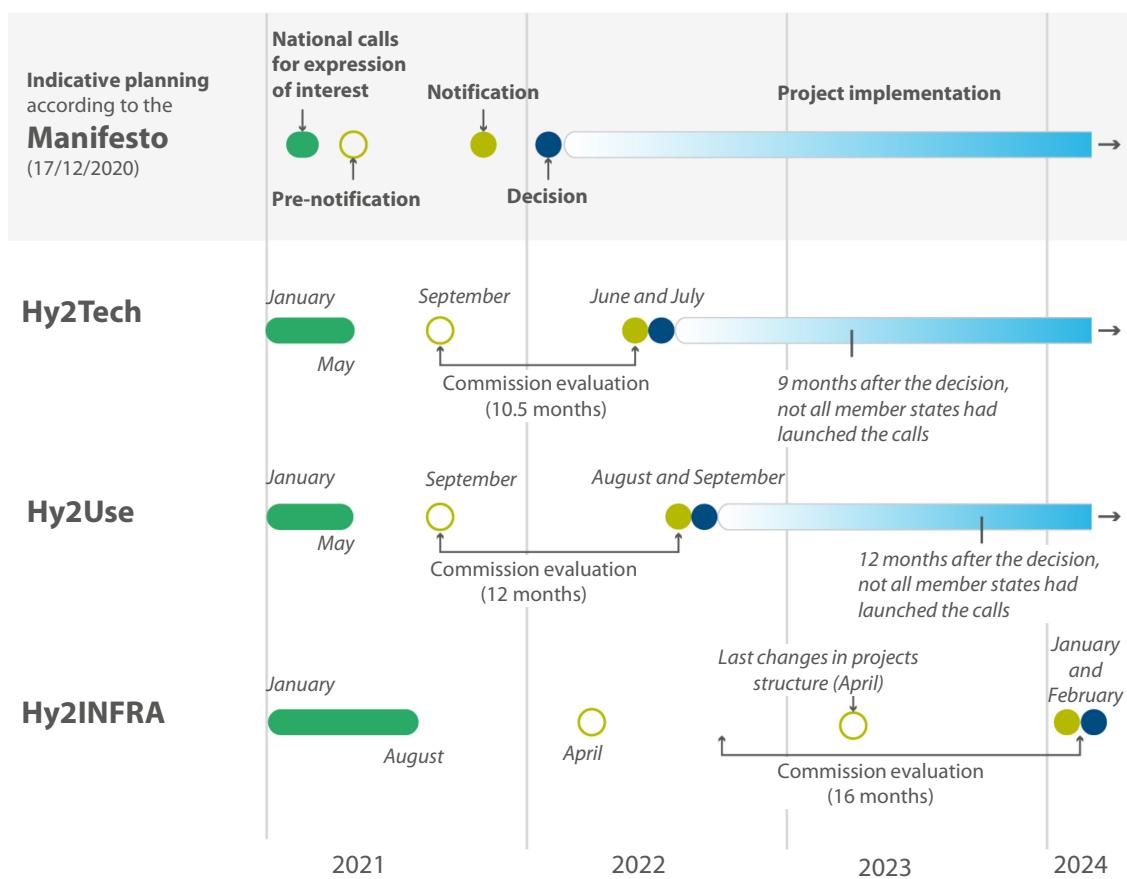
Date of adoption/revision	17.12.2020	18.2.2022	23.3.2023	23.6.2023
Set of rules	<b>IPCEI open to hydrogen</b> <i>Manifesto</i>	<b>CEEAG</b>	<b>TCTF</b>	<b>GBER</b>

*Note:* End-2020, 22 member states signed a [Manifesto](#), committing to start IPCEIs in the field of hydrogen (renewable and low-carbon).

*Source:* ECA.

**73** Industry representatives we met also complained about the length of time taken for the notification and approval process by the member states and the Commission. The longer it takes, the higher the risk that it will lead to a delayed project start and cost increases due to inflation. While applying for state aid does not preclude projects from starting earlier without aid at their own risk, project developers are often reluctant to do so. Timing can also be a factor that multinational companies take into account when deciding on the location (worldwide) and sequence of their investments. We therefore assessed the amount of time between the moment that projects or aid schemes were pre-notified to the Commission and when projects were awarded a grant by member state authorities. For three hydrogen-related IPCEIs *Figure 11* illustrates the time that elapsed between national calls for interest, notifications to the Commission, approvals by the Commission, and the grant award.

**Figure 11 – Time taken by the Commission to approve three IPCEIs**



*Note:* A further IPCEI (Hy2Move) is not included in our scope as it relates to the transport sector, which was not within the scope of our audit.

Source: ECA, based on Commission information.

**74** We found that two hydrogen-related IPCEIs were approved within a year of pre-notification. The evaluation phase for the third (Hy2Infra) was significantly longer and lasted 22 months. We analysed the reasons for this lengthy duration (Hy2Infra) and found the following.

- The Commission's workload was intense between 2021 and end-2023: in parallel, it had to evaluate five to seven IPCEIs from various sectors, on top of its work on non-IPCEI notifications.
- The Commission approved the IPCEIs as a whole. An IPCEI consists of numerous sub-projects from different developers in different member states (see [Annex X](#)). This implies that the more mature sub-projects will have to wait for the less mature sub-projects to catch up; member states pre-notified a few sub-projects between 2 and 12 months after April 2022.
- For a handful of sub-projects, the relevant member states introduced updated information in the course of the process (such as project size, companies involved or purpose).
- The Commission had to request additional information for all sub-projects, and for some sub-projects these requests required several rounds.

**75** In May 2023, the Commission issued a [code of good practice](#) to facilitate transparent, inclusive and faster design of the IPCEIs, which is meant to allow a streamlined assessment. In October 2023, the Commission set up the Joint European Forum for IPCEIs<sup>43</sup>, which brings together the Commission and member states to identify potential areas of European interest for future IPCEIs and to further streamline IPCEI procedures.

**76** The Commission's approval for the provision of state aid for the IPCEIs does not necessarily mean that public funding will eventually become available. For example, for the IPCEI Hy2Use, comparing the four member states we visited, neither Poland nor Spain has launched a process to make funding available, although they are two of the three countries with the largest amounts of planned aid for projects under this IPCEI. Member states may also need some time to make a grant decision. However, for the IPCEIs to achieve their objectives it is necessary that member states honour their financial commitments.

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<sup>43</sup> JEF-IPCEI.

**77** For hydrogen-related projects submitted under the CEEAG, our analysis of the time taken by the Commission to approve state aid (nine projects as at end-2023) showed that eight had been initially pre-notified under the IPCEI Hy2Use, but were then taken out of the IPCEI and assessed under the CEEAG. For three of these, the approval time under the CEEAG was similar to the approval time of the IPCEI itself; for five projects, it took the Commission an additional 5 to 10 months. The main reasons for this lengthy duration are similar to the ones described in paragraph [74](#).

**There are multiple EU funding sources for hydrogen projects, but no guarantee that they will be appropriate for developing an EU-wide market**

**78** Creating a market for renewable hydrogen requires large private and public investments along the entire value chain (see [Figure 1](#)). To make appropriate decisions on the volume of public funding to be provided alongside private sector investments, policy makers need a proper place-based needs analysis. Moreover, the Commission's funding approach should ensure that the hydrogen market is developed so that it addresses the value chain across the EU for the benefit of the EU's single market.

**79** We assessed whether:

- the Commission comprehensively estimated private and public funding needs;
- EU public funding addresses the whole value chain across the EU; and
- EU and national public funding will allow the EU domestic potential for producing renewable hydrogen to be harnessed.

**Estimates of investment needs by the Commission and member states are not exhaustive**

**80** We understand that estimates are necessarily subject to a certain degree of uncertainty in a nascent market. We also understand that reliable information about investment decisions may be of a sensitive nature and difficult to obtain. We analysed the different estimates of investment needs included in various Commission documents over time (see [Table 6](#)).

**Table 6 – Estimates of investment needs for the domestic production of renewable hydrogen until 2030<sup>1</sup> (in billion euros)**

	Hydrogen Strategy (2020)	REPowerEU plan <sup>2</sup> (2022)	Net Zero Industry Act proposal <sup>4</sup> (2023)
<b>Upscaling the manufacture of electrolyzers</b>		Up to 2	Max. 1.3 (if the capacity of domestically produced 10 Mt is entirely produced in the EU)
<b>Electrolyzers</b>	24-42	50-75	
<b>Industry and carbon capture and storage</b>	11		
<b>Pipelines</b>		28-38	
<b>Storage</b>		6-11	
<b>Infrastructure</b>	65		
<b>Additional electricity</b>	220-340	200-300	
<b>Total investment cost</b>	Not indicated	335-471 <sup>3</sup>	Not indicated

<sup>1</sup> The table does not include needs related to future imports (international value chain).

<sup>2</sup> Staff working document [SWD/2022/230](#).

<sup>3</sup> The total indicated in the staff working document does not correspond to the addition of the amounts by category. Difference: €45-49 billion.

<sup>4</sup> Staff working document [SWD/2023/68](#).

## 81 We found that:

- figures included in the documents, issued within a narrow timeframe, are not all consistent;
- figures for electrolyzers increased, but not to the same extent as the required increase in electrolyser capacity to be able to reach the production target (initial capacity of 40 GW versus updated estimate of up to 140 GW, see [Table 2](#));
- figures for pipelines and storage are low considering that estimates<sup>44</sup> for the German core network alone stand at €19.8 billion;

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<sup>44</sup> FNB Gas website.

- there is no comprehensive estimate in terms of the user industry's needs to be able to adapt production processes.

**82** We also analysed the hydrogen strategies of the four member states we visited and found that none included a complete estimate of investment needs. In particular, none of them referred to the funding required to adapt industrial processes (see [Annex V](#)).

### EU funding for the hydrogen value chain is scattered over several EU funding programmes

**83** The bulk of the investments along the hydrogen value chain will have to be financed by the private sector. Nevertheless, EU and national public funding can play a decisive role in supporting hydrogen infrastructure deployment all along the chain. We therefore assessed whether EU funding is available to project developers along the whole value chain.

**84** During the 2021-2027 period, several EU funding programmes are providing funding for investments in the field of renewable and low-carbon hydrogen, as shown in [Figure 12](#). They are managed by different Commission directorates-general (DGs) and according to different management modes. Due to data availability, for some programmes we indicate the amounts committed as of 31.12.2023, for others we indicate the amounts allocated for a given period. In the latter case, the actual amount that will eventually be spent on hydrogen may turn out to be higher or lower. Our current estimate is that there is €18.8 billion available for hydrogen-related projects, of which around 72 % is from the Recovery and Resilience Facility (RRF).

**Figure 12 – EU funding programmes for hydrogen-related projects (renewable and low-carbon hydrogen) as at 31.12.2023**

Funding programmes	EU funds (in million euros) and type of costs	Period (funding data, column 2)	Commission DGs
<b>DIRECT MANAGEMENT</b>			
<b>Recovery and Resilience Facility (including REPowerEU chapter)</b>	<b>13 628</b> (allocated)	2021-2026	SG RECOVER DG ECFIN
All types of projects along the hydrogen value chain	Capital and operating costs		
<b>Innovation Fund – Projects</b>			
Projects for production and use of hydrogen and electrolyser manufacture	<b>2 202</b> (committed)	2021-2023	DG CLIMA
	Capital and operating costs		DG CLIMA
<b>Innovation Fund – Hydrogen Bank</b>			
Promotes the domestic production and import of renewable hydrogen	<b>800</b> (committed)		
	Gap between renewable and fossil-based hydrogen		
<b>Connecting Europe Facility – Transport</b>			
Hydrogen refuelling stations, green hydrogen production and storage facilities	<b>250</b> (committed)	2021-2023	DG MOVE
	Capital costs		
<b>Connecting Europe Facility – Energy</b>			
Networks (transport infrastructure) and storage	<b>3.4</b> (committed)	2021-2023	DG ENER
	Studies and capital costs		
<b>Horizon Europe – Clean Hydrogen Joint Undertaking</b>			
Research and innovation projects	<b>1 200</b> (allocated)		
	Capital and operating costs	2021-2027	DG RTD
<b>SHARED MANAGEMENT</b>			
<b>Funds under cohesion policy</b> (European Regional Development, Cohesion and Just Transition Funds)	<b>See paragraph 85</b>	2021-2027	DG REGIO
All types of projects along the hydrogen value chain			
<b>INDIRECT MANAGEMENT</b>			
<b>InvestEU (implemented by the European Investment Bank; guarantee from EU budget)</b>	<b>799</b> (committed)	2019-2022	DG ECFIN
Renewable hydrogen production, supply (at commercial scale), and on-site storage projects as well as the deployment of low carbon technologies	Capital and operating costs		
<b>OUTSIDE THE EU BUDGET</b>			
<b>Modernisation Fund</b> (for lower income member states)	Unknown, as most of the funding is directed to grant schemes	2021-2027	DG CLIMA
All types of projects along the hydrogen value chain	Unknown (see previous line)		

Source: ECA, based on Commission data.

**85** Apart from the Modernisation Fund<sup>45</sup>, which is managed outside the EU budget, all other programmes are either funded by the EU budget or by [NextGenerationEU](#), which finances post-pandemic recovery and the EU economy's green and digital transformation. The RRF accounts for 90 % of the total NextGenerationEU budget. All of these programmes can be used to finance projects in several fields, so do not include a specific budget for hydrogen.

- For the RRF, we were able to identify the amounts that member states allocated to hydrogen measures in their recovery and resilience plans.
- For cohesion policy funds there was no requirement for project applicants or authorities to use a specific reporting code for hydrogen-related projects. We were therefore unable to extract the planned amounts for this type of project.

**86** Moreover, the European Investment Bank provides loans (either using its own funds, or based on mandates from governments or the Commission). Last but not least, national and regional governments can also allocate funding from their own budgets which, depending on the member states, can reach significant amounts.

**87** The industry representatives we met found this set-up unnecessarily complex, making it difficult for them to decide under which programme to apply. This set-up also contrasts with the much simpler approach under the US Inflation Reduction Act, where companies can apply for a tax credit for hydrogen production and investment (which is fixed per kilo of hydrogen produced) (see [Annex I](#)).

**88** In late 2023, the Commission president [announced](#) the creation of a one-stop shop under the European Hydrogen Bank, to guide hydrogen project developers on EU funding. At the time of the announcement, the Commission already had a [webpage](#) providing information on the various funding programmes, but it never became fully operational.

**89** Applying for EU funding is also perceived as complex because project developers need to resubmit proposals every time they apply to a different programme. This means that projects that were already positively evaluated by the Commission under one programme (but eventually did not receive funding due to a lack of budget) have to go through a new evaluation procedure if they apply under a different fund.

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<sup>45</sup> See explanations in [special report 05/2023](#), paragraph 43 and Box 4.

**90** In that respect, we take note that the co-legislators agreed<sup>46</sup> on the Commission's proposal (of June 2023) to create a "seal of sovereignty", which would be applicable to projects that were evaluated positively under a variety of EU instruments (under direct management), including Horizon Europe and the Innovation Fund. The features of this seal are the following.

- It would allow member states to provide support from other EU funding sources to these projects directly (such as from cohesion policy programmes, the RRF or the Modernisation Fund).
- Support remains subject to compliance with the applicable state aid rules and specific eligibility rules for the relevant programmes. Considering the time needed to obtain approval for state aid (see paragraphs 73-77), there is a risk that the benefits of this seal may be limited<sup>47</sup>. Moreover, member state authorities themselves decide whether or not to make use of the seal.

**91** EU programmes provide funding to cover both the supply side (scale-up of electrolyser manufacture, hydrogen production, transport and storage infrastructure) and the demand side (use by industry). However, they have a number of drawbacks, as detailed below.

**92** With regard to the demand side, we found that the Commission had not yet developed "Carbon Contracts for Difference", despite having announced that it would do so under the Hydrogen Strategy and the REPowerEU plan. Put simply, the purpose of such contracts is to provide grants to companies that are switching to a climate-friendly production process, to allow them to be competitive when faced with companies that use conventional technologies.

**93** The most significant share of EU funding for hydrogen is provided by the RRF (see [Figure 12](#)), but not all member states plan to use the RRF for that purpose. Details on the amounts earmarked by each member state are included in [Annex XI](#). While the RRF provided momentum for renewable energy-related projects, one major drawback is nevertheless that milestones and targets must be achieved by 2026 as set out in the relevant regulation<sup>48</sup> (end-date of the RRF). This is challenging for projects which have

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<sup>46</sup> Regulation (EU) 2024/795.

<sup>47</sup> See also [special report 23/2022](#), paragraph 74, on a similar concept, the "seal of excellence".

<sup>48</sup> Regulation (EU) 2021/241.

long lead times (see paragraph 41) and long-term operating costs (such as electricity). Project developers may have to find new funding sources for subsequent phases of their projects.

**94** For the four member states we visited, we analysed the national recovery and resilience plans and their degree of implementation. We also analysed those of Italy and France (to cover the member states that had earmarked the highest amount for renewable hydrogen) and found the following points.

- For some countries, the milestones and targets set in the respective Council implementing decisions (and based on a Commission proposal) related to electrolyser installation projects are stricter than in others. These differences in targets also reflect in the evidence expected to demonstrate that these milestones and targets are met. For Germany, proof of installation or project completion is expected. For Spain, proof of authorisation is sufficient and for Poland, after revision of the Council implementing decision at the end of 2023 resulting in easing the relevant milestone, proof of signature of subsidy agreements and transfer of money to the beneficiaries is sufficient.
- Where the required proof is stricter and more meaningful in terms of measuring results, there is an increased risk of missing the deadline for completion and the final project deadline of 2026. In particular, the time taken to approve state aid (see paragraphs 73-77), and the time taken by member states to make a grant decision can risk affecting some of the milestones and targets for Germany.
- Poland incurs an additional risk of missing its milestones and targets because, due to its rule of law issues<sup>49</sup>, Poland submitted its first payment request only in December 2023. In February 2024, the Commission made a positive preliminary assessment of all milestones relating to this payment request. In April 2024, the Commission made the first regular disbursement.

**95** The Innovation Fund is another major EU funding source for renewable hydrogen projects. It finances the following.

- Projects selected by the European Climate, Infrastructure and Environment Executive Agency, based on annual calls for projects. Details on the calls and funding are presented in [Annex XII](#).

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<sup>49</sup> For details, see [special report 03/2024](#).

- An innovative instrument, called the [Hydrogen Bank](#), launched in 2023. See details on the [pillars](#) of this instrument in [Box 4](#).

#### **Box 4**

##### **The pillars of the Hydrogen Bank**

Domestic pillar: EU producers of renewable hydrogen can bid for support at an auction in the form of a fixed premium per kilogram of hydrogen produced. In a market where non-renewable hydrogen is still cheaper to produce, the premium (subsidy) is intended to bridge the gap between the price of production and the price that consumers are currently willing to pay. The Innovation Fund finances this pillar.

International pillar: third country producers willing to export to the EU can bid for support at an auction in the form of a green premium.

Apart from these financing mechanisms, the aim of the Bank is to improve coordination between the existing EU and member state support instruments, and ensure transparency and coordination of information to support market and infrastructure development.

**96** The Innovation Fund was positively perceived by the stakeholders we met. Under the REPowerEU plan, the Commission announced that the funding available under the 2022 large-scale call would be increased to €3 billion. For the first time, this included a specific REPowerEU window to fund “innovative clean technology manufacturing” (such as electrolyzers). However, we also found that the time between the launch of a call for projects and the final grant decision was around 13 to 14 months. In an inflationary context, this time lag has an effect on final project costs.

**97** Points to note with regard to the European Hydrogen Bank.

- The Commission president [announced](#) in November 2023 that additional auctions for domestic hydrogen producers would take place in 2024. Combined with the 2023 auction (for €800 million), the total amount made available would reach €3 billion. The Commission has not yet made a financing decision for the additional €2.2 billion. There is still no clarity or certainty for the market in terms of the budget that will be available beyond 2024.

- The Commission has not yet allocated funding to the international pillar. Instead, it is considering combining resources from member states (“Team Europe approach”) and making use of the **H2Global** initiative, which was put in place by a German foundation. In 2022, with German funding, a subsidiary of the foundation organised the first auction for importers.

### No guarantee yet that available public funding allows hydrogen production potential across the EU to be harnessed

**98** To ensure that a hydrogen market with a European mindset develops, the following factors play a key role:

- as a priority, renewable hydrogen should be made available to hard-to-decarbonise sectors where no other energy or cost-efficient alternatives are available<sup>50</sup>;
- member states should use their potential for producing renewable hydrogen, in particular those that also have potential for producing the renewable power required, to export surplus renewable hydrogen within the EU;
- an interconnected European hydrogen backbone (transmission and distribution network, plus storage) should be created so that renewable hydrogen can be transported from producers to buyers.

**99** According to a research paper<sup>51</sup>, member states such as Spain, France, Sweden, Finland, Poland, Greece and Italy have high or good potential for creating a renewable energy surplus. This can be used to produce renewable hydrogen. At the same time, the majority of hard-to-decarbonise industrial sites are situated in Germany, Italy, France, Spain (but not necessarily in the regions of these countries which have good potential for producing hydrogen from renewable energies), Poland and the Netherlands. Not all of these countries have good potential to produce renewable hydrogen.

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<sup>50</sup> See for example 2024 directive (**gas package**), Article 3.

<sup>51</sup> Quitzow, R.; Triki, A.; Wachsmuth, J.; Fragoso Garcia, J.; Kramer, N.; Lux, B.; Nunez, A. (2023): *Mobilizing Europe’s Full Hydrogen Potential: Entry-Points for Action by the EU and its Member States*. HYPAT Discussion Paper No 5/2023. Karlsruhe: Fraunhofer ISI (Ed.).

**100** Both for renewable hydrogen production and network development, we analysed data from different sources for projects that are likely to be implemented ((i) project announcements collected by the International Energy Agency, (ii) projects included in the most relevant hydrogen-related IPCEIs, and (iii) [projects of common and mutual interest](#)). Furthermore, we analysed the EU funding available under the two most significant sources (the Innovation Fund and the RRF).

**101** Looking at hydrogen production (see [Annex XIII](#)), we found that the majority of projects that have been announced as being at an advanced stage or in the feasibility study stage (61 %, data of the International Energy Agency) are concentrated in four member states<sup>52</sup>. These four member states produce a significant share of the EU's total greenhouse gas emissions from hard-to-decarbonise industry. Moreover, we identified the following.

- Among the six member states with a significant share of hard-to-decarbonise industry, Poland in particular does not yet have any major-sized projects (in GW) that are at an advanced or feasibility study stage, nor is it among the biggest recipients of EU funds for hydrogen-related projects.
- Of the other 21 member states (i.e. those with a less significant share of hard-to-decarbonise industry, but which may also have future needs for energy storage and renewable hydrogen-based fuels), only seven have planned projects (as per data of the International Energy Agency). Among those seven are nearly all those with good or high potential for renewable energy production. The exception is Romania: it has good potential for renewable energy production but does not have any projects at an advanced stage or in the feasibility study stage.
- As these 21 member states only have a few projects, they have consequently received little or no funding from the Innovation Fund. Most of these countries only earmarked small amounts for renewable hydrogen under the RRF (see [Annex XI](#)). It is therefore not known whether or when these projects will be implemented.

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<sup>52</sup> Germany, Spain, France, the Netherlands.

**102** Looking at the hydrogen network (see *Annex XIV*), we found that around 90 % of the projects in the feasibility study stage (in terms new pipelines to be built) are concentrated in four member states<sup>53</sup>. These four member states produce a significant share of the EU's total greenhouse gas emissions from hard-to-decarbonise industry. Moreover, we identified the following.

- Of the six member states with a significant share of hard-to-decarbonise industry, all but Poland have projects that are in the feasibility study stage, but some member states are more advanced than others (see examples from the Netherlands and Germany in *Box 5*). Member states have only earmarked small amounts for hydrogen networks under the RRF.

#### Box 5

##### Network development in the Netherlands and Germany

In the last quarter of 2023 in the Netherlands, the transmission system operator started constructing the first part of the national hydrogen network. Around 85 % of the network is estimated to consist of repurposed gas pipelines<sup>54</sup>. The estimated cost for the entire national hydrogen network is €4.5 billion.

In Germany, a plan for a 9 700 km core network was published at the end of 2023. It is estimated that around 60 % of the network will consist of repurposed gas pipelines. The estimated core network cost (to be established by 2032) is €19.8 billion<sup>55</sup>.

- Of the other 21 member states, several have no projects in the feasibility study stage. In particular, south-eastern EU member states do not yet have any projects of common and mutual interest. Of those countries with good or high potential for renewable energy production, only Portugal had projects in an advanced stage or that already had a feasibility study (as of October 2023). Moreover, none of the countries has earmarked RRF funding for their networks.

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<sup>53</sup> Germany, Spain, France, Italy.

<sup>54</sup> Gasunie [website](#).

<sup>55</sup> FNB Gas [website](#).

- Projects of common and mutual interest can apply for funding under the Connecting Europe Facility-Energy. As hydrogen projects are mostly at an early stage the facility is likely to mainly finance feasibility and technical studies in the next few years. National funding will be necessary for other project stages. *Annex VII* shows the infrastructure as planned under the projects of common and mutual interest and the IPCEI Hy2Infra.
- The low amount of EU funding allocated for the network tallies with the national hydrogen strategies, most of which provided few or no details on infrastructure. We analysed the draft NECPs available as of 31.12.2023 for the three of the four<sup>56</sup> member states we visited, plus another five (Belgium, Czechia, France, Italy and Romania). We found that all but Romania refer to hydrogen infrastructure and, in particular, to the projects of common and mutual interest. However, four of these eight member states (Czechia, Spain, France and Romania) provided little or no information on how they expect the infrastructure to be financed.

**103** The fact that projects are planned (whether hydrogen production or network projects) does not mean that they will all be implemented. However, network functionality will crucially depend on all involved member states doing their part. Examples include the following.

- Projects under the IPCEIs do not automatically qualify for EU funding. Moreover, there is no guarantee that they will receive any national funding, because this depends on each country's fiscal space (see paragraph [76](#)).
- Member states have to analyse how to finance their network. Networks are usually financed with user fees. However, the hydrogen network needs to be developed at a time with uncertainty about future demand and uncertainty about when booked capacity will match the network's technical capacity. The gas package Regulation allows network development costs to be spread over time. Through an inter-temporal cost allocation, this allows member states to provide for the possibility that future users will pay part of the initial costs.

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<sup>56</sup> The Polish NECP was not available as of 31.12.2023.

**104** So far, RRF and Innovation Fund funding for hydrogen are concentrated in a limited number of member states (see also *Annex XI* and *Annex XII*). For the other EU funding sources, the situation is as follows.

- The Modernisation Fund: only eastern and central EU member states, Greece and Portugal (i.e. 13 lower-income member states) can make use of the Fund. However, only two member states (Czechia and Slovakia) have so far put in place multi-technology grant schemes, which may (but do not have to) include renewable hydrogen projects.
- Cohesion policy funds: no information is yet available regarding whether or to what extent member states and regions intend to use these funds for hydrogen-related projects (see paragraph [85](#)).

**105** In early 2023 the Commission [announced](#) that it would explore the possibility of pooling member states' resources and increasing efforts at EU level. It also [called](#) for greater EU funding to avoid exacerbating any regional disparities in scaling up the net zero industry. However, the resulting Regulation<sup>[57](#)</sup> establishing the Strategic Technologies for Europe Platform does not provide for additional funds. Instead, investments in critical technologies may benefit from higher co-financing (up to 100 %) under the 2021-2027 cohesion policy funds (and retroactively for the final accounting year of the 2014-2020 period).

**106** Looking at overall public funding (EU and national) for hydrogen-related investments, we found that the Commission does not have a complete or up-to-date overview. The Commission has requested annual studies on energy subsidies<sup>[58](#)</sup> since 2020, but these studies have mainly highlighted data quality issues (e.g. scattered or non-consolidated data). They did not provide their own estimates of national public funding for hydrogen-related investments. In fact, similarly to the Commission's programmes, member states' funding schemes are also often multi-technology programmes, which require assumptions about the share of funding that will be allocated to the different technologies, e.g. hydrogen.

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<sup>57</sup> Regulation (EU) 2024/795.

<sup>58</sup> Studies were carried out twice prior to 2020, once for 2014 and again for 2018.

## Insufficient coordination efforts by the Commission, both internally and with member states, but also with industry

**107** In a 2015 Communication<sup>59</sup>, the Commission expressed its vision of the Energy Union. Among other things, in this union “Member States see that they depend on each other to deliver secure energy to their citizens, based on true solidarity and trust”. The Commission also stressed that the EU should speak with one voice because “a stronger and more united EU can engage more constructively with its partners, to their mutual benefit.”

**108** We assessed the appropriateness of cooperation:

- within the Commission, and between the Commission and the member states; and
- between the Commission and industry.

**Neither internal Commission coordination nor coordination between the Commission and member states yet ensures that all parties are pulling in the same direction**

**109** Several Commission DGs are responsible for different aspects of the hydrogen value chain financing, as indicated in [Figure 12](#). Internal coordination is dealt with through various procedures and processes. To a certain extent, there may be differences in objectives various DGs pursue or between various policies. Some examples follow.

- There is an inherent trade-off between energy efficiency (a priority of DG ENER) and rapidly ramping up the value chain to allow certain industrial sectors to decarbonise (a priority of DG GROW) (see paragraph [56](#)).
- There is also a mismatch between energy security (reducing strategic dependence on Russia by reducing natural gas) and the use of low-carbon hydrogen, which is produced using fossil fuels with carbon capture methods. With the publication of the [Communication](#) on industrial carbon management for the EU in February 2024, low-carbon hydrogen (produced using natural gas with carbon capture methods) may come to the fore (see [Annex VIII](#)).

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<sup>59</sup> COM/2015/080.

- o The Commission announced or took initiatives either before there was any clarity or where there was (and is) no clarity about the availability of funding or the path to implementation (see also paragraph 97, last indent).

**110** Overarching coordination between the Commission and the member states mainly takes place through a specific network, the [Hydrogen Energy Network](#). This network organises meetings twice a year. Our review of the minutes showed that this network is a forum for sharing information (including the work of international organisations and the Commission) rather than for discussing strategic issues. As yet, however, this forum was not used to discuss a common vision for the hydrogen value chain in the EU. Examples of this would be the following.

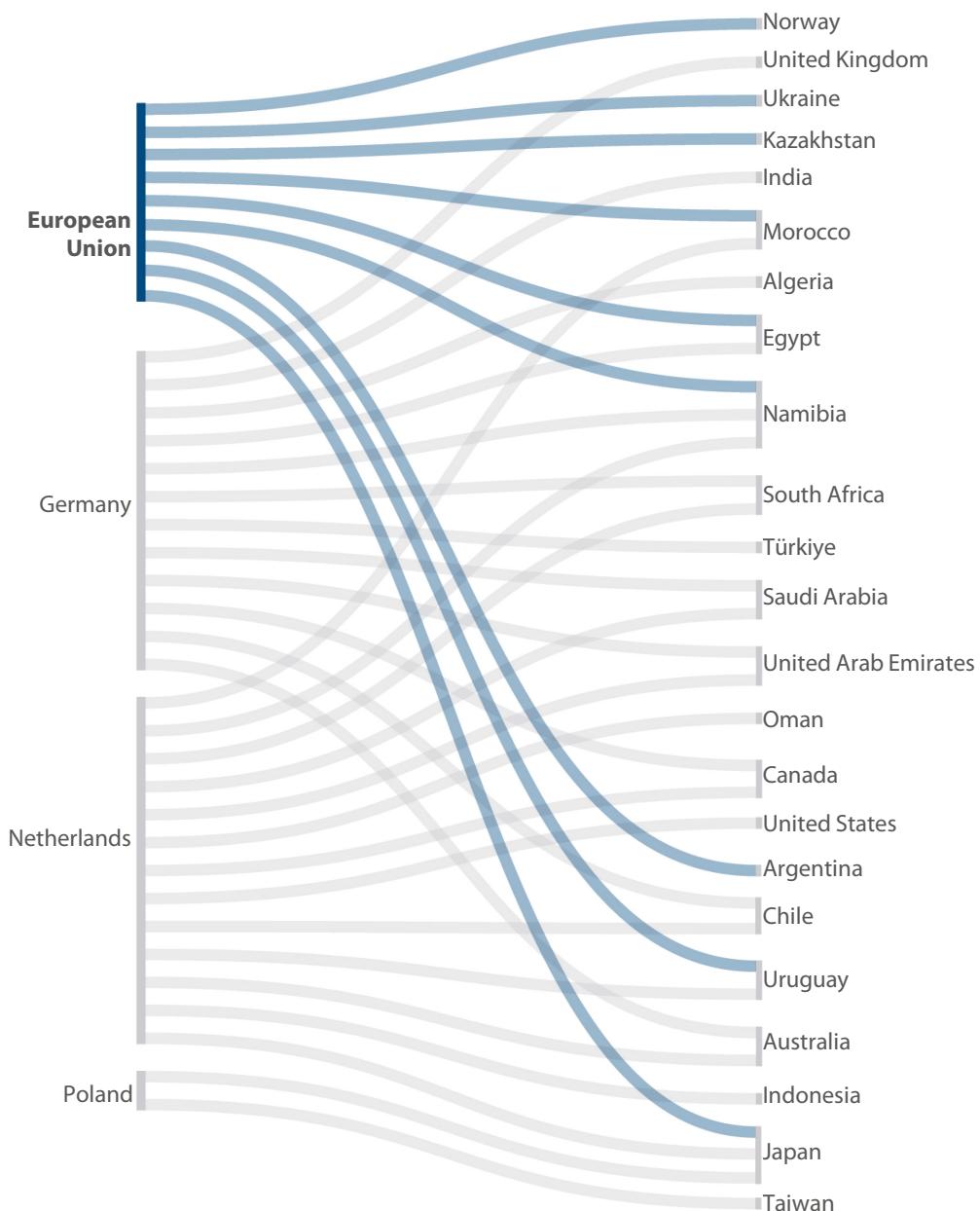
- o How can we best coordinate different funding sources to avoid an imbalance in development across the EU (see paragraphs 98-106)?
- o How and where can we ensure and support the production of renewable hydrogen in the EU? This is even more important, as member states may have diverging interests and approaches, including with regard to the level of protectionism.

The member state representatives we interviewed during our audit also confirmed that there was no single point of contact within the Commission for strategic hydrogen-related issues.

**111** Moreover, we found that the Commission did not provide any guidance or support to member states on how to establish their strategies, nor did it discuss its targets (either initial or updated, see [Figure 6](#)) with the member states to ensure that they were working together towards the same outcome (see paragraphs 31-37 on the diverging nature of the national strategies).

**112** To pave the way for possible hydrogen imports or for technological cooperation, three of the four member states we visited are actively establishing energy or hydrogen partnerships, or signing memoranda of understanding with countries outside the EU. In addition, the Commission is also active in establishing partnerships. The partnerships and memoranda are illustrated in [Figure 13](#).

**Figure 13 – Hydrogen partnerships and memoranda with countries outside the EU (as of mid-March 2024 for member states and as of end-2023 for the Commission)**



Source: ECA, based on Commission documents and our visit to four sampled member states.

**113** At present, there is no overall EU import strategy. The Commission coordinates EU external action in relation to hydrogen policy through the Council. As unanimity is required, the Commission also seeks Council's approval before signing a memorandum of understanding with a third country on behalf of the EU. However, the individual member states' steps to organise cooperation with third countries are not coordinated. This means that the EU is not yet speaking with one voice, although this

was one of the aims set out in a 2015 Commission communication (see paragraph 107).

**114** Nevertheless, in 2020, the Commission started [Team Europe initiatives](#), which are bundling efforts with member states to foster the development of renewable hydrogen projects in third countries. However, so far there have only been four such initiatives. Member states participate on a voluntary basis: those that have participated so far are Belgium, Germany, Spain, France and the Netherlands.

### **Good first results from coordination between the Commission and industry, but momentum slowed after 2 years**

**115** Immediately after issuing the Hydrogen Strategy in July 2020, the Commission set up the [European Clean Hydrogen Alliance](#), which consisted of members from industry, public authorities, civil society and other stakeholders. The Alliance's aim is to promote investments and stimulate clean hydrogen production and use, and to accelerate the decarbonisation of industry in line with climate change objectives. The Alliance set up a number of [roundtables and working groups](#), covering different areas of the value chain.

**116** The Alliance operates alongside other organisations that were set up by industry itself, such as [Hydrogen Europe](#) and the [European Hydrogen Backbone](#), which is an initiative of 31 energy infrastructure operators that define a developing network of essential pipelines.

**117** One major outcome of the Alliance's work, as requested by the Commission, was a specific [pipeline](#) of projects to stimulate rolling out the production and use of hydrogen. The list of projects was issued in November 2021 and was updated in November 2022. However, we found that the list included very limited information on project characteristics (e.g. there was no information on financial needs, viability, or production capacity) and project status (i.e. whether it was in the conceptual phase, or if feasibility studies were being carried out). Moreover, this pipeline is out of date: little new information was added with the 2022 update, and no further updates have been added since then. We note that after we discussed this with relevant Commission services, the latter launched a survey (in December 2023) to obtain updated project information.

**118** Apart from this list of projects, the Alliance also produced a number of other reports. The Commission did not systematically follow up all findings from all of the reports.

**119** The Commission changed the composition of the Alliance's roundtables in March 2023. We interviewed members from different roundtables who indicated that there was no clear mandate for upcoming work and that they had noted a general slowdown in activity.

## Conclusions and recommendations

**120** With the publication of the Hydrogen Strategy for the EU, for the first time the Commission had a central role to play in creating a new market. Our overall conclusion is that the Commission was partially successful in creating the necessary conditions for this market. While the Commission took a number of positive steps, challenges remain all along the hydrogen value chain.

**121** With its 2020 Hydrogen Strategy and the 2022 REPowerEU plan, the Commission set targets at EU level for renewable hydrogen production and for importing renewable hydrogen. Both documents are Commission communications, and as such are therefore non-binding. There was less focus on low-carbon hydrogen at the time: although it was mentioned, no targets were set (see paragraph [24](#)).

**122** We found that the renewable hydrogen targets were not clearly defined. Moreover, they were driven by political will rather than being based on robust analyses. In addition, at the time of writing, it is unlikely that these targets for 2030 can be achieved (see paragraphs [25-30](#) and [38-45](#)).

**123** It is not mandatory for member states to prepare hydrogen strategies, but they did have to provide updated national energy and climate plans by mid-2023 (final versions have to be submitted by mid-2024), including reporting on measures to achieve the non-binding EU targets. The Commission reviewed the draft national plans and issued recommendations to member states. However, it did not ask them to set targets in line with the EU's targets. The Commission did not establish a coordination process with member states to ensure a certain degree of alignment. In fact, member states did not necessarily align their targets and measures with those of the EU. They are not all moving at the same speed or with the same level of ambition. In late 2023, the Commission president announced that the Commission will assess how member states plan to implement the national hydrogen commitments to provide a clear roadmap towards 2030 in each member state (see paragraphs [31-37](#)).

**124** Within a relatively short period of time, the Commission has proposed most of the legal acts to regulate the hydrogen market. An act defining the methodology for assessing greenhouse gas emissions savings for low-carbon hydrogen is still outstanding. Work on standardisation and certification is still required (see paragraphs [47-50](#)).

**125** Industry representatives indicated to us that they had deferred investment decisions until the rules for producing renewable hydrogen (Delegated Act) were published in June 2023. Once published, these rules delivered the much needed legal certainty. However, the Commission had not yet assessed the impact of these rules on either the cost or the timing for rolling out renewable hydrogen. The Commission is now required to carry out such an assessment before mid-2028. In fact, several public studies show that the temporal correlation (hourly correlation) rule increases the production cost for renewable hydrogen, thereby reducing its competitiveness compared to fossil-based hydrogen (see paragraphs [42](#) and [61](#)).

**126** On the positive side, we found the following.

- Targets for the use of renewable hydrogen in industry and transport as introduced by several EU legal acts boost demand (see paragraphs [28](#) and [63](#)).
- The Commission asked member states to address the slowness of domestic permitting processes in their national energy and climate plans and took several legislative measures requiring member states to accelerate the process (see paragraphs [64-66](#)).

**127** The timelines established in the various legal acts relating to the permitting process varied. The Commission has not yet established a plan to monitor member states' implementation of permitting process reforms (see paragraphs [66-68](#)).

**128** The speed and degree of implementation of the legal requirements relating to demand targets and permitting depend on the member states. For example, some member states consider that certain demand targets are unrealistic and very difficult to achieve. Apart from lengthy and time-consuming infringement proceedings, the Commission has no means to ensure that member states adhere to these targets or requirements (see paragraphs [63](#) and [68](#)).

**129** The Commission estimated the amount of investment that would be needed to create a market for renewable hydrogen, but did not consider all parts of the hydrogen value chain. Our analysis showed that the demand side was not properly considered and that the Commission's estimates across different documents were not consistent (see paragraphs [80-82](#)).

**130** The Commission does not have complete data on allocated or planned national public funding for renewable hydrogen. For the 2021-2027 period, total EU funding for hydrogen-related projects is currently estimated at €18.8 billion, mostly funded by the

Recovery and Resilience Facility. EU funding is available for the supply and demand side of the hydrogen value chain. On the demand side, the Commission has not yet developed the key scheme announced in its Hydrogen Strategy, namely “Carbon Contracts for Difference”. Regarding the innovative Hydrogen Bank, there is still no clarity in terms of the budget that will be available beyond 2024 (see paragraphs [83-86](#), [91-97](#) and [106](#)).

**131** EU funding is scattered over several programmes with different funding rules. This makes it difficult for hydrogen project developers to determine which programme is best suited to their project. The Commission has developed a webpage to provide information on various EU funding programmes, but at the time of our audit this webpage was not yet fully operational. In late 2023, the Commission president announced that the Commission would relaunch a one-stop shop solution to guide project developers on EU funding (see paragraphs [83-90](#)).

**132** In the years to come, large amounts of investments will be required all along the hydrogen value chain, the bulk of which will have to be provided by the private sector. In an emerging market like hydrogen, there is a case to incentivise and support industry in making these investments, be it through national and EU public funding or through public authorities that build the essential infrastructure.

- The Commission amended certain state aid rules to ease the provision of state aid and support the green transition. However, long approval times for state aid, which was the case for some notifications, can negatively affect projects’ planned costs and start dates (see paragraphs [69-77](#)).
- Furthermore, even when the Commission allows state aid to be provided, it does not mean that member states actually have to deliver it (see paragraphs [76](#) and [103](#)).
- Member states set their own priorities on how to use some of the most important EU funding sources for hydrogen, namely the Recovery and Resilience Facility and cohesion policy funding. Given their specific situation and the importance they attach to renewable hydrogen, some member states use the Facility significantly more than others (see paragraphs [93-94](#), [101-102](#) and [104](#)).
- While the eastern and central EU member states (plus Portugal and Greece) can use the Modernisation Fund, so far only two member states have put multi-technology grant schemes in place, which can include hydrogen projects (see paragraph [104](#)).

**133** So far, planned projects (at an advanced and in the feasibility study stage) for renewable hydrogen (production and networks) have been concentrated in a limited number of member states, in particular those where hard-to-decarbonise industries are primarily located. The same applies to the bulk of the EU funding allocated. However, not all of the member states which are currently more advanced with regard to renewable hydrogen have sufficient potential for renewable energy production and consequently renewable hydrogen production. As yet, there is therefore no guarantee that available public funding allows the EU to (i) fully harness member states' hydrogen production potential and (ii) transport hydrogen across the EU (see paragraphs [98-106](#)).

**134** The Commission took steps to coordinate the ramp-up of the hydrogen value chain, but coordination within the Commission and between the Commission and member states does not yet ensure that all parties are moving in the same direction. Numerous Commission directorates-general are responsible for specific aspects of the hydrogen value chain and pursue objectives which are not always aligned. The Commission has not yet used the existing fora to discuss key strategic issues on the future of the hydrogen value chain in the EU with member states. Moreover, the Commission did not provide guidance or support to member states about how to establish their national hydrogen strategies. With regard to coordination with industry, the Commission set up the European Clean Hydrogen Alliance, but after a promising start, momentum slowed (see paragraphs [107-119](#)).

## **Recommendation 1 – Following a reality check, make strategic choices on the way ahead without creating new strategic dependencies**

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In close collaboration with the member states, the Commission should decide on the strategic way forward towards decarbonisation without altering the competitive situation of key EU industries, which could potentially result in further deindustrialisation. In particular, the Commission should

- (a) update its Hydrogen Strategy based on a careful assessment of the following aspects:
  - (i) how to calibrate market incentives for renewable and low-carbon hydrogen production and use, taking recent legislative changes into account,
  - (ii) how to prioritise scarce EU funding (e.g. focusing on which parts of the value chain),
  - (iii) the geopolitical implications of EU production compared to imports from non-EU countries (i.e. which industries does the EU want to keep and at what price),
- (b) update the renewable hydrogen production and import targets set by the REPowerEU plan so that they are ambitious but realistic. In so doing, it should consider regional and industrial sector specificities and the role of low-carbon hydrogen.

**Target implementation date: end-2025**

## **Recommendation 2 – Set out an EU roadmap and monitor progress**

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In close collaboration with the member states, the Commission should

- (a) set out and publish an EU roadmap for the development of a hydrogen value chain towards 2030 and beyond, based on its assessment of the national energy and climate plans and its updated Hydrogen Strategy,
- (b) monitor the EU's and member states' progress in achieving binding and non-binding targets by means of a scoreboard.

**Target implementation date: mid-2026**

## **Recommendation 3 – Obtain reliable national funding data and assess the appropriateness of EU funding arrangements accordingly**

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The Commission should do the following.

- (a) Work in close cooperation with member states and if necessary, propose reporting obligations to obtain information on investment plans and on planned and actual national public funding for the market ramp-up – at least for the industries to be identified under Recommendation 1. It should report on this overview, for example in the reports on the state of the Energy Union. The overview should cover all parts of the hydrogen value chain.
- (b) Assess whether the current EU funding arrangements are appropriate for the future development of the hydrogen value chain across the EU.

**Target implementation date: end-2025**

## **Recommendation 4 – Monitor permitting processes in the member states**

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The Commission should monitor permitting processes in the member states and check whether they adhere to the timelines set in various legal acts, potentially including this aspect in the European Semester process.

**Target implementation date: end-2025 (or later if the relevant legal acts set deadlines for transposing the legislation into national law that are after the end of 2025)**

## **Recommendation 5 – Take a clear decision on support and coordination actions with and for the hydrogen industry**

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The Commission should do the following.

- (a) Create a one-stop shop solution for stakeholders under the European Hydrogen Bank and guide hydrogen project developers on available EU funding.
- (b) Decide on the future of the Clean Hydrogen Alliance in terms of its scope and number of roundtables and adopt a clear and time-bound mandate for its future work.

**Target implementation date: mid-2025**

This report was adopted by Chamber II, headed by Mrs Annemie Turtelboom, Member of the Court of Auditors, in Luxembourg at its meeting of 5 June 2024.

*For the Court of Auditors*

Tony Murphy  
*President*

# Annexes

## Annex I – Support for renewable hydrogen in the United States

The US adopted two legal acts which are particularly relevant to renewable hydrogen:

- the [Bipartisan Infrastructure Law](#) (2021) includes \$9.5 billion for clean hydrogen initiatives, of which \$8 billion is for regional clean hydrogen hubs and \$1 billion is for a clean hydrogen electrolysis programme;
- the [Inflation Reduction Act](#) (2022) provides for a hydrogen production and investment tax credit.

The Inflation Reduction Act provides the following relating to hydrogen production.

- A tax credit<sup>60</sup> for the production of clean hydrogen, which is uncapped and available for 10 years from the moment a production facility comes into operation, but construction must start before 1 January 2033.
- Technology-neutral support, which is based on carbon intensity, meaning that the higher the carbon intensity, the lower the support. The highest carbon intensity for which support can be obtained is 4 kilogrammes (kg) of CO<sub>2</sub> equivalent per kilogramme of hydrogen. The amount of support ranges from \$0.6 to \$3 per kg of hydrogen produced. According to a study<sup>61</sup> by the *Institut der deutschen Wirtschaft*, the defined carbon intensity is such that (i) hydrogen produced using the current electricity mix in the grid is not within the carbon intensity range for which support can be obtained, and (ii) the highest support is currently only possible by operating using exclusively renewable electricity.
- A tax credit for carbon oxide sequestration<sup>62</sup>.
- Local content requirements: a 10 % increase in the tax credit is possible where an electrolyser is manufactured with US materials.

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<sup>60</sup> See Article 45V of the Internal Revenue Code.

<sup>61</sup> Küper, Malte, 2023, *Wasserstoff im Inflation Reduction Act. Was ist drin für Deutschland und die EU?*, [IW-Kurzbericht](#), Nr. 8, Köln.

<sup>62</sup> See Article 45Q of the Internal Revenue Code.

## Annex II – Renewable Energy Directive (RED III): targets

The Directive sets targets for the use of renewable fuels of non-biological origin (RFNBOs) (including renewable hydrogen) in industry and in the transport sector, as shown in the following table.

### 2030 and 2035 targets

Sector	Targets
Overall	Increase the share of renewable energy in the EU's overall energy consumption to 42.5 % by 2030, with an additional 2.5 % indicative top-up so that the 45 % target can be achieved.
Industry	<p>Industry will need to annually increase its use of renewable energy by 1.6 %.</p> <p>42 % of the hydrogen used in industry should come from RFNBOs by 2030 and 60 % from this source by 2035.</p> <p>Member states will be able to discount the RFNBOs' contribution for industrial use by 20 % if:</p> <ul style="list-style-type: none"> <li>○ the member state's national contribution to the binding overall EU target tallies with their expected contribution;</li> <li>○ the share of hydrogen from fossil fuels consumed in the member state does not exceed 23 % in 2030 and 20 % in 2035.</li> </ul>
Transport	<p>Member states will have the possibility to choose between:</p> <ul style="list-style-type: none"> <li>○ a binding target of a 14.5 % cut in greenhouse gas intensity from transport by using renewables (by 2030); or</li> <li>○ a binding share of at least 29 % from renewables in the transport sector's final energy consumption (by 2030).</li> </ul> <p>The new rules establish a binding combined sub-target of 5.5 % for advanced biofuels (generally derived from non-food-based feedstocks) and RFNBOs (mostly renewable hydrogen and hydrogen-based synthetic fuels) in the share of renewable energies supplied to the transport sector.</p> <p>Within this target, there is a minimum requirement of 1 % from RFNBOs in the share of renewable energy supplied to the transport sector in 2030.</p>

Source: EU legal acts.

### Annex III – Information on the member states we visited

	Germany	Spain	Netherlands	Poland
Strategic vision				
○ Hydrogen strategy (initial document)	YES, June 2020	YES, October 2020	YES, April 2020	YES, January 2021
○ Other document establishing targets	Not applicable	Updated NECP	Updated NECP; Letters to Parliament	NO
○ Update of the document	YES, July 2023	NO, but expected after the approval of the NECP	NO	NO
Targets for production: electrolyser installed capacity by 2030 in GW	10	4	4 GW (8 GW in 2032) <sup>3</sup>	2
Projects to increase the hydrogen production capacity in GW <sup>1</sup> and estimated to be in operation by 2030				
○ Final investment decision adopted or under construction	0.5	0.1	0.2	0.01
○ Projects under feasibility study, final investment decision adopted or under construction	5.7	12.6	8.8	0.3
○ All projects announced	11.7	45.9	13.1	1.3
Import				
○ Targets for import of hydrogen or	NO	NO	NO	NO

	Germany	Spain	Netherlands	Poland
o Estimation of amount of hydrogen to be imported	YES	NO	NO	NO
o Import strategy exists	No, but planned	NO	NO	NO
Partnerships with non-EU countries to prepare possible hydrogen imports	YES	NO	YES	NO
Demand-side measures exist	YES	YES	YES	NO
Targets based on an estimation of the needs/usage assumptions	YES	YES	NO	NO
Needs for additional renewable electricity generation capacity (solar/wind) estimated/taken into account	YES	YES	YES	Unknown
Network planning started at national level (beyond the process for identifying PCIs)	YES	YES	YES	NO
o integrating IPCEIs	YES	Not applicable	YES	NO
o integrating PCIs	YES	YES	YES	NO
o integrating cross-border connections	YES	YES	YES	NO
o integrating import points (such as harbours)	YES	YES	YES	NO
o integrating storage	YES	YES	YES	NO
Use of EU funds				
o Recovery and Resilience Facility	YES	YES	YES	YES
o Cohesion policy	The 2021-2027 programmes include the possibility of using funding for hydrogen. However, there is no or limited information on the amounts earmarked.			The 2021-2027 programmes include the possibility of using funding for hydrogen. However, there is no or limited information on the amounts earmarked.

	Germany	Spain	Netherlands	Poland
<input type="radio"/> Innovation Fund	YES	YES	YES	YES
National subsidy schemes exist	YES	Only for R&D projects	YES	Only for R&D projects
<input type="radio"/> Covering the whole value chain	YES	NO	YES	NO
<input type="radio"/> Covering capital expenditure	YES	NO	YES	NO
<input type="radio"/> Covering operational expenditure	YES	NO	YES	NO
Use of the TCTF state aid regime (cut-off date: 31.12.2023)	YES, including in the context of multi-technology schemes	YES, in the context of multi-technology schemes	NO	NO
Projects approved as PCIs	YES	YES	YES	YES
Projects included in IPCEIs				
<input type="radio"/> Hy2Tech	YES	YES	YES	YES
<input type="radio"/> Hy2Use	NO	YES	YES	YES
<input type="radio"/> Hy2Infra <sup>2</sup>	YES	NO	YES	YES

<sup>1</sup> ECA based on [International Energy Agency](#) data (as of October 2023).

<sup>2</sup> Pending approval.

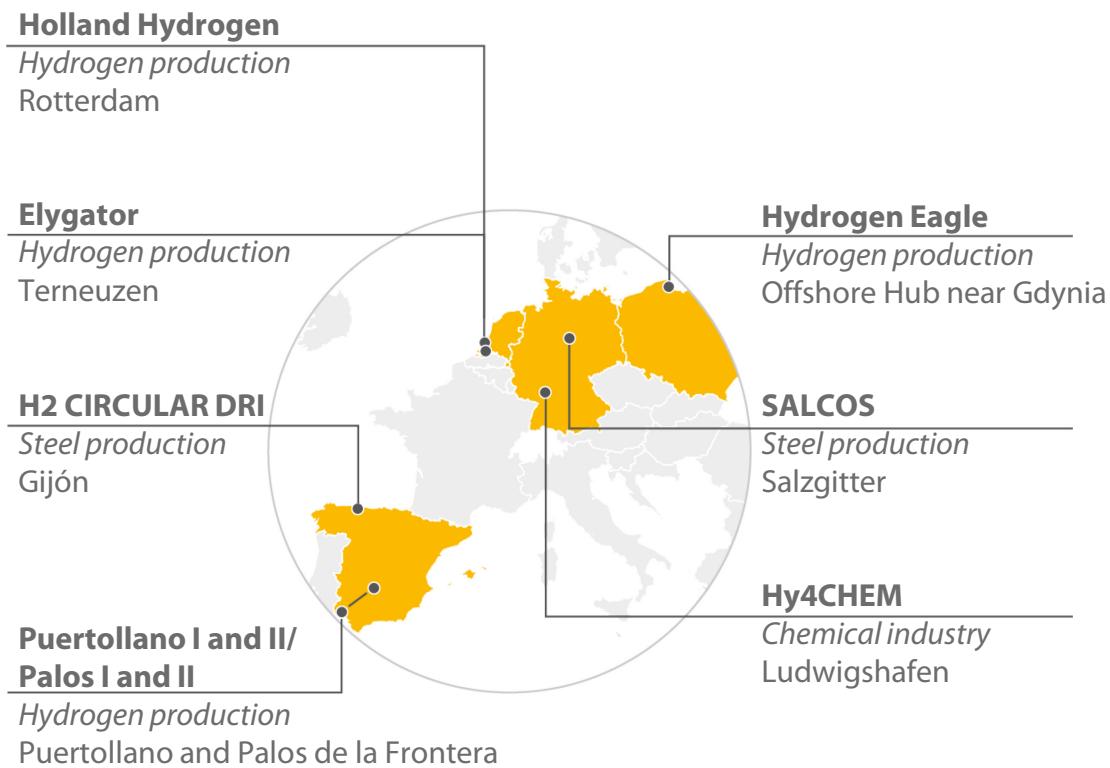
<sup>3</sup> As specified in the Minister's letter to Parliament of June 2023, the aim for 2032 is 8 GW.

Source: ECA.

## Annex IV – Information on the projects we analysed

The following figure shows the location of the projects visited as well their industrial sector. The table provides detailed information on the projects visited (as of February 2024).

### Location of projects visited



Source: ECA.

Project	HY4Chem	SALCOS	H2 CIRCULAR DRI	PUERTOLLANO I and II/ PALOS I and II	Holland Hydrogen	ELYgator	Hydrogen Eagle
Member state	Germany		Spain		Netherlands		Poland
Short description	Construction and installation of an electrolyser, amongst others to replace fossil-based hydrogen in chemical production processes	Construction and installation of a direct reduction plant and electric arc furnace to replace one blast furnace and substitute the use of carbon with hydrogen, amongst others  Construction and installation of an electrolyser	Migration of steel production from a carbon-intensive route to a direct reduction technology	Construction of electrolyzers in two different locations in four phases to produce renewable hydrogen (to be used initially mainly for the production of fertilisers)	Construction of an electrolyser in the Port of Rotterdam, which will operate with renewable electricity from offshore wind farms in the North Sea  The renewable hydrogen will be supplied to a refinery and later to the mobility sector	Construction of an electrolyser to enable renewable hydrogen generation for industrial and mobility customers	Construction of a comprehensive infrastructure for the production and distribution of low- and zero-carbon hydrogen in Poland, including: hydrogen production facilities, electrolyzers, hydrogen storage infrastructure and a network of refuelling stations
Industrial sector	Chemical	Steel	Steel	Hydrogen production	Hydrogen production	Hydrogen production	Hydrogen production and distribution

Project	HY4Chem	SALCOS	H2 CIRCULAR DRI	PUERTOLLANO I and II/ PALOS I and II	Holland Hydrogen	ELYgator	Hydrogen Eagle
Electrolyser	54 MW	100 MW	Not applicable	Total: 780 MW Phase 1: Puertollano I: 20 MW Phase 2: Palos I: 200 MW Phase 3: Puertollano II: 200 MW Phase 4: Palos II: 360 MW	400 MW (2 phases with 200 MW)	200 MW	110 MW
Project status	Started	Started	Awaiting final investment decision	Awaiting Final Investment Decision for phases 2, 3 and 4. Phase 1 operational and in final testing phase	Started (second phase awaiting final investment decision)	Under development	Awaiting final investment decision
Planned to be operational by	2025	2026	Unknown	Phase 1: 2022 Phase 2: 2026 Phase 3: 2027 Phase 4: 2028	2027	2026/2027	2031

Project	HY4Chem	SALCOS	H2 CIRCULAR DRI	PUERTOLLANO I and II/ PALOS I and II	Holland Hydrogen	ELYgator	Hydrogen Eagle
Project cost (in million euro)	134.8	1 592	924	1 060 (eligible cost) Phase 1: Puertollano I: 37  Phase 2: Palos I: 297  Phase 3: Puertollano II: 275  Phase 4: Palos II: 451	Data not public	Data not public	737
State aid regime	CEEAG	CEEAG	CEEAG	IPCEI Hy2Use	IPCEI Hy2Use	IPCEI Hy2Use	IPCEI Hy2Use
State aid approval date (Commission)	3.10.2022	4.10.2022	17.2.2023	21.9.2022	21.9.2022	21.9.2022	21.9.2022
Time between pre-notification and approval of state aid	13 months <sup>1</sup>	1 year <sup>1</sup>	1.5 years <sup>1</sup>	1 year <sup>1</sup>	1 year <sup>1</sup>	1 year <sup>1</sup>	1 year <sup>1</sup>
Grant approval date	31.8.2023	17.4.2023	Not yet approved	Not yet approved	National grant: 21.12.2022  Innovation Fund grant: 1.12.2022	National grant: 21.12.2022  Innovation Fund grant: 1.12.2022	Not applicable Grant process not launched

Project	HY4Chem	SALCOS	H2 CIRCULAR DRI	PUERTOLLANO I and II/ PALOS I and II	Holland Hydrogen	ELYgator	Hydrogen Eagle
Time between state aid approval and national grant approval	11 months	6.5 months	No grant yet	No grant yet (as of end February 2024)	3 months <sup>2</sup>	3 months <sup>2</sup>	No grant yet (as of end February 2024)
Grant amount (in million euro)	124.3	999.7	No grant yet	No grant yet	150 (approved so far) (national grant) 89 (Innovation Fund)	150.8 (national grant) 99 (Innovation Fund)	No grant yet
EU funding programme	Recovery and Resilience Facility	Recovery and Resilience Facility	Not applicable as no grant yet (planned under Recovery and Resilience Facility)	Not applicable as no grant yet (planned under Recovery and Resilience Facility)	Innovation Fund	Innovation Fund	Not applicable
Electrolyser built on existing industrial site	YES	YES	YES	YES	On port land	YES	No information  Studies are ongoing for hydrogen production installations

Project	HY4Chem	SALCOS	H2 CIRCULAR DRI	PUERTOLLANO I and II/ PALOS I and II	Holland Hydrogen	ELYgator	Hydrogen Eagle
Specific issues	Long period of time to obtain the national grant award (see above)	<p>In April 2023, the national authority launched a specific call for this project</p> <p>The project developer applied but made the execution of the project conditional on the successful subscription of energy supply contracts (renewable electricity and renewable hydrogen)</p> <p>Since these contracts have not yet been agreed, the grant has not yet been awarded</p>	--	No decision by the national authorities to award the grant yet although the company already applied for it in June 2020	The project developers have reportedly faced some difficulties with the increased price of electricity and due to the impact of the introduction of electrical grid fees at national level	<p>Higher cost due to price increases; sharp increase in tariffs for electricity transmission, absence of an incentivising regulatory framework</p> <p>See also paragraph <a href="#">94</a> on the rule of law issues</p>	National authorities have not yet launched a call for projects

<sup>1</sup> Pre-notification took place under IPCEI Hy2Use in September 2021.

<sup>2</sup> This is the time between IPCEI approval and the national grant approval. In addition, the two Dutch projects (Holland Hydrogen and Elygator) received a grant from the Innovation Fund.

Source: ECA.

## Annex V – Member states' hydrogen strategies

18 member states have hydrogen strategies (or in the case of Finland, a roadmap which is attached to the NECP). Based on our analysis of these documents, we found the following.

- Definition of hydrogen: six member states refer exclusively to renewable hydrogen, some take both renewable and low-carbon hydrogen into consideration, and others mainly refer to low-carbon hydrogen.
- Production: with the exception of five member states, all have targets for the installed electrolyser capacity (see *Table* below). The targets were expressed in GW; no member state set production targets for renewable hydrogen in terms of Mt.
- Demand-side measures: most strategies refer to different types of use, but barely include any estimates of needs. Moreover, with the exception of one strategy, none includes a clear set of instruments to support demand for renewable hydrogen.
- Import: hardly any targets have been set for import. Most strategies, however, indicate whether the country aims to be a main importer, exporter, or solely to produce for its own consumption.
- Transport and storage infrastructure: most strategies refer to the need for infrastructure, but most only include few or no further details, with the exception of Belgium, Denmark, Germany and the Netherlands.
- Investment needs: none of the strategies includes an estimate of the funding needs for the demand side, in particular the funding required to adapt industrial processes.

### Targets for renewable hydrogen in member states' strategies

Member state	Date of strategy	Targets for 2030 Electrolyser capacity in GW
Belgium	Oct-22	none
Bulgaria	May-23	none
Czechia	Sep-21	none
Denmark	Mar-22	4-6
Germany	Jun-20 updated in May- 23	10 (strategy targets updated in July 2023)
Estonia	Feb-23	0.15
Ireland	Jun-23	0.2-0.5
Spain	Oct-20	4
France	Sep-20	6.5
Croatia	Mar-22	0.07-1.3
Luxembourg	Sep-21	None
Hungary	May-21	0.24
Netherlands	Apr-20	3-4 GW Ambition ("streefdoel") for 2032 increased to 8 GW
Austria	Jun-22	1
Poland	Jan-21	2
Portugal	Aug-20	1.5-2.5
Slovakia	Jun-21	None
Finland	Sep-22	1

Note: Those adopted following the Commission's REPowerEU Communication are marked in light blue.

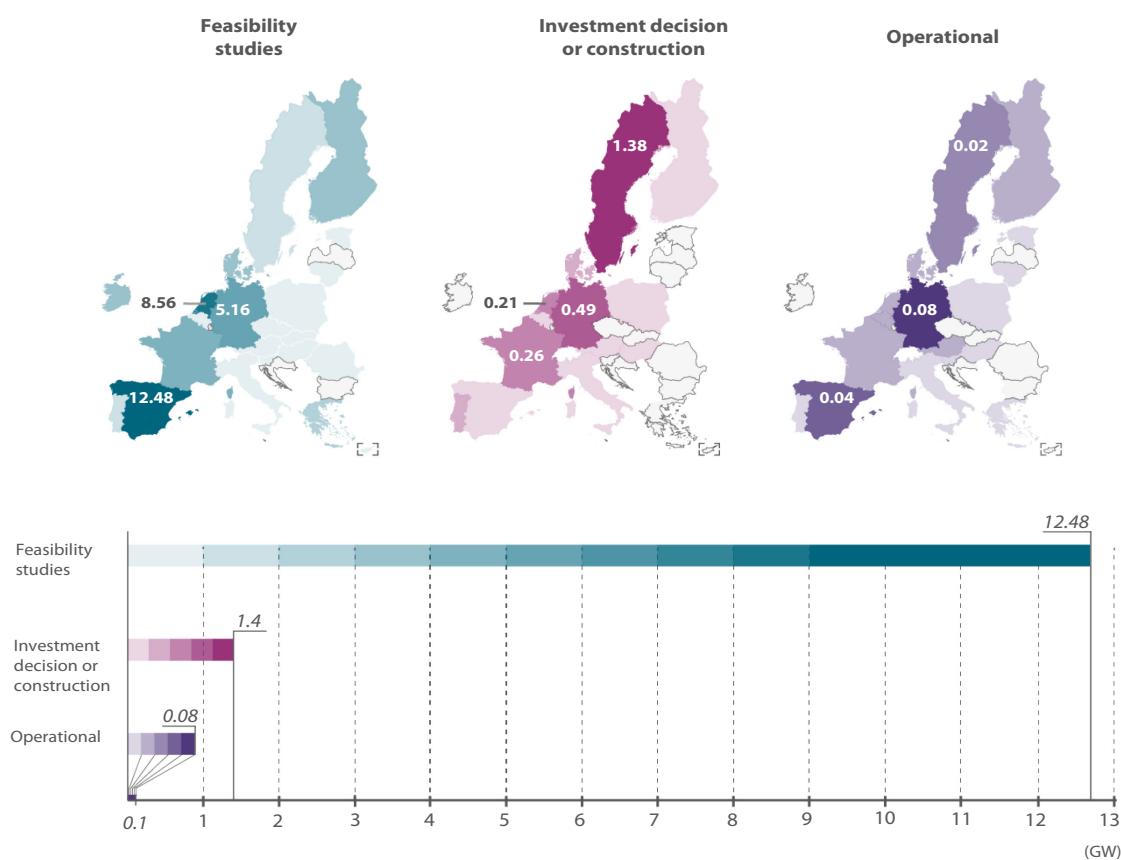
Source: ECA own analysis, based on publicly available information.

## Annex VI – Project announcements by member state

The following figure presents data on project announcements regarding electrolyzers for hydrogen production.

- For advanced stage projects (i.e. projects under construction or for which an investment decision has been taken): the overall capacity of advanced projects is only above 100 MW in the following seven member states, namely Sweden, Germany, France, the Netherlands, Denmark, Portugal and Spain.
- For advanced stage projects and projects for which feasibility studies are being carried out: the planned installed capacity of projects in 11 member states represents 97 % of the EU's total projected installed capacity. These member states are Spain, the Netherlands, France, Germany, Finland, Denmark, Ireland, Greece, Sweden, Portugal and Belgium.

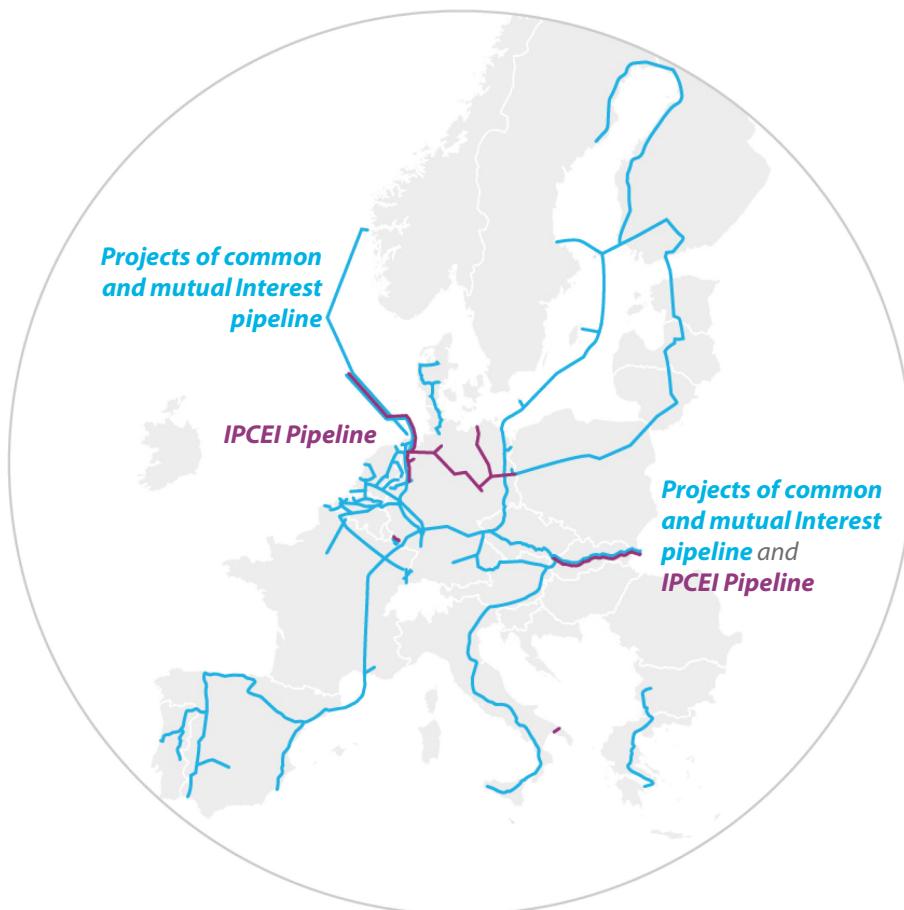
**Projects announced (i) as operational, (ii) as advanced stage, (iii) for which feasibility studies are being carried out (for installed capacity, GW)  
(as of October 2023)**



Source: ECA, based on data from the International Energy Agency.

## Annex VII – Legal provisions for the hydrogen network

The following figure shows the location of the projects of common and mutual interest and the projects planned under IPCEI Hy2Infra (mainly including pipelines, but also other types of projects).



*Source:* ECA, based on the 2023 list of projects of common and mutual interest and on data from the IPCEI Hy2Infra.

The gas package sets out rules for the hydrogen network.

### Network development plans for hydrogen

At EU level.

- Development of a non-binding, EU-wide 10-year network development plan for hydrogen by a new entity, the European Network of Network Operators for Hydrogen (ENNOH). However, the first such plan, due by 2026, will be developed by the European Network of Transmission System Operators for Gas, but will involve hydrogen transmission network operators as well as ENNOH as soon as it is established.

- The EU-wide 10-year network development plan should build on the national hydrogen network developments.

At national level (transmission network).

- Development of a 10-year network development plan (every 2 years) for hydrogen, including: detailed information on the main infrastructure that needs to be built or upgraded and investments already decided. It must also identify new investments and provide detailed information on infrastructure that can or will be repurposed.
- It must take into account cross-border exchanges, including with third countries, the role of hydrogen storage and the integration of hydrogen terminals.

### **Blending**

Injecting hydrogen into existing gas pipelines (blending) could theoretically be an option in the scaling up of the EU's hydrogen production capacity and would facilitate the transport of hydrogen. It could also be used as transitional tool for decarbonisation. However, it comes with challenges for the network and for users. The 2024 gas package regulation ([adopted](#), but not yet published as of the date our report was adopted) states that the blending of hydrogen into the natural gas system should be a last resort solution, because:

- it is less efficient compared to using hydrogen in its pure form and diminishes the value of hydrogen;
- it also affects the operation of natural gas infrastructure, end-user applications, and the interoperability of cross-border systems.

To limit the risk of market segmentation, the Regulation set the percentage of blending at 2 % for cross-border interconnection points between member states. This means that transmission system operators have to accept natural gas with a blended hydrogen level below this authorised EU-wide cap.

## Annex VIII – Low-carbon hydrogen, carbon capture and storage and carbon capture and utilisation

The EU recognised the following in legal acts.

- In a transitional phase, low-carbon hydrogen is needed to more rapidly decarbonise existing hydrogen production. This allows the focus to be on a range of clean technologies, and would enable economies of scale. One way of producing low-carbon hydrogen is to use natural gas along with carbon capture.
- The capture, storage and utilisation of CO<sub>2</sub> will inevitably be part of the EU's decarbonised future. This particularly concerns any CO<sub>2</sub> emissions which cannot be reduced through technical means, or where it is not economically viable to reduce those emissions. A mechanism should be in place to ensure that they can be captured and either stored or utilised, avoiding delayed emissions.

With its [Communication](#) on industrial carbon management for the EU, published in February 2024, the Commission gave this subject new impetus. The Commission expects significant amounts of CO<sub>2</sub> to be captured and stored by 2030, 2040 and thereafter. However, it is important to note the following points.

- In November 2022, in a [proposal](#) for Regulation establishing an EU certification framework for carbon removals, the Commission concluded that there were no significant industrial carbon removals in the EU. Moreover, while a network is required to transport the captured CO<sub>2</sub> to storage sites, the Commission identified significant barriers that made it difficult for investors to move ahead with CO<sub>2</sub> transport projects.
- A framework to govern the market does not yet exist.
- The estimated average lead-time of projects is 6 to 8 years (from concept to operation)<sup>63</sup>.

Among the actions that the Commission announced in its [Communication](#) on industrial carbon management for the EU (2024) are the following:

- work together with member states to develop and put in place a policy framework across the entire value chain, which is needed to increase certainty for investors;

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<sup>63</sup> [Scaling up the CCS Market to Deliver Net-Zero Emissions](#), Alex Townsend and Angus Gillespie, Global CCS Institute, 2020.

- consider setting specific objectives for carbon removals;
- assess if and how the CO<sub>2</sub> removed from the atmosphere, which is then safely and permanently stored, could be accounted for and covered by emissions trading;
- prepare a delegated act to specify the conditions under which permanent storage can be recognised, with a view to putting permanent carbon capture and utilisation, and carbon capture and storage on an equal footing within the emissions trading system;
- support member states in designing a possible IPCEI.

The Commission's Joint Research Centre estimated that the CO<sub>2</sub> transport infrastructure could span up to 7 300 km and that deployment could cost up to €12.2 billion by 2030, rising to around 19 000 km and €16 billion in 2040.

Cross-border carbon dioxide network development (infrastructure for transport and storage) is included as a thematic area under the TEN-E Regulation. Under the Net Zero Industry Act<sup>64</sup> both carbon capture and storage as well as CO<sub>2</sub> transport and utilisation technologies are considered as net zero technologies.

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<sup>64</sup> Regulation (EU)2024/1735.

## Annex IX – Legislative measures to accelerate national permitting processes

The following table presents the legislative measures taken by the Commission and adopted by the co-legislators to accelerate national permitting processes for renewable energy production and renewable hydrogen production projects.

### Legislative measures to accelerate national permitting processes

Area/legal act	Date of adoption	Short description
Renewable energy production (renewable energy projects and their related infrastructure, such as storage and grid connection)		
Council Regulation (EU) 2022/2577	22.12.2022	This was meant to bridge the gap until the Renewable Energy Directive (RED III) came into force and was applicable for 18 months. Among other things, it allowed member states to exempt certain renewable energy, energy storage and electricity grid projects from environmental assessment procedures.
Renewable Energy Directive EU/2023/2413 (RED III)	18.10.2023	<p>Timelines: the permitting process must not exceed 2 years, or 3 years in the case of offshore renewable energy projects. Deadline for transposing this provision: 21.5.2025.</p> <p>These timelines are reduced by 1 year for projects in “renewables acceleration areas”, which member states will designate. Deadline for transposing the provision (shorter timelines): 1.7.2024.</p> <p>Renewable energy deployment will also be presumed to be of “overriding public interest”, which will limit the grounds for legal objections to new installations.</p>
Commission Recommendation C/2022/3219	18.5.2022	Recommendations for improving several aspects of the procedure.

Area/legal act	Date of adoption	Short description
Projects of common interest and projects of mutual interest		
TEN-E Regulation (EU) 2022/869	30.5.2022	<p>Timelines for projects of common interest and projects of mutual interest: the permitting process must not exceed 42 months. The process consists of:</p> <ul style="list-style-type: none"> <li>○ the pre-application procedure with an indicative period of 24 months;</li> <li>○ the statutory permit granting procedure which shall not exceed 18 months.</li> </ul> <p>Extension of up to 9 months is possible.</p> <p>Member states must streamline environmental assessment procedures and must identify and take steps to do so:</p> <ul style="list-style-type: none"> <li>○ they should have taken the non-legislative measures identified by 24 March 2023;</li> <li>○ they should have taken the legislative measures identified by 24 June 2023.</li> </ul> <p>At the end of December 2023, the Commission launched a survey to monitor whether member states acted accordingly. At the time of writing, the Commission had received 13 replies. Twelve member states either reported that they had adopted measures or were in the process of doing so.</p>

Area/legal act	Date of adoption	Short description
Net zero technology manufacturing projects		
Net Zero Industry Act  <a href="#">Regulation (EU) 2024/1735</a>	27.5.2024	<p>Timelines for net zero technology manufacturing projects (including (i) hydrogen technologies: electrolyzers and fuel cells, (ii) solar photovoltaic, solar thermal electric and solar thermal technologies; and (iii) onshore wind and offshore renewable technologies), where the permitting process must not exceed:</p> <ul style="list-style-type: none"> <li>○ 12 months for the construction or expansion of net zero strategic projects with a yearly manufacturing capacity of less than 1 GW;</li> <li>○ 18 months for the construction or expansion of net zero strategic projects, with (i) a yearly manufacturing capacity of 1 GW or more or (ii) where the capacity is not measured in GW.</li> </ul> <p>The timelines for the construction or expansion of net zero strategic projects are shorter: 9 months and 12 months respectively.</p> <p>These timelines exclude the time required for the environmental assessment procedure.</p> <p>Environmental impact assessment: a reasoned opinion must be issued within 3 months of receiving all necessary information. The timeframes for consulting the public must not be longer than 90 days.</p>
Hydrogen production		
2024 gas package directive  (adopted, but not yet published as of the date our report was adopted)	21.5.2024	<p>Timelines: for projects such as hydrogen production facilities and hydrogen system infrastructure, member states must grant authorisations (including permits) within 24 months. Extension by 12 months is possible on the grounds of extraordinary circumstances.</p> <p>The timeline is without prejudice to obligations under applicable EU environmental and energy law, judicial appeals and proceedings.</p> <p>Deadline for transposing the Directive: 2026.</p>

## Annex X – State aid approved for renewable hydrogen projects

The following table provides data on (i) the approved amount of state aid to support renewable and low-carbon hydrogen projects, and (ii) the member states concerned. The submitted IPCEIs cover the whole value chain.

### State aid approved for hydrogen-related projects (as of 15.2.2024)

State aid rules	Number of projects	Amount of authorised aid (in billion euro)	Member states where projects are located	Planned installed electrolyser capacity (GW)
IPCEI <sup>1</sup> o Hy2Tech	41	5.4	Belgium, Czechia, Denmark, Germany, Estonia, Greece, Spain, France, Italy, Netherlands, Austria, Poland, Portugal, Slovakia, Finland <b>(15 member states)</b>	Not applicable
o Hy2Use	35	5.3	Belgium, Denmark, Greece, Spain, France, Italy, Netherlands, Austria, Poland, Portugal, Sweden, Slovakia, Finland <b>(13 member states)</b>	3.6
o Hy2Infra	33	6.9	Germany, France, Italy, Netherlands, Poland, Portugal, Slovakia <b>(7 member states)</b>	3.2

State aid rules	Number of projects	Amount of authorised aid (in billion euro)	Member states where projects are located	Planned installed electrolyser capacity (GW)
CEEAG	9	5	Belgium, Germany, Spain, France, Poland <b>(5 member states)</b>	0.4
TCTF	Not known (multi-technology) <sup>2</sup>	0.55 <sup>2</sup> Not known (multi-technology) <sup>2</sup>	Italy Czechia, Germany, Austria, Poland, Slovakia <b>(6 member states)</b>	Not available

<sup>1</sup> A further IPCEI (Hy2Move) relates to transport. It is not included in the table as this report focuses on renewable hydrogen for use by industry.

<sup>2</sup> The amount of aid authorised for hydrogen in the table shows the amount related to two schemes, focusing only on hydrogen technologies.

Five schemes are multi-technology schemes. Therefore, neither the number of projects nor the actual amount likely to be allocated to renewable hydrogen projects is known.

Source: ECA, based on Commission data.

## Annex XI – Recovery and resilience plans – data on funding earmarked for renewable and low-carbon hydrogen

The following table presents the amounts earmarked for hydrogen (i) in the initially approved recovery and resilience plans by member state and (ii) in the updated plans taking into account the specific REPowerEU chapter.

### Amounts earmarked for hydrogen (in million euro)

Member state	Amount earmarked for hydrogen – initial plans	Amounts earmarked for hydrogen – final plans (including REPowerEU)
Belgium	437	350
Bulgaria	35	33
Czechia	0	0
Denmark	0	0
Germany	2 547	2 547
Estonia	50	50
Ireland	0	0
Greece	0	60
Spain	1 555	3 155
France	2 425	2 426
Croatia	32	104
Italy	3 653	3 039
Cyprus	0	0
Latvia	0	0
Lithuania	20	20
Luxembourg	0	0
Hungary	0	250
Malta	0	0
Netherlands	98	98
Austria	248	270
Poland	800	800
Portugal	90	175
Romania	130	130
Slovenia	0	0
Slovakia	1	11
Finland	100	110
Sweden	0	0
<b>Total</b>	<b>12 221</b>	<b>13 628</b>

Source: ECA.

## Annex XII – Innovation Fund – data on EU hydrogen projects

Twice a year the Commission organises a call for projects. Up until 2023, calls addressed either small-scale projects (i.e. with a total capital expenditure no greater than €7.5 million) or large-scale projects. In November 2023, the Commission launched a single call, including both types of projects, and additionally medium-scale projects (i.e. with a total capital expenditure between €20 million and €100 million). Moreover, on the same day, the Fund launched the first pilot auction under the European Hydrogen Bank.

The following table provides data on EU hydrogen projects (renewable and low-carbon hydrogen as well as electrolyser manufacture) with a grant, and their location by member state. For renewable hydrogen production, it shows the following.

- 74 % of the total grant amount went to three member states (Sweden, the Netherlands and Spain (in decreasing order)). We note that the Swedish projects are cross-sector projects meaning that the grant amount will not solely be allocated to hydrogen production. A detailed breakdown is not available.
- The planned installed electrolyser capacity (in GW) for the projects in these three member states is 3.2 (or 85 % of the total). The Swedish projects represent 48 % of the total.
- There are only two projects in eastern European member states; the grant amount for these represents less than 1 % of the total.

### Data on hydrogen projects in the EU with a grant (as of 31.12.2023)

Date of call for projects	Number of projects	Member states where the selected projects are located	EU grant amount (million euro)	Planned installed electrolyser capacity (GW)
Renewable hydrogen				
2020	6	Spain, Italy, Poland, Finland, Sweden	249	0.6
2021	9	Czechia, Germany, Cyprus, Netherlands, Poland, Sweden	583	0.8
2022	12	Belgium, Germany, Spain, France, Netherlands, Austria, Sweden	1 051	2.4
<b>TOTAL</b>	<b>27</b>		<b>1 883</b>	<b>3.8</b>

Date of call for projects	Number of projects	Member states where the selected projects are located	EU grant amount (million euro)	Planned installed electrolyser capacity (GW)
Manufacture of electrolysers				
2022	4	Belgium, Denmark, Germany	162	Not applicable
Low-carbon hydrogen				
2022	2	Greece, Netherlands	157	Not applicable
<b>TOTAL</b>	<b>33</b>		<b>2 202</b>	

Source: ECA, based on Commission data.

### Annex XIII – Analysis of projects for renewable hydrogen production (electrolysers) and related funding

Member state <sup>1</sup>	Emissions of greenhouse gas (Mt of CO <sub>2</sub> equivalent) by hard-to-decarbonise industry (in % of total) <sup>2</sup>	Projects in advanced stage and projects in feasibility study stage (above 0.5 GW) <sup>3</sup>	Projects of common interest (list)	IPCEI (Hy2Use) <sup>4</sup> ( <i>Annex X</i> )	IPCEI (Hy2Infra) <sup>5</sup> ( <i>Annex X</i> )	Innovation Fund <sup>6</sup> ( <i>Annex XII</i> )	RRF <sup>7</sup> ( <i>Annex XI</i> ) Funding earmarked
Germany	21	YES	YES		YES	Beneficiary	Earmarked
Italy	12			YES	YES	Beneficiary	Earmarked
France	10	YES	YES	YES	YES	Beneficiary	Earmarked
Spain	10	YES	YES	YES		Major beneficiary	Earmarked
Poland	8			YES	YES	Beneficiary	Earmarked
Netherlands	7	YES	YES	YES		Major beneficiary	Earmarked
Belgium	5	YES		YES		Beneficiary	Earmarked
Austria	4			YES		Beneficiary	Earmarked
Czechia	4					Beneficiary	
Romania	4						Earmarked
Slovakia	3			YES			Earmarked
Greece	2	YES		YES			Earmarked
Sweden	2	YES		YES		Major beneficiary	
Portugal	2	YES	YES	YES	YES		Earmarked
Hungary	1						Earmarked
Finland	1	YES		YES		Beneficiary	
Bulgaria	1						Earmarked
Ireland	1	YES					

Member state <sup>1</sup>	Emissions of greenhouse gas (Mt of CO <sub>2</sub> equivalent) by hard-to-decarbonise industry (in % of total) <sup>2</sup>	Projects in advanced stage and projects in feasibility study stage (above 0.5 GW) <sup>3</sup>	Projects of common interest ( <a href="#">list</a> )	IPCEI (Hy2Use) <sup>4</sup> ( <a href="#">Annex X</a> )	IPCEI (Hy2Infra) <sup>5</sup> ( <a href="#">Annex X</a> )	Innovation Fund <sup>6</sup> ( <a href="#">Annex XII</a> )	RRE <sup>7</sup> ( <a href="#">Annex XI</a> ) Funding earmarked
Denmark	1	<b>YES</b>	YES	YES			
Croatia	1						Earmarked
Lithuania	1						Earmarked
	All other member states (6 in total) with less than 1 % are not included in this table.						

<sup>1</sup> In purple: the member states with high or good potential for renewable energy surplus that can be used to produce hydrogen, as extracted from a research paper, see paragraph [99](#). The research paper indicated the following: based on models, renewable energy potentials were estimated for individual European countries at costs of up to €60/MWh and contrasted with the sum of electricity demand required for direct use and for hydrogen production by electrolysis in 2050. The lighter the shade of purple, the lower the surplus (in absolute terms).

<sup>2</sup> Data from the European Environment Agency, 2021.

<sup>3</sup> Data from the [International Energy Agency](#) (as of October 2023).

Member states for which the total of the projects exceeds 2 GW are marked in **bold**.

<sup>4</sup> Member states for which the reply is marked in **bold** (2) included projects representing 71 % of the total electrolyser capacity to be installed.

<sup>5</sup> Member states for which the reply is marked in **bold** (3) included projects representing 91 % of the total electrolyser capacity to be installed.

<sup>6</sup> Major beneficiaries marked in **bold** (3) represent 74 % of the total funding for hydrogen production.

<sup>7</sup> The amount of funding earmarked for hydrogen by those member states where “earmarked” is marked in **bold** (4) represents 82 % of the total funding.

## Annex XIV – Analysis of projects for network development, storage, ports, and related funding

Member state <sup>1</sup>	Emissions of greenhouse gas (Mt of CO <sub>2</sub> equivalent) by hard-to-decarbonise industry <sup>2</sup>	Projects in advanced stage (final investment decision or under construction) <sup>3</sup>	Projects in feasibility study stage <sup>4</sup>	Projects of common interest (list)	IPCEI (Hy2Infra) <sup>5</sup> (Annex X)	RRF <sup>6</sup> (Annex XI) Funding earmarked
Germany	21		YES	YES	YES	Earmarked
Italy	12		YES	YES	YES	Earmarked
France	10		YES	YES	YES	
Spain	10		YES	YES		
Poland	8			YES		Earmarked
Netherlands	7	YES	YES	YES	YES	
Belgium	5		YES	YES		Earmarked
Austria	4		YES	YES		
Czechia	4		YES	YES		
Romania	4					
Slovakia	3		YES	YES	YES	
Greece	2			YES		
Sweden	2			YES		
Portugal	2		YES	YES	YES	
Hungary	1					
Finland	1			YES		
Bulgaria	1					
Ireland	1					
Denmark	1		YES	YES		
Croatia	1					

Member state <sup>1</sup>	Emissions of greenhouse gas (Mt of CO <sub>2</sub> equivalent) by hard-to-decarbonise industry <sup>2</sup>	Projects in advanced stage (final investment decision or under construction) <sup>3</sup>	Projects in feasibility study stage <sup>4</sup>	Projects of common interest (list)	IPCEI (Hy2Infra) <sup>5</sup> ( <i>Annex X</i> )	RRF <sup>6</sup> ( <i>Annex XI</i> ) Funding earmarked
Lithuania	1			YES		
	All other member states (6 in total) with less than 1 % are not included in this table.					

<sup>1</sup> In purple: the member states with high or good potential for renewable energy surplus that can be used to produce hydrogen, as extracted from a research paper, see paragraph 99. The research paper indicated the following: based on models, renewable energy potentials were estimated for individual European countries at costs of up to €60/MWh and contrasted with the sum of electricity demand required for direct use and for hydrogen production by electrolysis in 2050. The lighter the shade of purple, the lower the surplus (in absolute terms).

<sup>2</sup> Data from the European Environment Agency, 2021.

<sup>3</sup> Data from the International Energy Agency (as of October 2023).

<sup>4</sup> Data from the International Energy Agency (as of October 2023). Member states with the highest number of projects are marked in **bold**.

<sup>5</sup> Member states for which the reply is marked in **bold** (1) included projects representing close to 70 % of the aid amount approved.

<sup>6</sup> Based on an analysis of the Commission staff working documents on the national resilience plans of member states, we identified four which earmarked funding for the hydrogen network for a total amount of €1 202 million.

# Abbreviations

**CEEAG:** Climate, energy and environmental aid guidelines

**DG CLIMA:** Directorate-General for Climate Action

**DG ECFIN:** Directorate-General for Economic and Financial Affairs

**DG ENER:** Directorate-General for Energy

**DG MOVE:** Directorate-General for Mobility and Transport

**DG REGIO:** Directorate-General for Regional and Urban Policy

**DG RTD:** Directorate-General for Research and Innovation

**DG:** Directorate-general

**ETS:** Emissions trading system

**GBER:** General Block Exemption Regulation

**GW:** Gigawatt

**IEA:** International Energy Agency

**IPCEI:** Important projects of common European interest

**Mt:** Million tonnes

**MW:** Megawatt

**NECP:** National energy and climate plan

**RED II:** Renewable Energy Directive of 2018

**RED III:** Renewable Energy Directive, as amended in 2023

**RRF:** Recovery and Resilience Facility

**SG RECOVER:** Recovery and Resilience Task Force within the Secretariat-General of the Commission

**TCTF:** Temporary Crisis and Transition Framework

**TEN-E:** Trans-European networks for energy

# Glossary

**Bidding zone:** Largest geographical area (usually a country) in which electricity can be traded in Europe without technical constraints.

**Carbon Border Adjustment Mechanism:** EU system for putting a price on the carbon emitted during the production of carbon-intensive goods that enter the EU.

**Carbon capture and storage (CCS):** Practice of taking the CO<sub>2</sub> emitted by power stations or industry before it can enter the atmosphere, transporting it and storing it deep underground.

**Carbon capture and utilisation (CCU):** Practice of taking the CO<sub>2</sub> emitted by power stations or industry before it enters the atmosphere and using it to manufacture synthetic fuels, chemicals or other products.

**Delegated act:** Legally binding act used by the Commission, if Parliament and the Council express no objection, to supplement or amend non-essential parts of EU legislation, for example by giving details of implementing measures.

**Direct management:** Management of an EU fund or programme by the Commission alone, as opposed to shared management or indirect management.

**Emissions Trading System:** Emission reduction scheme based on capping total emissions through the allocation of allowances to companies or other organisations emitting CO<sub>2</sub>, which can buy and sell them according to their needs.

**European Green Deal:** EU growth strategy adopted in 2019, aiming to make the EU climate-neutral by 2050.

**European Hydrogen Bank:** EU instrument aimed at stimulating and supporting investment in sustainable hydrogen production. For example, it is meant to cover and lower the cost gap between renewable hydrogen and fossil fuels for early projects.

**Feedstock:** Raw material used in industrial processes.

**Gigawatt:** Unit of power equal to one billion watts.

**Greenhouse gas:** Gas in the atmosphere – such as carbon dioxide or methane – that absorbs and emits radiation, trapping heat and so warming the Earth's surface through what is known as the greenhouse effect.

**Hard-to-decarbonise industry:** Industry in which reducing carbon emissions is particularly difficult or costly.

**Hydrogen interconnector:** Hydrogen pipeline linking the national networks of two EU member states, or the part of a network linking a member state and a non-EU country and located outside EU territory.

**Hydrogen:** Hydrogen ( $H_2$ ) at standard conditions is a colourless, odourless, tasteless, non-toxic, and highly combustible gas.

**Indirect management:** Method of implementing the EU budget whereby the Commission entrusts implementation tasks to other entities (such as non-EU countries and international organisations).

**Innovation Fund:** EU programme that uses revenue from the EU's emissions trading system to support innovative low-carbon technologies.

**National energy and climate plan:** Ten-year document outlining a member state's policies and measures to meet the EU's climate objectives.

**(Pre-)notification of state aid:** Procedure by which a member state gives the Commission advance notice of proposed state aid for informal feedback on its compatibility with EU law, prior to mandatory notification.

**Project of common interest:** Cross-border infrastructure project between two or more EU countries in the context of a trans-European network.

**Projects of mutual interest:** Cross-border infrastructure project between the EU and one or more non-EU country in the context of a trans-European network.

**REPowerEU chapter:** Addition to a member state's initial national recovery and resilience plan, setting out its REPowerEU reforms and investments.

**REPowerEU:** EU initiative to end dependence on fossil fuels, diversify energy supplies and accelerate the clean energy transition.

**Shared management:** Method of spending the EU budget in which, in contrast to direct management, the Commission delegates to the member state while retaining ultimate responsibility.

**Temporal correlation:** Renewable electricity generation and hydrogen production should coincide temporally (for example hourly matching or monthly matching).

## Replies of the Commission

<https://www.eca.europa.eu/en/publications/sr-2024-11>

## Timeline

<https://www.eca.europa.eu/en/publications/sr-2024-11>

## Audit team

The ECA's special reports set out the results of its audits of EU policies and programmes, or of management-related topics from specific budgetary areas. The ECA selects and designs these audit tasks to be of maximum impact by considering the risks to performance or compliance, the level of income or spending involved, forthcoming developments and political and public interest.

This performance audit was carried out by Audit Chamber II Investment for cohesion, growth and inclusion spending areas, headed by ECA Member Annemie Turtelboom. The audit was led by ECA Member Stef Blok, supported by Johan Adriaan Lok, Head of Private Office and Laurence Szwajkajzer, Private Office Attaché; Marion Colonerus, Principal Manager; María Domínguez, Head of Task; Juan Antonio Vázquez Rivera, Nils Westphal, Miłosz Aponowicz and Borja Martin Simón, Auditors.



*From left to right:* Miłosz Aponowicz, Marion Colonerus, Laurence Szwajkajzer, Stef Blok, Borja Martin Simón, Johan Adriaan Lok, María Domínguez, Agnese Balode and Juan Antonio Vázquez Rivera.

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The Commission set the course for creating a renewable hydrogen market in its Hydrogen Strategy and REPowerEU plan, which included EU targets for hydrogen production and import. Renewable hydrogen is one way to decarbonise, especially for the hard-to-decarbonise sectors of industry. For the 2021-2027 period, total EU funding for hydrogen-related projects is currently estimated at €18.8 billion. We conclude that the Commission was partially successful in creating the right conditions for the emerging hydrogen market and associated value chain. The legal framework has mostly been adopted, but a number of challenges remain. One of our main recommendations is that future strategic choices should be based on a reality check – making strategic choices going forward without creating new strategic dependencies.

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