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Hydrogen readiness: a Trojan horse for fossil fuel lock-in

EU policy approaches and associated risks

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View of Fusina hydrogen power station, Italy
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Executive summary

→ **There is growing reference to the concept of 'hydrogen readiness' in EU-wide policy and law, as well as in popular, industry and political discourse.**

→ **Governments are beginning to approve, support and subsidise fossil gas power plants, pipelines, and LNG terminals based on vague commitments that the infrastructure will eventually be converted to use hydrogen or its derivatives.**

→ **Hydrogen readiness lacks a widely-accepted definition, and its nuances are often both uncertain and hard to pin down. Nevertheless, it can generally be defined as the declared ability of certain equipment or infrastructure to use hydrogen in the future.**

ABOUT HYDROGEN

- **Hydrogen is an energy carrier that is mostly produced artificially. Approximately 99% of hydrogen used today derives from fossil fuels – so-called 'grey' hydrogen – whereas less than 1% is made from renewable sources – so-called 'green' hydrogen.**

- **There are a number of technical, economic and social barriers to the use of hydrogen at scale:**
  → the production of hydrogen is inefficient, energy-intensive and costly,
  → hydrogen is difficult to store and transport due its physical properties and the lack of required infrastructure, and
  → there is high uncertainty around the availability of sufficient hydrogen supply to decarbonise existing fossil fuel uses in Europe, including as influenced by the environmental, cost and geopolitical implications of securing these supplies.

→ **The concept of hydrogen readiness is starting to make its way into law and policy.**

- **It is now included, in different formulations, across a number of EU rules:**

  1. the TEN-E Regulation (on the construction of international energy infrastructure),
  2. the Sustainable Finance Taxonomy (on green labelling of investments),
  3. the State aid guidelines and General Block Exemption Regulation (on conditions for granting subsidies), and
  4. the rules governing several EU funds, including the Recovery and Resilience Facility, the Cohesion Fund, the European Regional Development Fund, the Modernisation Fund, and the EIB's Energy Lending Policy.

- **Hydrogen readiness is also present in international public finance guidelines (OECD Arrangement on Officially Supported Export Credits) and in Member State national law (notably Germany).**

- **The application of hydrogen readiness in the laws and policies above has tended to be inconsistent, vague and permissive.**

→ **The idea of hydrogen readiness gives the false impression that the future use of hydrogen will make economic and environmental sense, that the infrastructure or equipment in question can and will be converted to use hydrogen, and that there will be sufficient hydrogen supplies available to decarbonise a wide range of existing fossil fuel end uses.**

→ **Several risks for consumers, investors and policy-makers arise from the concept of hydrogen readiness, including:**

1. Lock-in risk: hydrogen-ready infrastructure is likely to lock in greenhouse gas emissions that will prevent climate targets being met. This is because hydrogen may be produced with fossil gas (which can *increase* climate impacts) or there may not be enough hydrogen of any colour available at an economical price, leading to continued fossil fuel use. Hydrogen use also depends on and therefore further entrenches existing fossil fuel-based economic and infrastructure pathways, aggravating the rest of its associated risks.

2. Price risk: hydrogen price projections are uncertain and likely to be overshot. Furthermore, should hydrogen not be available at scale in the future, fossil gas will continue to be sourced for hydrogen-ready facilities, reinforcing the exposure to fossil gas prices, which are volatile and in a long-term upward trend.

3. Financial risks: such as asset stranding (investment projects not being able to pay back their costs) and litigation (arising from commitments to source hydrogen or from anti-greenwashing action).

4. External dependency risk: hydrogen will be mostly imported, same as with fossil gas. This will increase the exposure of the EU to external energy markets and any events that may disrupt them.

→ **To avoid these risks, the best approach would be to abandon the 'hydrogen readiness' concept altogether, unless and until the infrastructure or equipment in question can and will use 100% hydrogen from the outset without any need for further conversion. Anything else risks confusion and an off-track energy transition. It is also important to emphasise that even such 'hydrogen using' infrastructure and equipment can have significant negative environmental and cost impacts and that questions will often remain about their sustainability.**

→ **While this report focuses on the EU region, the key messages around the risks of 'hydrogen readiness' are intended to apply more broadly and across regions.**

Contents

1. Introduction

There is growing reference to 'hydrogen readiness' in EU and Member State policy and law, as well as in popular, industry and political discourse. Governments are approving or granting special regulatory status to and subsidising fossil gas[1] power plants, pipelines, and LNG terminals based on vague commitments that the infrastructure will eventually be converted to use hydrogen or its derivatives.

Consumers are buying 'hydrogen-ready' fossil gas boilers on the promise that these can and will one day burn hydrogen. Fossil gas transmission and distribution infrastructure owners are delaying or planning to delay the decommissioning of their assets – which is a necessary step for the widespread renewables-based electrification of heat and other existing fossil gas end uses – arguing (or hoping) that such infrastructure could instead eventually be converted to transport hydrogen.

As we will show, the 'hydrogen readiness' concept is hard to pin down, with different formulations and treatments being advanced across policies and sectors. However, it can be generally defined **as the declared ability of certain equipment or infrastructure to use hydrogen in the future**. Two fundamental aspects of this idea seem to vary across the different formulations:

1. Whether the infrastructure or equipment in question must be fully capable of using hydrogen from the outset (i.e., with no need for any type of adaptation or conversion), or only that future adaptation or conversion to the use of hydrogen would be feasible from a technical or economic point of view.
2. Whether the infrastructure or appliances in question must be 'ready' only for the use of pure hydrogen or for a blend containing a certain volume of hydrogen.

1 The common name is 'natural gas'. As it is a fossil fuel, this briefing uses the name 'fossil gas' or 'methane'.

Hydrogen-ready or ammonia-ready?

The concept of hydrogen readiness has been used to suggest that infrastructure and equipment have been designed in a way to allow later conversion to enable hydrogen use. Converting fossil gas infrastructure at a later stage however requires extensive retrofitting at great expense. For LNG infrastructure, technical studies[2] and the International Energy Agency (IEA)[3] warn that there is limited experience and that it is uncertain that there is a future case. While the steel used for LNG storage tanks could be compatible with hydrogen, 50% of the initial investment cost for an LNG terminal would be wasted (if hydrogen compatible materials are used from the outset) to convert the terminal to use hydrogen. Fossil gas pipelines, plants and other appliances and equipment face a similar issue of significant and costly retrofitting or replacement.

Given these challenges, LNG terminals currently under construction in Europe are being developed to be 'ammonia ready' instead.[4] The conversion of LNG terminals into ammonia terminals seems technically and financially more feasible than hydrogen. A conversion would require 6 to 20% additional capital expenditure, depending on the initial design and planning.[5] However, as the direct use of ammonia is limited mainly to being a feedstock to produce chemicals and as a fuel for maritime shipping, it would need to be converted to hydrogen, involving significant losses.

The objective of this report is to shed light on the emerging concept of 'hydrogen readiness' and the associated risks. To this end, the report first introduces basic facts about hydrogen and hydrogen readiness (Section 2). It then provides an overview of EU and some national law and policy where the concept is surfacing, in its different forms, descriptions and applications (Section 3). The briefing then further outlines the different risks associated with the concept and its use (Section 4). Finally, alternative policy options are proposed (Section 5). While the report is focused on the EU region, the key messages are intended to apply more broadly and across regions.

2 Fraunhofer Institute, Conversion of LNG terminals for liquid hydrogen or ammonia – analysis of technical feasibility under economic considerations, Nov. 2023, p.6.

3 IEA, Global Hydrogen Review 2022, p. 7.; More technical details at pp.143-150.

4 Hanseatic Energy Hub, , Mar. 2024.

5 Fraunhofer Institute, Conversion of LNG terminals for liquid hydrogen or ammonia – analysis of technical feasibility under economic considerations, Nov. 2023, p.40.

2.

Basic facts on hydrogen and 'hydrogen readiness'

2.1.

Main facts about hydrogen

Hydrogen (H_2) is generally not a primary energy source, such as fossil or renewable energy, but an energy carrier, meaning that it is usually a human-made gas capable of storing and delivering energy. Hydrogen only exists in very small quantities as a naturally available gas (so-called 'white' hydrogen[6]), so it must generally be produced by separating the naturally occurring molecules that contain it. More than 99% of hydrogen used today is produced from fossil fuels, whereas less than 1% is made using renewable energy.[7] Depending on the **production process**, industry has labelled hydrogen with different colours, the most discussed being:

→ **'GREY'** hydrogen is produced by splitting the hydrogen and carbon atoms in fossil gas or methane (CH_4), using a process called Steam Methane Reforming (SMR). CO_2, a greenhouse gas, is emitted into the atmosphere as a by-product when producing grey hydrogen.

→ **'BLUE'** hydrogen follows the same production process as grey hydrogen, but the CO_2 is partially captured and stored in a suitable underground location in a process known as carbon capture and storage (CCS). Blue hydrogen can also be produced by Auto Thermal Reforming (ATR), which is a similar process to SMR but differs in how heat is introduced during the process.

→ **'GREEN'** hydrogen is produced through a different process: electrolysis, whereby water (H_2O) is split into hydrogen and oxygen. In this case, oxygen (O_2) is the by-product, rather than CO_2. Electrolysers run on electricity, which, in the case of green hydrogen, must be sourced from renewables.

→ **'PINK'** hydrogen also relies on electrolysis but sources the electricity from nuclear power.

6 World Economic Forum, White hydrogen: 5 critical questions answered, Aug. 2024.

7 International Energy Agency (IEA), Global Hydrogen Review 2024, p.61.

Hydrogen's **current main use** is in refining, by the chemical industry (as a feedstock to produce ammonia, methanol and other chemicals) and the steel industry (as a reducing agent). The uptake of hydrogen and its derivatives, such as ammonia, methanol, jet fuel or other e-fuels, in **new applications** including heavy industry, transport, the production of hydrogen-based fuels or electricity generation and storage, remains minimal (<0.1% global demand). This is mainly due to the lack of competitiveness of hydrogen with fossil fuels, the lack of commercial maturity of end-use technologies and the existence of more efficient low-emission alternatives for these applications.[8]

Although hydrogen is often presented as an environmentally friendly alternative for fossil gas (methane, CH_4), **hydrogen and methane have very different properties**[9]:

Molecular weight: hydrogen is 8 times lighter, and smaller than methane, meaning it leaks more easily and needs high pressurization to be transported.

Energy density: hydrogen contains over twice the energy density of methane for weight unit, but, since it is much less dense, it needs almost 3 times the volume for the same amount of energy.

Combustion: hydrogen combustion produces water vapour, whereas the combustion of methane releases carbon emissions (CO_2).

Flammability: hydrogen combusts with both higher and lower concentrations of air present and its flame speed is almost 10 times higher than methane, making combustion of hydrogen more challenging to control.

State of matter: hydrogen only liquifies at -253°C (boiling point), whereas methane liquifies at -162°C (LNG).

8 Ibid., pp.22-23.

9 Ibid., p.131; POWER Engineers, 6 Things to Remember about Hydrogen vs Natural Gas, Aug. 2021.

2.2.

A 'hydrogen economy': physical, economic and environmental challenges

The 'hydrogen economy' is a vision of using hydrogen as a low-carbon energy source across the economy, to phase-out the use of fossil fuels and limit climate change. The road towards this economy however presents physical, economic and environmental uncertainties and challenges. In practice, this vision may simply delay the transition to a sustainable economy and prolong the use of fossil fuels. Even if a hydrogen economy were to become viable, it is likely that it would involve a substantial amount of fossil gas-based grey and blue hydrogen.

The limitations of hydrogen as a broad solution have been noted by the scientific community. The **European Scientific Advisory Board on Climate Change** has said that "*[t]he EU's massive policy support for the hydrogen value chain does not sufficiently reflect the techno-economic limits of hydrogen and its most efficient uses in an integrated and decarbonised energy system.*"[10] These limitations are also reflected in the latest reports issued by the **Intergovernmental Panel on Climate Change (IPCC)**.[11]

EU institutions and agencies have also recognised the challenges associated with the hydrogen economy. The **Commission**, in its Hydrogen Strategy, admits that "*today renewable and low-carbon hydrogen are not yet cost competitive compared to fossil-based hydrogen.*"[12] In its Energy System Integration Strategy, it stated that "*direct electrification and renewable heat present the most cost-effective and energy-efficient decarbonisation options in many cases*". While this last strategy does mention that "*a number of renewable or low-carbon fuels could be used, such as sustainable biogas, biomethane and biofuels, renewable and low-carbon hydrogen or synthetic fuels*", it is only in relation to end-use applications where electrification may not be feasible or have higher costs.[13]

10 European Scientific Advisory Board on Climate Change, Towards EU climate neutrality – Progress, policy gaps and opportunities, 2024, p.24.

11 "*The [Integrated Assessment Model] scenarios imply a modest role played by hydrogen, with some scenarios featuring higher levels of penetration. The consumption of hydrogen is projected to increase by 2050 and onwards in scenarios likely limiting global warming to 2°C or below, and the median share of hydrogen in total final energy consumption is 2.1% in 2050 and 5.1% in 2100 (Box 12.4, Figure 1) (Numbers are based on the AR6 scenarios database). There is large variety in hydrogen shares, but the values of 10% and more of final energy use that occur in many roadmaps are only rarely reached in the scenarios. Hydrogen is predominantly used in the industry and transportation sectors. In the scenarios, hydrogen is produced mostly by electrolysis and by biomass energy conversion with CCS (Box 12.5, Figure 1).*" IPCC, AR6 WGIII Full Report, 2022, Ch12, p.1315. And even that modest role may be an overestimate: "*Most models and studies fail to address system impacts of widespread new technology deployment, for example: (i) material and resources needed for hydrogen production or additional emissions and energy required to transport hydrogen […] These impacts could limit regional and national scale-ups.*" Ibid., Ch4, p.442.

12 Communication – A hydrogen strategy for a climate-neutral Europe, COM/2020/301 final, p.2.

13 Communication – Powering a climate-neutral economy: An EU Strategy for Energy System Integration, COM/2020/299 final, p.11.

More recently, the **European Court of Auditors** has put into question the political initiatives around the hydrogen economy, noting that "*[t]he EU's industrial policy on renewable hydrogen needs a reality check*" and that "*[t]he EU should decide on the strategic way forward towards decarbonisation without impairing the competitive situation of key EU industries or creating new strategic dependencies.*"[14] The Court of Auditors also doubted the volume of the EU targets for imports and production of renewable hydrogen (10 million tonnes each by 2030), considering that they "*were driven by political will rather than being based on robust analyses.*"[15]

Some of the main physical, economic and environmental challenges of hydrogen are:

→ **The production process of hydrogen is inefficient, making it uncompetitive in most cases**

Hydrogen is an energy carrier that does not exist in any significant amount in nature and therefore needs to be produced using existing energy (see Section 2.1). The different production processes entail significant energy losses, making it a very inefficient and expensive solution. Even the production of green hydrogen results in around 30-35% energy loss and, depending on its final use, higher energy losses may be incurred.[16]

Hydrogen is therefore unlikely to be available at a large enough scale to significantly displace current fossil fuel use. Direct electrification is in nearly every case more efficient and cheaper than converting electricity to hydrogen. Such options already exist in key sectors, such as heating and road transport, and should be prioritised.[17]

→ **The quantities of available near-zero emission hydrogen are and will be scarce**

The only near-zero emissions hydrogen is green hydrogen (aside from the very small quantities of available white hydrogen). Grey and blue hydrogen are as polluting or even more polluting than the direct use of fossil fuels. The greenhouse gas footprint of blue hydrogen can be up to 20% worse than burning fossil gas for heat, because blue hydrogen is produced from fossil gas, which amplifies the issue of methane leaks in the supply chain, and CCS does not capture all the emissions.[18] Yet, producing green hydrogen is very energy-intensive and requires significant land and resources.

Hydrogen must therefore be used sparingly and prioritised for applications where it is the least harmful solution, such as hard to decarbonise sectors.

14 Renewable hydrogen-powered EU: auditors call for a reality check, 2024. https://www.eca.europa.eu/en/news/news-sr-2024-11

15 European Court of Auditors, Special report 11/2024: The EU's industrial policy on renewable hydrogen – Legal framework has been mostly adopted – time for a reality check, 2024, p.63.

16 International Renewable Energy Agency (IRENA), Green Hydrogen – A guide to policy making, 2020, p.13.

17 See for example this proposal for the classification of hydrogen uses: Hydrogen Ladder version 5.0. developed by Michael Liebreich, 2023.

18 R. Howarth, How green is blue hydrogen?, Energy Science & Engineering, 2021.

→ Transporting hydrogen by ship is technically difficult and inefficient due to energy losses

Countries with high renewables potential (such as Oman, Morocco, Namibia or Chile) are marketing themselves as future green hydrogen hubs. Yet green hydrogen demand is expected to come from heavily industrialised and populated regions in Europe, North America and Asia. To transport hydrogen globally, there are two main options: (1) to liquify hydrogen (LH2) and ship it in liquefied form or (2) to convert hydrogen into ammonia, liquify the ammonia, and ship it as a 'hydrogen carrier'.[19]

The first option is very challenging. Hydrogen needs to be cooled to -253°C to liquify, nearly 100°C less than LNG, which means higher energy losses (it is estimated that between 25 and 35% of the energy stored in the initial hydrogen needs to be used for liquefaction, compared to around 10% for LNG).[20] Due to its cost, transporting LH2 by ship is currently seen as an option with less potential economic feasibility when compared to the shipping of ammonia.[21]

Although ammonia is easier to handle as it liquifies at -33°C and has a higher energy density by volume than LH2,[22] it is also inefficient since the conversion of hydrogen to liquid ammonia is an energy-intensive process leading to between 7-18% of the hydrogen being wasted in the process, and a similar amount for regasification, a total loss of 14-36%. Its high toxicity and corrosiveness add another layer of logistical complexity to this option.[23]

As moving hydrogen across large distances will not only be costly, but also extremely inefficient with big energy losses along the supply chain, locally produced hydrogen should be prioritised. Yet, space and resources to deploy renewables in Europe is limited, meaning that direct electrification of applications should always be prioritised over relying on hydrogen imports.

→ Converting existing fossil gas pipelines is technically complex and will in almost all cases be economically unjustified

At regional or local level, hydrogen can be transported via pipeline. Fossil gas pipelines cannot handle pure hydrogen as it corrodes steel structures, reduces the steel's fracture resistance and would leak due to its light weight.[24] Hydrogen's lower volumetric energy density would also need to be compensated by increasing the pipeline's pressure, which would amplify safety concerns. This means that converting existing fossil gas pipelines would involve modifying compressors, valves and other components, replacing entire pipeline segments and welds with compatible materials, adapting the

19 International Renewable Energy Agency (IRENA), Geopolitics of the Energy Transformation -The Hydrogen Factor, 2022, pp.35-37; EU Agency for Cooperation of Energy Regulators (ACER), Transporting Pure Hydrogen by Repurposing Existing Gas Infrastructure: Overview of existing studies and reflections on the conditions for repurposing, July 2021, pp.15-16.

20 ACER, op. cit., p.11.

21 IRENA, op. cit., p.36; ACER, op. cit., p.15.

22 ACER, op. cit., p.11.

23 IEA, The Future of Hydrogen – Seizing today's opportunities, June 2019, pp.75 & 56.

24 Z. Hafsi, M. Mishra, S. Elaoud, Hydrogen embrittlement of steel pipelines during transients, Procedural Structural Integrity, Vol.13, 2018, pp.210-217 (open access); National Renewable Energy Laboratory, Hydrogen Blending into Natural Gas Pipeline Infrastructure : Review of the State of Technology, Oct. 2022, p.8.

leak detection system, etc. Such conversions would be costly and complex, and would in any event not be feasible for older pipelines (30+ years).[25]

This means that many hydrogen pipelines will be purpose-built, which will be extremely costly and take many years. In Europe, based on "*the industrial hydrogen demand and the technology and cost assumptions (…), there is no justification for creating a larger, pan-European hydrogen backbone*", that goes beyond certain specific "*no regret*" corridors.[26]

→ Blending hydrogen with fossil gas is wasteful

Blending hydrogen with fossil gas reduces the energy content, meaning more is needed to deliver the same amount of energy. It also has limited emission savings: mixing 20% of hydrogen with fossil gas, which is the maximum that much of the existing fossil gas infrastructure can carry before needing expensive upgrades, can only save around 7% of carbon emissions,[27] yet it significantly increases the price for consumers.[28]

→ The environmental impact of hydrogen: high global warming potential and air pollution

Over a period of 20 years, hydrogen is 33 times worse for the climate than CO_2.[29] It is not a greenhouse gas in itself but it extends the lifetime of methane, amplifying its greenhouse effect. Yet, as the smallest molecule in the universe, hydrogen is hard to contain and can leak more easily, especially during transport such as by ship.[30]

Moreover, combusting hydrogen can release high levels of nitrogen oxides (NO_x) which impacts local air pollution,[31] unless the emissions are controlled.

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25 Institute for Energy Economics and Financial Analysis (IEEFA), Hydrogen: Not a solution for gas-fired turbines, Aug. 2024, pp.17-19.

26 Agora Energiewende and AFRY Management Consulting, No-regret hydrogen: Charting early steps for H_2 infrastructure in Europe, 2021, p.18.

27 Hydrogen Science Coalition, Principles, p.4.

28 Paul Martin, LinkedIn, Why Hydrogen Blending Into the Gas Network is Bollocks, posted 17 Dec. 2023, updated 27 Aug. 2024. See also, Fraunhofer Institute, The limitations of hydrogen blending in the European Gas Grid, Jan. 2022.

29 Nicola Warwick et al., Atmospheric implications of increased Hydrogen use, Apr. 2022, p.54.

30 Frazer Nash Consultancy, Fugitive hydrogen emissions in a future hydrogen economy, Mar. 2022 (commissioned by the UK government).

31 US Department of Energy, Does the use of hydrogen produce air pollutants such as nitrogen oxides?, (last accessed Jan. 2025).

Equity concerns for the production of green hydrogen

Countries with high potential for renewable energies (e.g. Namibia, Morocco, Oman or Chile) have announced their interest in producing large amounts of green hydrogen, mostly for export only. There is a risk that this comes at the expense of the local population and basic human rights, such as:

Energy poverty:

This is a major issue in many high potential countries. Power generation through renewables should be dedicated to the local population prior to being connected to electrolysers to produce green hydrogen for export. Project promoters should therefore be obliged and bear the costs of additional renewable capacities for populations where the electrification rate is below 100% to improve their economic sustainability.

Water supply:

Many high potential countries are in arid regions where water is scarce. As water is needed to produce green hydrogen, it can exacerbate water stress. Water resources or desalination plants in such areas must first meet the needs of affected populations before fresh water can be used for hydrogen production.

Health:

The production of hydrogen can have negative effects on local air pollution. Such impacts need to be prevented by introducing emission limits.

Food security:

Land-use conflicts, land conversion and forced resettlement can lead notably to food insecurity for the local population. This must be mitigated by securing local agricultural production.

In light of these challenges, the role of hydrogen in the economy should be based on key principles:

→ Green hydrogen should be directed solely at priority, hard-to-abate sectors where it is the least harmful solution for meeting energy demand, and where the demand in question cannot be avoided.

→ Hydrogen should not be used to delay deploying electrification and energy efficiency solutions.

→ Locally produced and consumed green hydrogen should be prioritised, before exporting and importing it. Any import of hydrogen must respect basic human rights in exporting countries.

→ Given how scarce and valuable green hydrogen is, it should not be blended with fossil gas due to the limited impact on emissions savings.

3.

'Hydrogen readiness' in law and policy

This chapter provides an overview of different pieces of legislation and policy where the concept of hydrogen readiness is surfacing. The findings have been grouped in different legal and policy areas: the use of the concept by industry, EU energy law and policy, private finance, public finance, and national laws and policies.

Legal and policy frameworks related to energy and hydrogen are in constant development, which does not lend itself well to an exhaustive review of the relevant frameworks. This analysis strives to cover the most relevant pieces of law and policy, but does not provide a comprehensive review.

3.1.

Use of the hydrogen readiness concept by industry

An agreed understanding of 'hydrogen readiness' has also not yet emerged amongst industry. Public statements from industry characterizing certain fossil gas assets as hydrogen ready vary in terms of the thresholds applied. For example, RWE claimed that their Magnum gas-fired power plant in Eemshaven is hydrogen ready because it can co-fire up to a 30% hydrogen blend,[32] while Baker Hughes claimed that its turbo-compressors would help serve a to-be-constructed hydrogen-ready pipeline, noting the compressors could operate at an up to 10% hydrogen blend.[33]

Some industry actors have **proposed hydrogen readiness definitions and certification schemes** for fossil gas power plants and other infrastructure. These approaches generally focus on technical capabilities and expected conversion costs. In Germany, the technical association of energy plant operators vgbe energy e.V., has proposed that a **fossil gas power plant** be considered 'H2-ready' if it "*can be operated at 100% with hydrogen during its service life*."[34] But, as observed by the Reiner Lemoine Institut, such a standard is in effect meaningless, since any fossil gas power plant today can conceivably be converted during its lifetime to burn 100% hydrogen, provided the technology to do so is commercially available.[35]

The EU Turbines and EUGINE associations propose a tiering framework for defining hydrogen readiness, which refers to both the proportion of hydrogen in the fuel mix that can be burned (with different classifications for 10%, 25%, and 100% hydrogen) and the cost of upgrading the plants as a proportion of initial overall plant building costs (with different categories for 5%, 10%, and 20%).[36] But this standard says nothing of the likelihood of the power plants being converted to use 100% hydrogen later. The TÜV SÜD Hydrogen-Ready Gas Power Plant Certification expands the assessment beyond questions of technical capability and pricing. It introduces certifications for three key stages of the plant's life cycle – bidding with concept design, planning and construction, and transitioning from fossil gas to hydrogen use.[37] By issuing certifications at each stage, this approach introduces some level of accountability towards ensuring that necessary conversions to burn 100% hydrogen take place, which could assist in upfront commercial risk allocation between contractors, operators, owners and other parties. However, such a scheme cannot meaningfully ensure that a conversion eventually takes place, since changed circumstances may remove commercial and other incentives for the parties to convert.

Beyond fossil gas power, some industry efforts have been undertaken to develop hydrogen readiness standards for **pipelines and related equipment and infrastructure**. The H2 Gas Assets Readiness Working Group seeks to develop new standards and technologies and share technical knowledge on hydrogen asset readiness, and to build a common view on the H2 readiness

32 RWE, RWE acquires 1.4-gigawatt power plant from Vattenfall and develops Eemshaven site into a leading energy and hydrogen hub in Northwest Europe, June 2022.

33 Baker Hughes, Baker Hughes to Supply Snam with Hydrogen-Ready Technology to Support Decarbonization and Resilience of the Italian Gas Network, Apr. 2024.

34 Vgbe energy e.V., Factsheet: H2-readiness for gas turbine plants, Jan. 2023, p.3.

35 Reiner Lemoine Institut, H2-Ready Gas-fired Power Plants, Nov. 2023, p.12.

36 EU Turbines, EUGINE, H2-Readiness of Turbine Based Power Plants – A Common Definition, Sep. 2021.

37 TÜV SÜD, H2-Ready Certification, last accessed Jan. 2025.

of infrastructures.[38] However, this work remains ongoing at the time of publication of this briefing, with no agreed hydrogen readiness definition distributed publicly. TÜV SÜD also issues 'H2-ready' certificates for hydrogen pipelines, which evaluates pipelines' suitability for hydrogen operation.[39]

Industry has also begun promoting the hydrogen readiness concept in the **home heating** context, with different efforts across jurisdictions to promote or market certain fossil gas boilers as 'hydrogen-ready' or 'hydrogen-blend ready'. For example, the UK Competition and Markets Authority (CMA) recently closed enforcement proceedings against Worcester Bosch, who agreed to change or remove misleading marketing materials. Among other concerns, the CMA noted that consumers may be misled by claims that the company's boilers are 'hydrogen-blend ready' because they can run on an up to 20% hydrogen blend, when most boilers on the market are already technically capable of doing this. Concerns were also raised that marketing such boilers as hydrogen-blend ready gave a false impression that they would help consumers 'future-proof' their heating systems and reduce their carbon footprints.[40] Recognizing also the scientific uncertainties of hydrogen blending, the CMA secured an undertaking[41] from the company (also applicable to boiler manufacturers, third party retailers, or boiler installers) that prohibits "*stating or conveying the impression that the widespread introduction of a Hydrogen blend into the gas network, and its availability in any particular place and for any particular Consumer, is a certainty*."

The CMA also found evidence of an industry-wide problem. Prior to opening its enforcement action against Worcester Bosch, the CMA undertook a review of consumer protection issues in the green heating and insulation sector. It concluded in a 2023 findings report[42] that "*we are concerned that claims and messaging around hydrogen capable boilers used by several businesses may constitute greenwashing and mislead consumers into thinking that these products are more environmentally friendly or 'greener' than they are.*"

3.2.

EU energy law and policy

Over the last few years, EU energy policy and legislation have started to reflect the emergence of a 'hydrogen readiness' concept.

Oddly enough, **the notion is absent from key pieces of energy policy of the last Commission**, like the European Green Deal,[43] the Hydrogen Strategy,[44] or the Energy System Integration Strategy.[45] These policies do not mention 'hydrogen readiness' and rather focus on the repurposing of existing fossil gas infrastructure or the construction of dedicated hydrogen infrastructure. The main EU legislation from the last Commission focusing on the development of a future EU internal hydrogen market – the hydrogen and decarbonised gas market package[46] – does not mention the concept either.

'Hydrogen readiness' seems to have gained prominence with the gas supply and price crisis arising before and aggravated by Russia's war against Ukraine. It is mentioned several times in the REPowerEU Communication[47] and the REPowerEU Plan,[48] which were adopted as a response to the crisis. In the first of these communications, the Commission announced that it would "*assess as a matter of priority whether measures and investments are needed in hydrogen-ready gas infrastructure*

38 De la Flor, F. P., H2 Gas Assets Readiness (H2GAR), 34th Madrid Forum, Oct. 2020, p.2.

39 TÜV SÜD, Hydrogen Pipelines – Safety and Certification of Hydrogen Transport, last accessed Jan. 2025.

40 CMA, Leading UK boiler brand is changing marketing practices following CMA action, Aug. 2024.

41 Undertakings to the Competition and Markets Authority of Bosch Thermotechnology Limited

42 CMA, Consumer protection in the green heating and insulation sector, May 2023.

43 Communication – The European Green Deal, COM/2019/640 final.

44 Communication – A hydrogen strategy for a climate-neutral Europe, COM/2020/301 final.

45 Communication – Powering a climate-neutral economy: An EU Strategy for Energy System Integration, COM/2020/299 final.

46 Directive (EU) 2024/1788 of the European Parliament and of the Council of 13 June 2024 on common rules for the internal markets for renewable gas, natural gas and hydrogen, OJ L, 2024/1788, 15.7.2024, and Regulation (EU) 2024/1789, of the European Parliament and of the Council of 13 June 2024 on the internal markets for renewable gas, natural gas and hydrogen, OJ L, 2024/1789, 15.7.2024.

47 Communication – REPowerEU: Joint European Action for more affordable, secure and sustainable energy, COM/2022/108 final.

48 Communication from the Commission – REPowerEU Plan, COM/2022/230 final.

and interconnections to overcome bottlenecks to the full use of the EU's LNG capacity".[49] In the REPowerEU Plan, the Commission, assisted by ENTSOG, identified several gas projects that would alleviate bottlenecks by allowing a larger eastward gas flow through the EU.[50] It was argued that, with some of the projects being hydrogen-ready, the risk of lock-in of fossil gas would be mitigated.[51]

Within **energy legislation**, perhaps the closest concept to 'hydrogen readiness' at EU level can be found in the **Regulation on Trans-European Networks for Energy (TEN-E Regulation)**,[52] revised in 2022. The TEN-E Regulation governs the selection of critical cross-border energy infrastructure projects that benefit from expedited permitting and which can opt for public financial support. Since the revision of the Regulation, eligible infrastructure includes hydrogen pipelines, terminals and storage facilities,[53] but not fossil gas transmission or storage infrastructure, which was excluded after years of support.[54]

The TEN-E Regulation includes the term 'dedicated hydrogen assets', which seems to be inspired by a 'hydrogen readiness' approach. 'Dedicated hydrogen assets' are defined as "*infrastructure ready to accommodate pure hydrogen without further adaptation works, including pipeline networks or storage facilities that are newly constructed, repurposed from natural gas assets, or both*".[55]

The definition is clear that adaptation works should not be needed for the dedicated hydrogen assets to work with hydrogen. However, it does not specify whether dedicated hydrogen assets should or may also be compatible with fossil gas use, or a blend. The rest of the text of the Regulation does not help solve the question with certainty: a reading in conjunction with the definition given for repurposing may indicate that, at least when repurposed, infrastructure should be only hydrogen-compatible, since repurposing is "*the technical upgrading or modification of existing natural gas infrastructure in order to ensure that it is dedicated for the use of pure hydrogen*".[56] On the other hand, an interpretation where dedicated hydrogen assets are only compatible with pure hydrogen may conflict with the methane blending exception in Art. 31 of the Regulation (see point 2 below).

The concept of **dedicated hydrogen assets is used in two contexts** by the TEN-E Regulation:

1. The **interconnection of Cyprus and Malta** to the trans-European gas network.[57] The TEN-E Regulation contains a derogation under which two fossil gas projects, that would link each insular State to the mainland, are allowed to continue to benefit from the preferential treatment, despite the general exclusion of support to fossil gas infrastructure.

   Some general conditions are established for the derogation to apply, including that such projects "*shall ensure the future ability to access new energy markets, including hydrogen*". In this respect, it is required that promoters provide "*sufficient evidence of how the interconnections [...] will allow access to new energy markets, including hydrogen, in line with the Union's overall energy and climate policy objectives*". The evidence "*shall include an assessment of the supply and demand for renewable or low-carbon hydrogen as well as a calculation of the greenhouse gas emissions reduction enabled by the project*". The Commission is tasked with verifying the calculations and overseeing the timely implementation of the projects.

   Additional conditions apply if projects request public financial support. In that case, the projects "*shall not lead to a prolongation of the lifetime of natural gas assets*", and "*[...] clearly demonstrate the aim to convert the asset into a dedicated hydrogen asset by 2036 if market conditions allow, by means of a roadmap with a precise timeline*."

   Although this provision seems to be written mostly with hydrogen in mind (for example, the evidence to be provided is focused on the availability and carbon savings only of hydrogen, and financial assistance requires an aim to convert to dedicated hydrogen assets), it does not rule out other fuels, since it refers to other "*new*" or "*future energy markets*".

49 REPowerEU Communication, p. 7.

50 REPowerEU Plan, Annex 3.

51 Ibid., p. 13.

52 Regulation (EU) 2022/869 of the European Parliament and of the Council of 30 May 2022 on guidelines for trans-European energy infrastructure, OJ L 152, 3.6.2022.

53 TEN-E Regulation, Annex II(3).

54 The previous text of the Regulation (No 347/2013), allowed the support to gas pipelines, storage, and LNG terminals (Annex II(2)).

55 TEN-E Regulation, Art. 2(17) (emphasis added).

56 Ibid., Art. 2(18) (emphasis added).

57 Ibid., Art. 24.

Two gas projects are currently benefiting from this derogation: EastMed for Cyprus and Melita TransGas for Malta. Despite being gas projects, they maintain their status of projects of common interest and are included in the First List of Projects of Common Interest and Projects of Mutual Interest.[58] Both are currently presented as hydrogen-ready by their respective promoters.[59]

2. The second instance where the TEN-E Regulation uses the concept of 'dedicated hydrogen assets' is in the establishment of a transitional period allowing **methane blending in hydrogen projects**.[60] Until the end of 2029, "*<u>dedicated hydrogen assets</u> converted from natural gas assets […] <u>may be used for transport or storage of a predefined blend of hydrogen with natural gas or biomethane</u>*."[61] This transitional period seems to apply to all hydrogen projects that are based on the conversion of fossil gas assets.

   Again, this provision requires promoters to provide evidence about a potential switch to hydrogen. In particular, they must "*provide sufficient evidence, including through commercial contracts, how, by the end of the transitional period, the assets […] <u>will cease to be natural gas assets and become dedicated hydrogen assets</u> […] and <u>how the increased use of hydrogen will be enabled</u> during the transitional period.*"[62] This section introduces ambiguity as to whether and when infrastructure can be considered a 'dedicated hydrogen asset', since it refers on the one hand to assets that blend fossil gas as eventually becoming dedicated hydrogen assets (i.e., they are not 'dedicated hydrogen assets' from the outset), while in the first paragraph they are called "*dedicated hydrogen assets converted from natural gas assets*" (i.e., they are 'dedicated hydrogen assets' from the outset) (see quote in the paragraph above).

   Similar to the exception for the interconnection of Cyprus and Malta, the evidence to be provided by promoters "*shall include an <u>assessment of the supply and demand</u> for renewable or low-carbon hydrogen as well as a <u>calculation of the greenhouse gas emissions reduction</u> enabled by the project.*"[63] In this case, it is ACER, and not the Commission, as the entity tasked with verifying the transition.

At first glance, it may seem trivial to parse the TEN-E Regulation's treatment of the term 'dedicated hydrogen assets.' However, such treatment carries important implications for whether and when some of the largest new fossil gas projects across the EU can be labelled 'hydrogen-ready.' Allowing these projects to claim 'dedicated hydrogen asset' status at the outset risks misleading the public as to the decarbonisation contribution of such projects, since it can create the false impression that they will soon use hydrogen or that they already do. Indeed, the most recent list of promoted energy infrastructure projects prepared under the TEN-E Regulation[64] contains hydrogen projects which to some degree overlap or are related to past fossil gas projects, such as the Hydrogen interconnector Portugal – Spain (PCI no. 9.1.2) and the RHYn (Rhine Hydrogen Network, PCI no. 9.2.1).

It is unclear at this point, however, whether these projects will request to make use of this methane blending derogation, using either fossil gas or biomethane.

In conclusion:

→ The concept of 'hydrogen readiness' is emerging in EU energy law and policy, but it remains vague.

→ The main pieces of EU energy policy of the past legislature do not focus on 'hydrogen readiness'. However, the notion gained traction following Russia's aggression against Ukraine, with the REPowerEU initiatives.

58 Ibid., Annex VII (B)(15).

59 See the submissions from the promoters during the preparation of the first PCI/PMI List, available in the Communication and Information Resource Centre for Administrations, Businesses and Citizens (CIRCABC): https://circabc.europa.eu/ui/group/3ba59f7e-2e01-46d0-9683-a72b39b6decf/library/dce36567-5a4f-4e95-afca-de02c428ee5a?p=1&n=10&sort=modified_DESC (last accessed in Jan. 2025).

60 TEN-E Regulation, Art. 31.

61 Ibid., Art. 31(1) (emphasis added).

62 Ibid., Art. 31(3) (emphasis added).

63 Ibid. (emphasis added).

64 Commission Delegated Regulation (EU) 2024/1041 of 28 November 2023 amending Regulation (EU) 2022/869 of the European Parliament and of the Council as regards the Union list of projects of common interest and projects of mutual interest, OJ L 2024/1041, 8.4.2024.

→ The idea of 'hydrogen readiness' is present in the regulation that governs support to the deployment of hydrogen cross-border infrastructure (TEN-E Regulation), where it is used to offer exemptions to former fossil gas projects. The exemptions are limited with deadlines for full fuel switch and requirements to provide evidence about how the switch will take place.

→ The formulation of 'hydrogen readiness' in the TEN-E Regulation presents ambiguities, especially when it comes to the fuels that hydrogen-ready projects must accommodate. This incentivizes fossil gas project promoters to claim the 'hydrogen-ready' label before there is any use of hydrogen or demonstration that hydrogen will be used. This risks overestimating and overstating the decarbonisation contribution of these projects.

3.3.

Private finance: the EU taxonomy for sustainable activities

The EU has a sustainable finance framework for private finance that aims to channel funds towards sustainable investments. One of its main components is the **EU taxonomy**, a classification system that defines which economic activities, and under which conditions, can be labelled as 'sustainable' investments.

The main rule of the EU taxonomy framework, the Taxonomy Regulation,[65] establishes that in order to qualify as environmentally sustainable an economic activity shall meet all of the requirements below:[66]

a) contribute substantially to one of the following six environmental objectives: climate change mitigation, climate change adaptation, sustainable use and protection of water and marine resources, transition to a circular economy, pollution prevention and control, and protection and restoration of biodiversity and ecosystems;

b) do no significant harm (DNSH) to the remaining five environmental objectives;

c) be aligned with minimum safeguards in human rights;[67] and

d) comply with the technical screening criteria that set the parameters for a particular economic activity to be assessed as contributing substantially to any of the environmental objectives, and as doing no significant harm to the other objectives. The technical screening criteria are set by the Commission through delegated acts.

The idea of 'hydrogen readiness' can be read between the lines of one of the delegated acts from the Commission, known as the Complementary Delegated Act (the CDA).[68] The CDA was adopted in 2022 to include a few energy-related economic activities in the taxonomy classification, including several fossil gas-burning activities.

'Hydrogen readiness' seems reflected in one of the two alternative sets of criteria[69] for three gas-burning economic activities to be considered to contribute substantially to climate change mitigation. These economic activities are: "Electricity generation from fossil gaseous fuels", "High-efficiency co-generation of heat/cool and power from fossil gaseous fuels", and "Production of heat/cool from fossil gaseous fuels in an efficient district heating and cooling system". [70]

The criterion requires that *"the [gas-burning] facility is designed and constructed to use renewable and/or low-carbon gaseous fuels and the switch to full use of renewable and/or low-carbon gaseous fuels takes place by 31 December 2035, with a commitment and verifiable*

65 Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088, OJ L 198, 22.6.2020.

66 Ibid., Art. 3.

67 Ibid., Art. 18.

68 Commission Delegated Regulation (EU) 2022/1214 of 9 March 2022 amending Delegated Regulation (EU) 2021/2139 as regards economic activities in certain energy sectors and Delegated Regulation (EU) 2021/2178 as regards specific public disclosures for those economic activities, OJ L 188, 15.7.2022.

69 The two sets of criteria are built around two alternative emissions thresholds. Either:
(a)A life-cycle GHG emissions lower than 100gCO2e/kWh, with additional criteria.
(b)Direct GHG emissions lower than 270gCO2e/kWh or average annual direct GHG emissions lower than 550kgCO2e/kWh over 20 years, with additional criteria, including the hydrogen readiness criterion we outline in this subsection.

70 CDA, Annex I, 4.29, 4.30 & 4.31.

plan approved by the management body of the undertaking;".[71] It should be noted that the switch to hydrogen is not the single option under this provision, since other gases can fall under "*renewable and/or low-carbon gaseous fuels*". Nevertheless, in the economic activities affected, hydrogen is likely to be among the options, if not the main option, for fuel switching. Unlike the uncertainty under the TEN-E Regulation as to whether and when a project promoter can claim their assets are hydrogen-ready, this criterion plainly states that the asset in question must be able to use hydrogen or other renewable or low-carbon gaseous fuels from the outset.

The CDA establishes as a safeguard that an "*independent third party*" shall verify compliance with the criteria, including the one quoted above. This third party shall have the necessary resources and expertise, be free of conflict of interest, and carry out the verification diligently. As part of its work, it shall prepare a yearly report, publish it, and send it to the Commission "*assessing whether the activity is on a credible trajectory to comply*" with the fuel switch requirement. The Commission can address opinions to the operators on the basis of the reports from the independent third party verifier.

In conclusion:

→ The concept of hydrogen readiness is present in one of the alternative sets of criteria that some fossil gas-burning projects would have to meet to be labelled as sustainable.

→ The formulation is more straightforward and detailed in the taxonomy than in the TEN-E Regulation. Its application also differs: in the TEN-E Regulation it is used to grant exemptions, while under the taxonomy it acts as a safeguard.

→ The verification of 'hydrogen readiness' by an independent third party is included as a requirement. The third party has to meet standards in terms of independence, capability and resources, and produce a report that shall be published and sent to the Commission.

3.4. Public finance: national subsidies and EU financing

The concept of hydrogen readiness has been introduced across various public financing tools and frameworks, to varying degrees. It has been integrated in EU State aid rules that govern national subsidies to companies (Section 3.4.1), in several EU funds and in the European Investment Bank's lending policy (Section 3.4.2), and in international public finance frameworks (Section 3.4.3).

3.4.1. EU State aid rules governing national subsidies

The EU State aid rules apply to any **State aid**[72] given by a government (national or regional) of an EU Member State to an undertaking. In the energy sector, governments grant investment aid (e.g. the construction of infrastructure) and operating aid (e.g. electricity or heating generation). Fossil gas infrastructure, such as storage, LNG terminals, import pipelines and interconnectors are typically financed by market actors and subject to competition, and therefore subject to EU State aid rules.[73]

State aid is **in principle prohibited** to protect competition, but it can also be a powerful tool for governments to boost certain economic sectors or address underinvestment from private actors. It can therefore be allowed in a targeted, controlled and effective way. The European Commission controls State aid. It needs to be **notified to and greenlighted by the Commission** before it can be implemented (there are exceptions for smaller aid amounts/projects). The EU State aid rules set out how, for what reasons, and under what conditions, Member States can hand out State aid.

71 Ibid. (emphasis added).

72 State aid refers to any form of support (subsidies, tax advantages, State guarantees, preferential loans, etc.) by a State or through State resources whereby an advantage is given to one or more undertakings (no matter the legal status), which (may) lead(s) to a distortion of competition on the EU internal market and likely affects trade between Member States. For more on EU State aid, please consult ClientEarth's guide on State aid control in the EU (February 2024).

73 The existence of State aid is excluded for energy infrastructure that is a legal or natural monopoly, due to the lack of competition. For more on the application of EU State aid rules to energy infrastructure, please consult the European Commission's Infrastructure analytical grid for Energy Infrastructure (2016-2017).

Several frameworks of the EU State aid rulebook[74, 75] apply to energy and have adopted the notion of **hydrogen readiness**.

a. **State aid Guidelines for climate, environmental protection and energy (CEEAG)**[76]

The CEEAG apply to several types of energy projects above certain financial thresholds and require Member States to notify and obtain the greenlight from the Commission.[77]

Energy infrastructure (Section 4.9 CEEAG)

When a Member State plans to grant more than EUR 70 million in aid (per undertaking per project) for energy infrastructure[78] (excluding generation – see next subsection), which is mostly the case for LNG terminals or fossil gas pipelines, it must demonstrate that:[79]

(I) the infrastructure is "***ready for the use of hydrogen***" and leads to an increase of the use of renewable gases or, if this is not the case, the reason why it is not the case and how the project does not lead to a lock-in of fossil gas, and

(II) the investment contributes to achieving the EU's 2030 and 2050 climate targets.

The CEEAG do not further specify how these conditions are to be applied, but the Commission's decision-making practice provides insight on its interpretation:

– The Commission recently published **two decisions approving aid for LNG terminals that are considered 'hydrogen-ready'**. Aid was approved for the construction and operation of the new on-shore LNG terminal in Brunsbüttel, Germany,[80] although the Commission clearly acknowledges that the terminal is not practically operational for the use of hydrogen at its inception and that subsequent costly investments at the time of conversion will be needed. Despite those facts, the Commission deems the 'hydrogen readiness' condition to be met as *(i)* it seems to have been demonstrated that the necessary upfront investments are undertaken so that components are already suitable for the import of ammonia (not hydrogen), *(ii)* the project owner has committed (in a non-public shareholder agreement) to convert the terminal for the import of green energy carriers by 2043, and *(iii)* the project is *capable* of leading to an increase in the use of renewable gases.[81] The same type of reasoning is applied by the Commission to approve new aid for the construction of the LNG terminal in Alexandroupolis, Greece.[82]

– Conversely, the aid for the expansion of the LNG terminal in Krk, Croatia, was approved although it does **not meet the 'hydrogen-ready' standard**. For the Commission it was sufficient that the project *indirectly* contributes to the increase in the use of hydrogen since the expansion supports connected fossil gas transmission pipelines that are hydrogen-ready. It also does not consider the terminal to lead to a lock-in of fossil gas in 2050 as it is expected to stop operating in 2040.[83]

74 Another framework that could potentially be relevant is the Important Projects of Common European Interest Communication (IPCEI). It applies to (very) large projects that involve cooperation between several Member States and private companies, aiming to address strategic challenges, enabling breakthrough innovation or building cross-border infrastructure projects, in view of achieving common EU policy objectives. The IPCEI Communication does not contain specific rules on energy (and therefore does not refer to hydrogen readiness) but requires projects to comply with the 'do no significant harm' principle of Article 17 of the Taxonomy Regulation 2020/852. So far, the Commission has approved 4 hydrogen IPCEI (Hy2Tech, Hy2Use, Hy2Infra, H2Move). Some of the selected projects concern (new and converted) transmission pipelines dedicated to hydrogen only, that seem to be designed to align with Annex I, Section 4.14 of the Taxonomy Climate Delegated Act (EU) 2021/2139 (Transmission and distribution networks for renewable and low-carbon gases).

75 The Temporary Crisis and Transition Framework (TCTF) also allows for State aid to be granted to hydrogen-ready industrial equipment under Section 2.6. An Italian scheme to support investment for the use of hydrogen in industrial processes has recently been approved by the Commission (SA.107476).

76 Communication from the Commission – Guidelines on State aid for climate, environmental protection and energy 2022, C/2022/481.

77 For more on the CEEAG, please consult ClientEarth's briefing on the CEEAG, Dec. 2021.

78 Defined in para 19, point 36 CEEAG, which includes transmission and distribution pipelines, interconnectors, LNG terminals, storage, etc.

79 CEEAG, para. 382, (d).

80 For more on this State aid decision, please see ClientEarth's opinion published in Euractiv, "Why backing Germany's LNG investment is a roadblock – not a bridge to the future", Jul 2024.

81 SA.102163, para.166-171.

82 SA.105781, para.145-147.

83 SA.106299, para.131-135; This project is part of Croatia's RRP and also complies with the RRF technical guidance.

– Similarly, aid for the expansion of the Chiren natural gas storage facility in Bulgaria was approved although the project cannot be designed or converted to store hydrogen. Yet, the expansion in itself is not considered to create lock-in effect for fossil gas and allows the decrease of the use of coal.[84]

<u>**Fossil gas cogeneration (Section 4.9 CEEAG), security of supply measures (Section 4.8 CEEAG) and district heating and cooling (Section 4.10 CEEAG)**</u>

For aid to new **fossil gas cogeneration** above EUR 30 million (per undertaking per project), **security of supply measures** or **district heating or cooling** above EUR 50 million (per undertaking per project), there is no explicit 'hydrogen-ready' condition. Yet, for State aid to be approved by the Commission for any such projects, "*Member States must explain how they will ensure that the aid contributes to achieving the Union's 2030 climate target and 2050 climate neutrality target and, in particular, how a lock-in of the gas-fired energy generation will be avoided. For example, this may include binding commitments by the beneficiary to implement decarbonisation technologies such as CCS/CCU or replace natural gas with renewable or low-carbon gas or to close the plant on a timeline consistent with the Union's climate targets.*"[85] A hydrogen-ready project is one way (but not the only way) of meeting this requirement, as it would in theory allow an operator to replace fossil gas with hydrogen (or another renewable or low-carbon gas).

Just as for energy infrastructure, the **Commission's decision-making practice** offers more insight into the application of the above conditions. In the approved investment aid scheme for high-efficient cogeneration plants using natural gas in district heating in Romania, one of the eligibility requirements for a plant to apply for aid is that it must be hydrogen-ready, which in this case means that the plant will be using a blend of fossil gas and hydrogen for a certain period and use 100% hydrogen by 2050, in line with the national hydrogen strategy (not adopted at the time of approval). Aid beneficiaries must also sign a declaration on honour that by 2050 the plants will run on hydrogen or have invested in CCS. These vague commitments seem to be sufficient for the Commission to consider the lock-in of fossil gas to be avoided.[86]

b. <u>The general block exemption regulation (GBER)</u>[87]

Similarly to the CEEAG, the GBER applies to several types of energy projects but below the same financial thresholds. These smaller aid amounts do not need to be notified and obtain the greenlight from the European Commission, provided all conditions of the GBER are fulfilled.[88]

For investment aid for **fossil gas infrastructure** below EUR 70 million (per undertaking per project), the GBER requires the infrastructure to be "***dedicated to the use for hydrogen*** *and/or for renewable gases, <u>or</u> used for the transport of more than 50% hydrogen and renewable gases.*"[89]

There are no known projects so far where this condition has been applied, making it difficult to understand to what extent this condition differs (or not) in practice from the condition in the CEEAG (which uses the more open phrasing "*ready for the use*").

For investment aid for **cogeneration** projects below EUR 30 million (per undertaking per project; Art. 41) and **district heating or cooling** projects below EUR 50 million (per undertaking per project; Art. 46), there is no explicit 'hydrogen readiness' conditionality. However, the project needs to comply with Section 4.30 (high-efficiency cogeneration) or 4.31 (district heating or cooling) of Annex I to the Taxonomy Delegated Regulation 2021/2139, which contain two sets of alternative criteria, one of which includes a requirement akin to hydrogen readiness (see above Section 3.3).

84 SA.106120, para.120-122; This project is part of Bulgaria's RRP and also complies with the RRF technical guidance.

85 CEEAG, para. 369 (security of supply measures) and similar wording in para. 129 (decarbonisation measures, which includes new fossil gas plants) and para. 397 (district heating/cooling).

86 SA.101723, paras. 26, 33, 116-119.

87 Commission Regulation 651/2014 of 17 June 2014 declaring certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty, OJ L 187 26.6.2014.

88 For more on the GBER, please consult ClientEarth's briefing on the GBER, May 2023.

89 Ibid. Art. 48 (emphasis added).

In conclusion

→ The actual application of **the 'hydrogen readiness' condition by the Commission in State aid decisions on gas transport infrastructure has been very weak to date**. The Commission considers a project to be ready for the use of hydrogen based on the vague commitment to convert the infrastructure in the (far) future based on project plans (that can change), private contracts (that can be modified, breached or terminated, and that the Commission or national governments cannot enforce) or phase out dates in national law (that can change). The Commission has not made the disbursement of aid conditional upon actually being hydrogen-ready at some point in the future. In addition, the Commission is bending its own guidelines when it considers it to be sufficient that a project is "capable of leading" or "indirectly leads" to an increase of the use of renewable gases, whereas the requirement as written in the CEEAG is that it should simply lead to an increase in such use.

→ Finally, **the Commission's assessment is equally problematic for projects that are not considered hydrogen-ready and must demonstrate that they do not lead to a fossil gas lock-in**. The fact that infrastructure will (in principle) no longer be operational in 2050 seems to be sufficient for the Commission to find a lack of lock-in, whereas the concept of lock-in and its assessment is much more comprehensive, at least to be a meaningful safeguard against unbridled fossil gas expansion (see Section 4).

3.4.2.

EU financing: EU funds and the European Investment Bank

The concept of hydrogen readiness has been introduced in a few EU financing tools. The terminology used for hydrogen readiness varies across the funds. Whereas in some funds it is a binding condition to obtain financing (e.g. Cohesion Fund, European Regional Development Fund), in other cases it is left as one of the options for a project to meet certain climate standards (e.g. Modernisation Fund).

→ The Recovery and Resilience Facility

The Recovery and Resilience Facility (RRF)[90] is a large EU flagship initiative with the purpose of mitigating the economic and social impact of the COVID-19 pandemic. As a performance-based fund, it is available to Member States to implement reforms and investments for the green and digital transition, but also to implement the REPowerEU Plan. In principle, the facility only supports measures that respect the Do No Significant Harm Principle, but an exception is made for REPowerEU measures necessary to meet immediate security of supply needs.[91] Further Commission guidance sets out several conditions that need to be met for **energy infrastructure and facilities essential to meet immediate security of supply** to receive support from the RRF. Fossil gas infrastructure more specifically must be **future-proof where possible** to facilitate the future repurposing for sustainable fuels, which implicitly refers to hydrogen readiness of the infrastructure. It also specifies that "*For example, Member States should explain if the infrastructure would be enabled to operate with 100% pure hydrogen or its derivatives, and if it is not possible, set out relevant reasons*."[92]

→ The Cohesion Fund and the European Regional Development Fund

The objective of the Cohesion Fund and the European Regional Development Fund (ERDF) is to strengthen economic, social and territorial cohesion in the EU.[93] Whereas the cohesion fund specifically supports investments in the field of environment and trans-European transport infrastructure in Member States with a low gross national income per capita, the ERDF finances projects to reduce disparities between the levels of development of the various regions of the EU. Investments in energy are possible under both funds. Investments into the production, processing, transport, distribution, storage or combustion of fossil fuels are in principle excluded, but investments in the expansion and repurposing, conversion or retrofitting of gas networks are possible provided it makes the networks "***ready for adding renewable and low carbon gases****, such as hydrogen, biomethane and synthesis gas, into the system and allows to substitute solid fossil fuels installations*".[94]

90 For more on the RRF, please consult the Commission's webpage on the RRF.

91 Article 5 and 21c of the Regulation (EU) 2021/241 of the European Parliament and of the Council of 12 February 2021 establishing the Recovery and Resilience Facility, OJ L 57, 18.2.2021 (as amended by Regulation (EU) 2023/435 and Regulation (EU) 2024/795).

92 Part II, I, 3 of Commission notice – Guidance on Recovery and Resilience Plans in the context of REPowerEU, 3.3.2023.

93 For more on both funds, please consult the Commission's webpage on the cohesion fund and the ERDF.

94 Article 7, 1, h of Regulation 2021/1058 of the European Parliament and of the Council of 24 June 2021 on the European Regional Development Fund and on the Cohesion Fund, OJ L 231, 30.6.2021 (emphasis added).

Connecting Europe Facility

The Connecting Europe Facility (CEF) supports the trans-European networks in the transport, energy and digital sectors. For the energy sector, projects that contribute to the development of projects of common interest (PCI projects) or facilitate cross-border cooperation in the area of energy, can be funded. In terms of hydrogen readiness, the eligibility of projects is determined in line with the criteria set out in the TEN-E Regulation (see Section 3.2).

Modernisation Fund

The Modernisation Fund[95], funded by the EU Emission Trading System (ETS), supports projects to modernise energy systems and improve energy efficiency in 13 lower-income Member States, which are typically still heavily relying on coal.[96] It distinguishes between priority (80%) and non-priority (20%) investments. Both types of investments must comply with conditions related to greenhouse gas reduction and contribute to EU climate targets. While the EIB assesses whether a project qualifies as priority (or not) and the Investment Committee recommends financing for non-priority investments, it is the Commission that takes the final investment decisions. Whereas some investments into fossil gas infrastructure can be financed without any compliance with the Do No Significant Harm Principle, other investments must go through a "do no significant harm" assessment starting in 2025 by showing alignment with the taxonomy criteria set out in the CDA, under which a future conversion of the infrastructure to hydrogen is one of the options (see Section 3.3 above).[97] In practice, project promoters often pledge that the fossil gas infrastructure will be hydrogen-ready to ensure that the project will be accepted for funding.

European Investment Bank

The European Investment Bank (EIB), one of the world's largest multilateral financial institutions, provides long-term financing to projects, such as for climate action, within and outside the EU. The EIB prides itself to have decided in its 2019 Energy Lending Policy to phase out the financing of unabated fossil fuel energy projects, including fossil gas. Instead, EIB decided to support low-carbon fuel projects and infrastructure needed to integrate low-carbon gases into existing gas infrastructure.[98]

Gas network projects that "*are planned to transport low carbon gases, including the rehabilitation and adaptation of existing gas infrastructures when it is part of this goal*" can be supported.[99] There is no further guidance on what exactly such plans should contain in terms of technical feasibility, timeline and financial viability, potentially making it an open door for network projects to use fossil gas for their entire lifetime.

Moreover, despite its commitment to phase out fossil fuel support, financing can be provided to fossil gas-fired power generation projects and district heating and cooling projects below certain emissions standards, which can be met by for instance providing a credible plan to blend increasing shares of low-carbon gas (such as green or blue hydrogen) over the economic lifetime of the project.

95 For more on the Modernisation Fund, please consult the Commission's webpage as well as the dedicated website. For the role of fossil gas in the modernisation fund and the concrete examples in Romania, see the report by Bankwatch, The Modernisation Fund, An open door for fossil gas in Romania, Mar. 2024.

96 Article 10d of Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a system for greenhouse gas emission allowance trading within the Union (ETS directive); See also the Assessment Guidance Document of the Modernisation Fund, Dec. 2023.

97 Respectively article 10d(4) and 10d(1) of the ETS Directive.

98 Para 10-11 of the executive summary and 18-24 of Section 3 of the EIB Energy Lending Policy.

99 Ibid., para. 46.

3.4.3.

International public finance

Large overseas energy projects by European companies often benefit from **export credit finance** to mitigate certain financial risks linked with investing outside of the EU. For the orderly use of officially supported export credits[100] and to encourage competition among exporters, the EU together with other countries have, within the framework of the Organisation for Economic Cooperation and Development (OECD), agreed on the "**Arrangement on Officially Supported Export Credits**" (OECD Arrangement).[101] This gentlemen's agreement (non-legally binding) between participating countries provides a framework that applies to all official support provided by or on behalf of a government for export of goods and/or services. The OECD Arrangement is implemented by regulation[102] in EU law and therefore binding upon national export credit agencies in the EU.

The OECD Arrangement does not require fossil fuel projects as such to be hydrogen-ready to benefit from export credit. However, the construction of storage, transmission and distribution facilities connected to clean hydrogen production plants or facilities that are expected to be connected within five years, as well as conversion of fossil gas facilities and repurposing of gas networks, benefit from an extended maximum repayment term for the export credit of 22 years, instead of the usual 15 years.[103] Hydrogen-ready facilities are therefore given an advantage without a clear obligation to actually transport hydrogen. Most national export credit agencies have updated their export credit policies in line with the OECD Arrangement (see Section 3.5.1 for instance for Germany).

The concept of hydrogen readiness has been introduced across various public financing frameworks, to varying degrees:

→ State aid rules on national subsidies include the concept, which has already been used in the approval of aid for at least two LNG terminals. However, a clear definition has not been set and the Commission's understanding of hydrogen readiness has to be read between the lines in its State aid decisions.

→ Some EU fund frameworks and the EIB use the concept, but without a harmonised terminology. In some funds, hydrogen readiness is a binding condition (such as in the Cohesion Fund), while in other cases it is only one of the alternative options to meet climate standards (Modernisation Fund).

→ In international public finance, the non-binding OECD Arrangement on Officially Supported Export Credits does not require hydrogen readiness, but suggests extended repayment terms for projects that commit to switch fuels in the future.

100 Export credit refers to financing or credit facilities (including insurance and guarantees) that are given to exporters to enable them to sell goods and services in overseas markets. Export credit is provided by export credit agencies (ECA) or investment insurance agencies, which are private or quasi-governmental institutions, that act as an intermediary between national governments and exporters to issue export financing or credit facilities. Each European Member State has one or more ECA (e.g. Euler Hermes or KFW in Germany, Bpifrance Assurance Export in France or SACE in Italy).

101 OECD, Arrangement on officially supported export credits (as modified in July 2023). The participating countries are Australia, Canada, the EU, Japan, Korea, New Zealand, Norway, Switzerland, Türkiye, the UK and the US.

102 Regulation 1233/2011 of the European Parliament and of the Council of 16 November 2011 on the application of certain guidelines in the field of officially supported export credits and repealing Council Decisions 2001/76/EC and 2001/77/EC, OJ L 326, 8.12.2011.

103 OECD Arrangement, p.47, Project Class F, Type 3.

3.5. National law and policy

Although many countries have adopted or are working on a hydrogen strategy, which often revolves around the promotion of the production of green hydrogen and the construction of a hydrogen 'backbone' in industrial clusters, not all of them have introduced the idea of 'hydrogen readiness' in their law and policy, at least for the moment. This seems to be the case of Member States such as Belgium, France, the Netherlands, Poland and Spain. On the other hand, Germany stands out for having adopted the concept in law and relying on it for policy decisions.

3.5.1. Germany

As Europe's largest economy, Germany has bet big on hydrogen to decarbonise its industry. It has adopted several policies and laws to support the development of hydrogen as such, but it has also allowed for extending support for fossil gas infrastructure, provided it is hydrogen-ready, as this is considered to be a stepping stone for the uptake of hydrogen. Although there are variations in the application of the concept, these laws and policies **tie the possibility to support fossil gas infrastructure to a commitment to convert it in the future**. In practice, if these commitments are unsound and/or not legally padlocked, this may simply result in a lifeline for new fossil gas projects.

During the recent energy crisis following Russia's invasion of Ukraine, Germany adopted the **LNG Acceleration Act**[104] to secure its national energy supply through the rapid integration of LNG into the energy system. The purpose of the law is to accelerate the authorisation for the construction and commissioning, as well as the implementation of procedures for the award of public contracts and concessions, of LNG terminals and connection pipelines. In the longer term, Germany wants to convert these infrastructures to import hydrogen and/or ammonia to decarbonise its economy. Therefore, LNG terminals and connection pipelines that are to be operated beyond 2043 will only be granted a permit if operated with climate-neutral hydrogen and its derivatives.[105] The application for a permit beyond 2043 needs to be submitted by the end of 2034 and proof needs to be provided that a conversion is technically possible. There are no further details on what is required in terms of technical feasibility. Other important aspects, such as the financial viability of the conversion and the existence of hydrogen supply and demand, do not seem to matter.

Similarly, for electricity generation, the **Combined Heat and Power Act** entitles operators of CHP plants to the payment of the CHP surcharge (which is a subsidy) after 30 June 2023 if, amongst others, the plant can be converted from 1 January 2028 with a maximum of 10% of the costs of a CHP plant that would run exclusively on hydrogen.[106] Likewise, for heating, the revised **Building Energy Act** (also called the heating act) that aims to reduce emissions from heating in buildings still allows the installation of hydrogen-ready gas boilers, if local authorities and the distributor of the gas network can commit that hydrogen will be supplied by 2045 in that area.[107]

Moreover, to decarbonise its energy system and become a climate-neutral industrial country by 2045, Germany adopted a new "**Power Plant Strategy**". As part of that strategy, the German government had proposed the Power Plant Safety Act, which was to set up a subsidy scheme for the build out of new hydrogen-ready fossil gas power plants and hydrogen-ready modernisations of existing plants, provided the plants switch to hydrogen from the 8th year of their commissioning/modernisation.[108] Consultations were held in September to October 2024 on the proposed State aid to be provided under the Power Plant Safety Act.[109] Although tenders were expected to begin in early 2025, the proposal has since been stalled due to the collapse of the governing coalition in late 2024 and resulting lack of majority support.[110]

104 Law to accelerate the use of liquefied natural gas (*LNG Acceleration Act – LNGG*).

105 §5(2) of the LNG Acceleration Act.

106 §6(1) nr.6,7 Law on the maintenance, modernization and expansion of combined heat and power (Combined Heat and Power Act – KWKG).

107 § 71 Law on saving energy and using renewable energies to generate heat and cold in buildings (Building Energy Act – GEG).

108 Press Release from the Ministry for Economy and Climate, Jul. 2024.

109 Press Release from the Ministry for Economy and Climate, Sep. 2024.

110 Handelsblatt, Ministry: Power plant law no longer coming, Dec. 2024.

Finally, in terms of **public finance**, Germany's state-owned investment and development bank (KFW), which amongst other functions grants State aid (see Section 3.4.1) and provides export credit finance[111] (see Section 3.4.3), has also adopted the concept of hydrogen readiness in its Paris-aligned sector guidelines (KFW guidelines):[112]

- For the power generation sector, the KFW guidelines state that fossil gas power plants that "*are capable of using hydrogen in the future*" can be financed and are considered as transitional. However, due to the uncertainties associated with the availability of hydrogen, fossil gas plants can be financed if they contractually commit to operate with hydrogen as from 2035 in industrialized countries or 2040 in developing and emerging countries <u>*or*</u> are hydrogen-ready by 2030 in industrialized countries or 2035 in developing and emerging countries and declare their intent for operation with hydrogen (although it is unclear as from when that operation effectively needs to take place).[113]

- For the oil and fossil gas sectors, unlimited financing can be provided for pipelines that are technically designed for 100% hydrogen use (including conversion measures), without the actual obligation to use those pipelines to transport hydrogen.[114]

3.5.2.

Other EU Member States

Some member states are supporting the development of a national hydrogen economy, without an emphasis on hydrogen readiness, but rather on new dedicated hydrogen infrastructure. That is the case in Spain, where the Hydrogen Pathway[115] focuses on the production of green hydrogen and its transport infrastructure, but there is no push to support new gas infrastructure based on hydrogen readiness.

In Italy, at least two gas projects are being proposed as hydrogen-ready: the Adriatic Line[116] and the SoutH_2 Corridor[117]. Snam, the main Italian gas TSO, is involved in the development of both of them. In a decision from December 2023, the Italian Energy Regulator tasked Snam, along with other gas companies, to work on the definition of "*a set of a set of minimum requirements and parameters that allow the unambiguous identification of network sections suitable for hydrogen transport*".[118] Snam is part of the H2GAR initiative, a platform of TSOs sharing expertise on the effects of hydrogen's injection in the fossil gas system.

In Poland, some projects are being proposed as hydrogen-ready by industry (including the modernisation of Dolna Odra[119] and Żerań[120] power plants). However, the country does not seem to be relying on the idea to justify new gas infrastructure, which still can be built without having to comply with hydrogen-readiness requirements.

111 The German government adopted specific sector guidelines that only apply to export credit, notably for the energy sector: Klimapolitische Sektorleitlinien der Bundesregierung für die Exportkredritgarantien.

112 KFW, Paris-aligned sector guidelines of KFW Group (version 05/2024).

113 KFW guidelines, p.12; Other options such as fossil gas plants with CCUS or for balancing capacity or buffer renewables are also possible.

114 KFW guidelines, p.21.

115 Ministry for the Ecological Transition, *Hoja de ruta del hidrógeno: una apuesta por el hidrógeno renovable (Hydrogen pathway : a bid for renewable hydrogen)*, Oct. 2020.

116 SNAM, The Adriatic Line (last accessed Jan. 2025).

117 SNAM, SoutH2 Corridor (last accessed Jan. 2025).

118 ARERA, Deliberazione 12 Diciembre 2023, p. 12 (unofficial English translation).

119 GE Vernova, The right solution for Poland's low-emission energy needs (last visited Jan. 2025).

120 Global Energy Monitor, Zeran power station (last visited Jan. 2025).

The concept of hydrogen readiness is starting to make its way into national law and policy:

→ Germany is developing policies that include the notion of hydrogen readiness, although without a clear definition. Different policies that allow for new gas infrastructure to be built or receive public support require hydrogen readiness, but without substantial safeguards when it comes to the availability or emissions profiles of such hydrogen.

→ Other countries are not so focused on using this concept, even when they have different approaches, such as a heavy focus in green hydrogen (Spain), or promoting new gas infrastructure that will be hydrogen-ready (Italy).

4.

Risks of 'hydrogen readiness'

The adoption of the notion of 'hydrogen readiness' into EU energy law and policy triggers numerous risks for investors in projects with that label, as well as for the achievement of EU energy and climate objectives:

1. **Price risk**. Hydrogen price projections involve highly uncertain estimates, which entails that an overshoot over the costs currently projected by industry is possible. Furthermore, should hydrogen not be available at scale in the future, fossil gas will continue to be sourced for hydrogen-ready facilities, reinforcing the system's exposure to volatile fossil gas prices.

   The price risk associated with 'hydrogen readiness' would affect not only the viability of projects, but the Energy Union's aim to ensure affordable prices. The political direction to contain prices has been reinforced in recent years, including by the Mission Letter to the Commissioner-designate for Energy and Housing, which tasked him with putting forward the Commission's new Action Plan for Affordable Energy Prices to bring prices down for households and business.[121]

2. **External dependency risk**. As is currently the case with fossil gas, hydrogen will be mostly imported. This reinforces the exposure of the EU to external markets and any events that may disrupt them. By contrast, other available solutions, such as electrification or energy efficiency measures, would reduce the need to import energy carriers.

   Incentivising investment, or investing, in infrastructure that further aggravates the external dependency of the EU would be difficult to reconcile with objectives of the REPowerEU Plan, which emphasises limiting the EU's reliance on imported energy sources. It would also contrast with the overarching objective of the EU energy policy to ensure security of supply.[122]

3. **Lock-in risk**. This risk refers to the prospect of creating a situation of lock-in; i.e., a situation in which choices are limited in the future due to past decisions which create rigidity and force a system to bear inefficiencies.

   An example of lock-in is the existence narrow gauge railways, which are generally less efficient in terms of stability and amount of cargo that can be transported. Despite these inefficiencies, they still are prevalent today, given the huge investments that would be needed to rebuild existing infrastructure. In some instances, these railways are even still expanded, given the incentive to show compatibility with old, existing infrastructure.[123]

   In the context of hydrogen readiness, lock-in would manifest itself in different ways, mainly by exacerbating other risks identified in this Section, since it would create barriers to the adoption of other energy solutions in the future:

   - Asset lock-in: The infrastructure and equipment labelled as hydrogen-ready would require the consumption of fossil gas in the first phase and, potentially, of hydrogen in the future. Given that such assets are long-lived and costly, this would create a bias towards the continued use of hydrogen (or fossil gas) for a long period of time, despite future prices, sourcing difficulties, or attractiveness of other alternatives. Another potential outcome of asset lock-in would be asset-stranding, addressed below within financial risks.

   - Carbon lock-in: The term 'carbon lock-in' refers to the tendency for certain carbon-intensive technological systems to persist over time, 'locking out' lower-carbon alternatives, and owing to a combination of linked technical, economic, and institutional factors.[124]

121 Mission Letter to Dan Jørgensen, 17 Sept. 2024, p.5.

122 TFEU, 194(1)(b).

123 Palley, T., A theory of economic policy lock-in and lock-out via hysteresis: Rethinking economists' approach to economic policy, Economics E-Journal 11(1), July 2017.

124 P. Erikson et al., Assessing carbon lock-in, Environmental Research Letters, Vo. 10, No. 8, Aug. 2015.

- Institutional lock-in: This type of lock-in refers to situations where institutions, both public and private, become entrenched in supporting a particular technology or policy option, making it difficult to shift in the future. This includes ways of thinking, or research that receives public funding.

The outcomes of lock-in risk could collide with different principles and provisions of EU energy law and policy, for example in Article 194 of the Treaty on the Functioning of the European Union:

- Security of supply (Art. 194(1)(b)): A portion of energy demand would be restricted (locked-in) to a fuel that must be imported, may be expensive and may not be available at scale. An interpretation where 'hydrogen readiness' alleviates dependencies on fossil gas and therefore mitigates fossil gas lock-in is risky, since it fails to take into account the lock-in effect of hydrogen, the increased exposure to hydrogen prices, and the prolongation of the lock-in of fossil gas in case of lack of enough or economical sources of hydrogen.

- Energy efficiency, savings, and renewable forms of energy (Art. 194(1)(c)): Locking in future hydrogen and/or fossil gas use can impede the implementation of more efficient decarbonisation pathways, namely reducing energy demand, renewable energy, energy efficiency, and flexibility.

4. **Financial risks**: Betting on 'hydrogen readiness' also has associated financial risks. While investors would bear most of the direct risk, given the strategic importance of the energy sector and the commitment of public authorities with ensuring security of supply, derived financial losses are likely to be socialised through taxes, public expenditure, or energy tariffs. To these potential costs, opportunity costs of any public funds spent in supporting 'hydrogen readiness' should also be added.

   - Asset-stranding. Stranded assets can be defined as infrastructure that has suffered from unanticipated or premature write-downs, devaluations or conversion to liabilities.[125] Stranded assets and lock-in are related but distinct concepts. Stranded assets refer to the financial risk of investments not being paid back and losing value, while lock-in describes the broader impact of being tied to a specific technology or supplier. In short, lock-in can result in or contribute to stranded assets (although it is a wider concept), and stranded assets can be caused by factors other than lock-in. In the context of hydrogen readiness, assets could be stranded if hydrogen is not available at the volume and price expected when designing projects, rendering them unprofitable.

   - Litigation. Litigation could arise in connection with hydrogen-ready projects (for example, for misleading claims, or for infringement of contract obligations to source hydrogen at a certain price) and fines imposed on project developers or even funders.

   - Inefficient public spending. When implementing the EU budget, the Commission must ensure sound financial management, including efficiency considerations.

5. **Climate risks**. The uncertain carbon profile of the hydrogen to be burned by 'hydrogen-ready' facilities, the potential prolongation of the use of fossil gas to compensate for hydrogen unavailability, and the diversion of funds that could be used for already available solutions all contribute to the risk of failing to deliver on climate targets.

   The EU has a binding climate-neutrality objective for 2050, a 55% reduction target for 2030, and a Commission-proposed 90% target for 2040. The timelines tied to hydrogen readiness identified in this report, which venture into the 2040s, could greatly interfere with the delivery of the EU's climate commitments.

6. **Risks associated to the incompatibility with EU legal principles**. Based on the current traits of the emerging concept of 'hydrogen readiness', it can be inferred that it could be incompatible with a number of EU law principles:

   - Precautionary principle. This principle proposes that authorities should err on the side of caution when facing an uncertain situation. In the case of hydrogen readiness, there are substantial doubts about the future availability and price of hydrogen.

   - Energy efficiency first principle. Energy efficiency is one of the aims of EU energy policy.[126] The energy efficiency first principle requires, when making energy policy, planning and investment decisions, that efficiency approaches (including those which promote a more efficient conversion,

125 Caldecott, B., et al, Stranded Assets and Scenarios, Oxford Smith School, 2014.

126 TFEU, 194(1)(c).

transmission and distribution of energy) are considered.[127] The recently revised Energy Efficiency Directive specifically obliges Member States to ensure application of the principle in all planning, policy and major investment decisions in energy and non-energy sectors alike,[128] and the Commission has since elaborated detailed guidance on how this requirement is to be complied with in practice.[129] The processes for hydrogen production and use implies chemical reactions that lead to energy loss that are generally larger than those from electricity, and efficiency solutions must be considered when assessing whether to promote hydrogen production.

- Principle of legal certainty. There is an obligation under the general principles of EU law for rules of law to be clear and predictable in their effect, so that interested parties can ascertain their position in situations and legal relationships governed by EU law.[130] The current lack of clarity on the concept of hydrogen readiness may delay investment decisions in alternative solutions that are already available, lead to inefficient investments, or give rise to conflicts between definitions from different domains, since it is unclear how the concept will be adapted to different contexts and if they will be compatible.

7. **Reputational risks**. The use of the label 'hydrogen-ready' could affect the reputation of investors and project developers. Failure to source hydrogen at price and volume and failed projects would reduce companies' trustworthiness. Additionally, although 'hydrogen readiness' does not necessarily entail clear obligations on climate action nor ensure Paris-alignment, company statements that projects are hydrogen-ready could be publicly perceived as greenwashing, especially if such projects continue burning fossil gas for longer than anticipated.

In summary, the reliance on the concept of hydrogen readiness has a number of risks associated which could impact investors, companies using hydrogen, consumers, and EU policy objectives.

Risks	**Potential Impacts**
Price risks	Energy affordability Energy poverty Inflation and industry competitiveness
External dependency risk	Security of supply
Lock-in risk	Reduced options for policy-makers and project owners Exacerbates rest of risks
Financial risks	Companies incur stranded asset losses Wasted public funds Consumers or taxpayers foot the bill if losses are socialised
Climate risks	Increased emissions Sustainability of the Energy Union
Risks associated to EU law principles	Increased chances of legal challenges against companies, investors and energy policies
Reputational risks	Damaged reputation of companies and investors Reduced company and brand value

127 Art. 2(18), Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, OJ L 328, 21.12.2018.

128 Art. 3, Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955, OJ L 231, 20.9.2023.

129 Commission Recommendation (EU) 2024/2143 of 29 July 2024, OJ L 2024.2143, 9.8.2024.

130 Judgment of 15 February 1996, *Duff and others*, Case C63/93, Para 20.

5.

Suggested ways forward

5.1.

Do away with the 'hydrogen readiness' concept altogether

Use of 'hydrogen readiness' so far has left **many key questions unanswered**. **Industry formulations tend to focus on the technical and commercial feasibility of conversion**, without providing reasonable assurances that any conversion or future hydrogen use will in fact occur, nor whether such use represents the most efficient and least harmful decarbonisation pathway for the fossil fuel end use in question. This focus does little to address the main physical, economic, and environmental challenges of the hydrogen economy (Section 2), nor the key legal, financial, lock-in, and other risks of the hydrogen readiness concept (Section 4). Labelling a piece of infrastructure or equipment as hydrogen-ready without properly considering these broader risks and issues simply puts the cart before the horse.

Policy frameworks attempt to place some guardrails around these considerations, although their effectiveness is questionable. For example, the Climate, Environmental Protection, and Energy Guidelines for State aid (CEEAG) require the Commission to assess whether the fossil gas infrastructure in question is hydrogen-ready and whether the planned aid will lead to an increase in renewable gases (or if not, whether fossil gas lock-in will be avoided). In theory, providing this vetting function to the Commission should help ensure that both conversions and hydrogen use will in fact occur. However, as discussed in Section 3.4, application of these provisions has so far been weak and has not demanded certainty around future conversion and use. Similarly, as discussed in Section 3.2, the revised TEN-E Regulation charges ACER with verifying the progress of fossil gas infrastructure towards becoming 'dedicated hydrogen assets', but there is no enforcement or other power to intervene to ensure this transition. And in the policies discussed, there is little to help ensure that – compared to other options – hydrogen is the preferable decarbonisation solution from an economic, social, or environmental view.

Due to these shortcomings, **the hydrogen readiness concept appears to do little more than support new fossil gas infrastructure and equipment**. It gives the false impression that infrastructure and equipment so labelled can and will be converted, that it will use hydrogen, and that this use makes sense. This also provides a false sense of comfort that the fossil gas industry's business as usual can continue, because one molecule can (and will) simply be replaced with another molecule.

Therefore, **the clearest and best solution for preventing these misconceptions** (and to mitigate the price, external dependency, lock-in, financial, climate, legal, and reputational risks discussed in Section 4) is to **abandon the 'hydrogen readiness' term altogether** – unless and until the infrastructure or equipment in question can and will use 100% hydrogen from the outset without conversion. Anything else risks confusion, which impedes the energy transition. As outlined in Section 2.2 above, it is also important to emphasise that **even such 'hydrogen using' infrastructure and equipment can have significant negative environmental and cost impacts and that questions will often remain about their sustainability.**

> The **hydrogen readiness concept should be abandoned** – this is the only way to effectively guard against the significant risks and misconceptions around using the term – unless and until the infrastructure or equipment in question can and will use 100% hydrogen from the outset.

5.2.

Proposed requirements and procedural considerations

However, if notwithstanding the above, policy frameworks and industry standards do adopt the concept, **then certain minimum safeguards must be introduced** to reduce as far as possible the price, external dependency, lock-in, financial, climate, legal, and reputational risks discussed in Section 4. Decision makers must require robust evidence and attach enforceable conditions to provide full confidence that the infrastructure or equipment in question will be converted to use hydrogen, that hydrogen will in fact be used, and that such use represents the most cost-effective and least harmful (socially and environmentally) decarbonisation solution.

The following is a list of complementary requirements – beyond the more commonly discussed technical and financial aspects – that should be attached to any use of the hydrogen-ready concept, followed by some more procedural considerations to ensure proper implementation and enforcement.

a. Substantive Considerations

Conversion and Use Deadlines – Even if a piece of infrastructure and equipment can be converted, there must be a specific date by which the conversion occurs and hydrogen use begins. This is necessary to ensure that hydrogen use occurs soon enough to help achieve climate targets.

Upfront Financing or Securities – To ensure future hydrogen conversion and use occurs by the required deadline, projects benefiting from the 'hydrogen-ready' label should also be required to make an upfront showing that future conversion costs will be covered. This could, for example, be shown through incorporating these costs into the overall project costs and procuring related financing from the outset, or through procuring appropriate securities, guarantees, or insurance to cover the costs if the conversion does not occur. Conversion costs in principle should not be subsidized by existing fossil gas customers.

Supply and Demand Assessments – Deadlines around conversion and use will not have any practical impact if there is no credible guarantee that there will be sufficient supply and demand for hydrogen by the required date. Project promoters should therefore be required to make an upfront showing that there will be sufficient supply and demand for hydrogen by the time of conversion and throughout the normal useful life of the infrastructure or equipment. At a minimum, such a showing should be based on commercial contracts and independently verified and publicly available supply and demand projections. Such a requirement would build on similar provisions in the Hydrogen and Decarbonised Gas Markets Package which require certain operators to regularly perform and report demand and market assessments for renewable and low-carbon gases.[131]

Confirmations Regarding Use – Hydrogen and its derivatives should only be used to decarbonise those fossil fuel end uses which cannot be decarbonised through electrification or other approaches. Therefore, it must be verified that, from an overall system perspective, the proposed hydrogen use in question represents the least harmful and most efficient solution. For example, this could include a requirement that new hydrogen-ready fossil gas import and transport infrastructure be developed only to serve identified downstream clusters (or 'valleys') consisting only of hard-to-abate industries that cannot be otherwise decarbonised, and not to serve generally customers across the existing fossil gas network.

Confirmations Regarding Production and Transport – Similarly, one can only credibly demonstrate or verify that hydrogen is an appropriate decarbonisation solution if upstream environmental and socioeconomic impacts are properly understood. Promoters of hydrogen-ready projects should therefore be required to assess in advance, and on an ongoing basis, the environmental and human impacts of upstream hydrogen production and transport, and to adopt measures to mitigate these impacts. Several recently adopted EU legislative frameworks could either be directly applied or their approaches used as proxies to guide these assessments. These include the green hydrogen production rules under Delegated Act on Renewable Fuels of Non-Biological Origin under the Renewable Energy Directive,[132] the monitoring, reporting, verification, and mitigation

131 See, e.g., Art. 9, Regulation (EU) 2024/1789 of the European Parliament and of the Council of 13 June 2024 on the internal markets for renewable gas, natural gas and hydrogen, OJ L, 2024/1789, 15.7.2024

132 Commission Delegated Regulation (EU) 2023/1184 of 10 February 2023 supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council by establishing a Union methodology setting out detailed rules for the production of renewable liquid and gaseous transport fuels of non-biological origin, OJ L 157, 20.6.2023.

requirements under the new Methane Regulation,[133] and supply chain due diligence laws like the Corporate Sustainability Due Diligence Directive.[134]

Demonstrations of Future Permit Compliance – Lastly, even if all the above conditions are met, it would not make sense to condition an approval on the 'hydrogen readiness' concept if it is unlikely that the infrastructure in question will obtain the necessary permits or amendments of existing permits for the conversion and use. As discussed in Section 2, there are numerous potentially relevant differences between hydrogen and fossil gas – e.g., higher risk of embrittlement, higher risk of explosion, higher leakage risks, different technical requirements for cooling and shipping – any of which could provide sufficient justification to apply different conditions for permitting and other authorisations. Project promoters should be required show upfront that existing permitting regimes will be complied with.

b. Implementation and Enforcement

The effectiveness of the above more substantive requirements will depend on the manner in which they are implemented and enforced. Relevant decisionmakers and public authorities must be given proper monitoring, enforcement, and other powers to ensure that hydrogen-ready projects do in fact convert and begin using hydrogen by the required date, and that such use makes economic and environmental sense. The nature of the implementation and enforcement frameworks will vary due to the specific characteristics of each jurisdiction's legal system, but some general principles should apply:

Assessments, Monitoring and Verification – appropriate regulatory authorities should be empowered to assess, monitor, and verify compliance across all the above requirements. Whether hydrogen use makes sense from an economic and environmental perspective, the upstream environmental and social impacts of this use, relevant market developments, and the operator's progress in conversion works to meet the applicable deadline, are all issues that can either be assessed by a regulator in the first instance, or verified following an assessment by the project operator. Assessments and verifications should generally be made in advance, but also on ongoing basis, supported with regular monitoring.

Independent Auditing and Advice – assessment, monitoring, and verification should also be supported by independent third parties with appropriate technical expertise on the given subject matter. For example, an auditing firm can assess and verify compliance with progress in conversion works, and non-departmental climate advisory bodies can advise (at least at a system level) whether and when hydrogen use will represent the least harmful and most efficient decarbonisation approach.

Enforcement Powers – where the project operator fails to meet certain substantive requirements, the regulator should be empowered to take corrective action. For example, if the operator lacks financial resources to convert, the regulator should be able to seek a third party to finance or undertake this work. Further, if the hydrogen market develops in such a way that hydrogen use for the given application no longer makes sense by the required conversion date, regulatory pathways should be created to mothball or decommission the fossil gas infrastructure to ensure that climate targets can still be met. Financing conditioned on the hydrogen readiness concept should be clawed back, or it should be disbursed only on a forward-looking basis, upon delivering milestones which provide implementation certainty.

If – contrary to the main recommendation of this report – the hydrogen readiness concept is used, **certain minimum safeguards must be introduced** to mitigate the risks and misconceptions discussed herein. **Substantive requirements** should include firm conversion and use deadlines, the provision of upfront financing or securities for conversion costs, regular supply and demand assessments to ensure sufficient hydrogen supply, ongoing confirmations that hydrogen will be used in only those applications where it makes economic and environmental sense, assessments and corrective actions to identify and mitigate upstream environmental and social harms, and demonstration around future permit compliance. To ensure **proper implementation and enforcement** of these requirements, appropriate regulatory authorities should be given assessment, monitoring, and verification powers, supported by independent third parties. Public authorities should also be effectively empowered to enforce noncompliance with substantive requirements.

133 Regulation (EU) 2024/1787 of the European Parliament and of the Council of 13 June 2024 on the reduction of methane emissions in the energy sector, OJ L 20241787, 15.7.2024.

134 Directive (EU) 2024/1760 of the European Parliament and of the Council of 13 June 2024 on corporate sustainability due diligence, OJ L 2024/1760, 5.7.2024.

6.

Conclusion

Although increasingly discussed, the concept of 'hydrogen readiness' does little more than provide cover for continuing the fossil gas based status quo. Variations of the concept are starting to appear across EU and national laws and policies relating to the energy sector and financing more broadly. These policies enable financing and preferential regulatory treatment to be given to fossil gas infrastructure and equipment, with little to no certainty that these assets will ever use hydrogen, or that hydrogen use will make sense from a cost or environmental perspective. As a result, and due to the different characteristics of hydrogen and fossil gas, the continued use of the 'hydrogen readiness' concept for infrastructure and equipment creates lock-in, price, financial, and external dependency risks. **To avoid these, the term should be abandoned altogether unless the asset can use 100% hydrogen from the outset. Alternatively, if the term is to be used outside these circumstances, robust minimum safeguards should be introduced (and properly implemented and enforced) to provide full confidence that conversion and use will occur, and that such use makes sense economically and environmentally.**

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