THE OXFORD INSTITUTE FOR ENERGY STUDIES

September 2020

EU Hydrogen Vision: regulatory opportunities and challenges

1. Introduction

On 8 July 2020 the European Commission (EC) published its EU Hydrogen Strategy,[1] and its EU Energy System Integration Strategy.[2] The Hydrogen Strategy is complementary to and supportive of the Energy System Integration Strategy. It is also complementary to the EU Industrial Strategy [3] which was published in March this year. All of the strategies are part of the overall EU Green Deal [4] aiming at climate neutrality by 2050.

A recent OIES Comment provided a brief review of the key aspects of the Hydrogen Strategy [5] and concluded that the Strategy covers 'all potential possibilities for hydrogen in the energy transition', including both renewable (also known as 'green') and low carbon hydrogen (including hydrogen from natural gas where the carbon is captured).[6] The Strategy makes clear that renewable hydrogen is the priority as the end game but acknowledges that other forms of low carbon hydrogen will play a role in the short and medium term.[7] The Strategy is significantly more forthcoming and detailed on renewable, rather than low carbon, hydrogen.

This Insight focuses on the Commission's vision for regulatory treatment of renewable and low carbon hydrogen, and how it might translate into future EU legislative initiatives.

2. EU Hydrogen Strategy

2.1 Renewable and low carbon hydrogen: Teacher's Pet and Underdog

A draft version of the Hydrogen Strategy was leaked to the media on 18 June 2020.[8] Unlike the final Strategy, the leaked version barely mentioned low carbon hydrogen, and readers were left wondering whether the final Strategy would see any role for the latter at all. On 24 June 2020, GasNaturally, leading a wide coalition, including EU industry, the gas sector, trade unions, and energy technology producers, called for the adoption in the Hydrogen Strategy of a technology-neutral approach, so that all clean

[1] "A hydrogen strategy for a climate-neutral Europe." EU Commission 8th July 2020.
[2] "Power a climate-neutral economy: An EU Strategy for Energy System Integration." EU Commission 8th July 2020.
[3] "A New Industrial Strategy for Europe." EU Commission 10th March 2020.
[4] "A European Green Deal." EU Commission
[5] Martin Lambert, "EU Hydrogen Strategy – A case for urgent action towards implementation." Oxford Institute for Energy Studies, July 2020.
[6] The EU Hydrogen Strategy mentions both methane reforming with carbon capture and storage (CCS) ('blue' hydrogen), and pyrolysis which produces hydrogen and solid carbon ('turquoise' hydrogen).
[7] Martin Lambert, "EU Hydrogen Strategy – A case for urgent action towards implementation." Oxford Institute for Energy Studies, July 2020.
[8] LEAKED: Europe's draft hydrogen strategy. Euractiv 18th June 2020 and Towards a hydrogen economy in Europe: a strategic outlook. EU Commission draft.

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hydrogen technologies could be used as part of the energy transition, thus including renewable hydrogen *and* low carbon hydrogen.[9]

It is not known whether this last-minute intervention proved decisive. The Hydrogen Strategy makes it clear that renewable hydrogen is its favourite – "a teacher's pet" – stating it is 'the priority for the EU to develop renewable hydrogen', referred to as 'the most compatible option with the EU's climate neutrality and zero pollution goal in the long term and most coherent with an integrated energy system'. Nevertheless it acknowledges that 'in the short and medium term' low carbon hydrogen is 'needed *primarily to rapidly reduce emissions* from existing hydrogen production [10] and support the parallel and future uptake of renewable hydrogen', thus viewing low carbon hydrogen as something of an underdog.

The Strategy's preference for renewable hydrogen is very clear as it only expects €3-18 billion investment in low carbon hydrogen between now and 2050,[11] compared to expected total investment in renewable hydrogen production capacity of €180-470 billion.[12] By 2030, the Strategy expects €24-42 billion to be invested in electrolysers,[13] plus a further €220 – 340 billion for 80 – 120 GW of renewable generation to supply the electrolysers,[14] and €65 billion for hydrogen transport, distribution and storage, and hydrogen refuelling stations for vehicles.[15]

The Strategy sets a target of 6 GW of electrolysers by 2024, 40 GW by 2030 (with a further 40 GW to be imported from third countries[16]), and 500 GW by 2050. Achieving these targets would require a major effort, given that at present electrolyser production capacity in Europe is less than 1 GW per year, and the largest electrolyser under construction has a capacity of 10 MW,[17] which, as noted in an earlier OIES Comment, means that 60 such electrolysers would be required to meet the 6 GW target by 2024.[18]

This shows a very limited commitment on part of the EU to low carbon hydrogen. Whereas the EU expects investment of up to €382 billion in the next 10 years for renewable hydrogen (electrolysers plus renewable generation), it anticipates only €18 billion by 2050 in low carbon hydrogen. (Note that the natural gas supply chain already exists, unlike the generation and connections for renewable electricity.) Yet the EU expects renewable hydrogen to become cost competitive only gradually between 2024 and 2030, and the volumes to remain small by 2030 at 10 Mt per year,[19] or about 334 TWh (about 32 bcm of natural gas). However, this assumes a very high load factor of 95% for the 40 GW of electrolysers. A more realistic lower load factor of about 45% would equate to only about 160 TWh (15 bcm of natural gas) compared to expected annual natural gas demand of 400 bcm. [20] This suggests that low carbon hydrogen would have to make very rapid progress during the 2020s for EU decarbonisation targets to be met, without resorting to full electrification (if methane were to fail to decarbonise via a low carbon

[9] "Wide industry coalition call for a Hydrogen Strategy inclusive of all clean hydrogen pathways." GasNaturally Press release 24th June 2020.
[10] Thus the Strategy appears to be concerned more with decarbonisation of existing production installations for high carbon hydrogen by means of retrofitting rather than with investment in new production installations for low carbon hydrogen.
[11] Hydrogen Strategy, p. 2. Notably, the Strategy does not provide a source for this estimate.
[12] It is not entirely clear whether this figure only includes investment in the electrolysers or whether it also includes investment in renewable generation capacity to supply the electrolysers.
[13] This assumes that costs for electrolysers reduce in the next few years.
[14] Renewables - biomass, hydro, wind and solar - only accounted for 35% of EU power generation in Q4 2019, the last quarter unaffected by COVID 19, and 40% in Q1 2020. Total EU 27 + UK installed capacity for wind and solar was approximately 330 GW at the end of 2019. Source: European Commission Quarterly Report on European Electricity Markets. Volume 12, Issue 4 and European Commission Quarterly Report on European Electricity Markets. Volume 13, Issue 1.
[15] Hydrogen Strategy, p. 7.
[16] I.e. outside the EU.
[17] There are several projects (not yet under construction) of 100 MW size.
[18] Martin Lambert, "EU Hydrogen Strategy – A case for urgent action towards implementation." Oxford Institute for Energy Studies, July 2020.
[19] EU Hydrogen Strategy page 6.
[20] Ibid. 400 bcm is the lowest estimate for the European gas demand in 2030 (as in the IEA Sustainable Development scenario) whereas other scenarios (IEA Stated Policies, BP Energy Outlook, Shell Sky, Equinor Rivalry, Equinor Renewal) all estimate it within the range of 450-500 bcm.

hydrogen pathway).[21] By promoting hydrogen the EU has accepted that full electrification would be significantly more expensive than a 'hybrid' electrification (using a mix of electrification and gas) as a lower cost decarbonisation pathway, and would possibly not be technically feasible. Yet, even if these targets are met – which is far from certain – it is clear that renewable hydrogen's role in replacing methane in the EU energy balances by 2030 would be very limited.

Yet despite its very limited ability to displace methane from the EU energy balance by 2030 and possibly by 2040, the Strategy envisages significant regulatory and financial support for renewable hydrogen, whilst expecting very little investment in low carbon hydrogen. '*Direct and transparent, market-based' support schemes'* are limited to renewable hydrogen only.[22] Other support instruments in the Strategy are available to low carbon hydrogen, for example, *carbon contracts for difference (CCfD).* However, the future of low carbon hydrogen depends on how such instruments are designed, and also on Member States' support. The Strategy's proposals for regulatory and financial support for renewable and low carbon hydrogen are analysed below.

2.2 EU regulatory and financial support for hydrogen: supply, demand, and infrastructure

The Hydrogen Strategy recognises that "building up a hydrogen economy in Europe requires a full value chain approach" including the parallel development of production, supply, demand and infrastructure. It envisages the introduction of EU-wide instruments to 'tailor a supportive policy framework', which would reflect hydrogen's benefits in reducing carbon emissions during the transition phase, thus suggesting that both renewable and low carbon hydrogen could (and should) benefit from it. The key elements of the suggested policy framework in relation to both renewable and low carbon hydrogen are analysed below.

2.2.1 Terminology and certification

The Strategy's suggested regulatory framework is envisaged to include 'a comprehensive terminology and European-wide criteria for the certification of renewable and low carbon hydrogen'.[23] It is also to include 'a common low carbon threshold/standard for the promotion of hydrogen production installations based on their full life cycle greenhouse gas performance'.

As far as the terminology is concerned, the Strategy presents a set of definitions including:

- `Electricity based hydrogen' produced via electrolysis of water regardless of the energy source. The emissions lifecycle of the hydrogen depends on how the electricity is produced.
- 'Renewable hydrogen' produced from renewable electricity via electrolysis, or via conversion of biogas or biomass. Also referred to as 'clean hydrogen'
- `Fossil based hydrogen' with carbon capture where hydrogen is derived from fossil fuels (such as coal or natural gas) and where the CO_2 is captured via CCS or as solid carbon via pyrolysis. The variable ability of the different processes to capture carbon needs to be taken into account.
- `Low carbon hydrogen' which includes fossil-based hydrogen with carbon capture, and also electricity based hydrogen with 'significantly reduced' emissions.
- `Hydrogen-derived synthetic fuels' such as kerosene or diesel. However, the hydrogen component must be renewable for the synthetic fuel to be considered renewable.

[21] As an earlier OIES paper argues, low carbon hydrogen has an important role to play in the 2030s and the 2040s until renewable hydrogen takes over at scale thanks to massively reduced costs. See Ralf Dickel "Blue hydrogen as an enabler of green hydrogen: the case of Germany", Oxford Institute for Energy Studies, June 2020.
[22] Allocation is envisaged to be made through competitive tenders, coordinated 'within a transparent, efficient and competitive hydrogen and electricity market', which provides price signals 'rewarding electrolysers'.
[23] Possibly building on the existing ETS monitoring, reporting and verification and the provisions set out in the Renewables Energy Directive

This terminology is useful as it clearly defines different types of hydrogen, which is important for creating 'a common decarbonisation vocabulary' for the EU, and avoids some of the current confusion surrounding the colour coding approach (green, blue, turquoise hydrogen etc).[24] By linking the definitions to the carbon footprint of the hydrogen, the terminology ensures that it is sustainability rather than production method which is important, contributing to the "technology neutral" aspirations of the Green Deal. It underpins the recognition of the role that hydrogen from natural gas can play. However, there is still scope for confusion. For example, electrolysis using nuclear electricity has zero GHG emissions, but will not be considered renewable under the definitions, and therefore not eligible for the support offered to renewable hydrogen. Also support for low carbon hydrogen will enable support for electrolysis where the source of the electricity still has GHG emissions. This could be counter-productive because the GHG emissions of the electricity source would be magnified by the conversion losses associated with electrolysis, and demand for electrolysis would increase the use of fossil fuel power generation in the EU until there is sufficient renewable or nuclear generation to cover all electricity demand.

The EU plans to develop certification proposals, which would include European-wide criteria for the certification of renewable and low carbon hydrogen, by June 2021.

2.2.2 Project selection and financing instruments

The Hydrogen Strategy states that the **European Clean Hydrogen Alliance (ECHA)**, established as part of the EU's New Industrial Strategy, 'will play a crucial role in facilitating and implementing the actions' of the Hydrogen Strategy and in 'supporting investments to scale up production and demand for renewable and low carbon hydrogen'.[25] The ECHA will identify 'viable investment projects' to facilitate coordinated investments along the hydrogen value chain, and cooperation between private and public stakeholders, providing public support and attracting private investment. The Strategy does not specify the criteria for selecting projects. The Commission will 'follow up' on the recommendations made by the Strategic Forum for Important Projects of Common European Interest (IPCEI),[26] which 'will contribute to a swift uptake of activity' in the ECHA, which will 'facilitate cooperation in a range of large investment projects, including IPCEI projects'. IPCEI status allows projects to secure State aid that is compatible with the internal market acquis.[27] According to the Strategy this State aid would be used 'to address market failures for large cross border projects for hydrogen and fuels derived from hydrogen'. The EHCA investment agenda should be ready by the end of 2020.

Other EU financing facilities for which renewable and/or low carbon hydrogen projects would be eligible include:

- **the InvestEU programme**, which mobilises public and private investment in different areas (including sustainable infrastructure) using EU budget guarantee.[28]
- **the European Regional Development Fund**,[29]

[24] See Alex Barnes "Can the current EU regulatory framework deliver decarbonisation of gas?" Oxford Institute for Energy Studies, June 2020, p. 5 for explanation of the colour coding.
[25] The EC has introduced the European Hydrogen Alliance as part of its New Industrial Strategy.
[26] "Strengthening Strategic Value Chains for a future-ready EU Industry. Report of the Strategic Forum for Important Projects of Common European Interest." November 2019. Six value chains were identified including hydrogen technologies and systems, and Low-CO_2 emission industry.
[27] The IPCEI instrument has existed since 2014, when it was first introduced in EC Communication on State aid modernisation of 8 May 2012 but has been rarely used. See EU Commission Website "State Aid Modernisation and its Implementation" and the EU Commission Communication on EU State Aid Modernisation, May 2012. https://ec.europa.eu/competition/state_aid/modernisation/index_en.html. Also Hydrogen for Climate Action website for IPCEI relevance for hydrogen: "What's an IPCEI?"
[28] The InvestEU Programme, brings together the European Fund for Strategic Investments and 13 EU financial instruments currently available, mobilising public and private investment using EU budget guarantee, and is expected to mobilise at least €650 bn euros in additional investment in several areas, including sustainable infrastructure, during 2021-2027.
[29] European Regional Development Fund. "The ERDF aims to strengthen economic and social cohesion in the European Union by correcting imbalances between its regions." EU Commission website.

- **the Cohesion Fund**,[30]
- **the Just Transition Mechanism**[31] (for carbon intensive regions),
- **Connecting Europe Facility**[32] (CEF), and
- **Connecting European Facility Transport**[33] (CEFT).

The Strategy also notes that the new Sustainable Finance Strategy[34] and Sustainable Finance Taxonomy[35] will be used to guide the private sector investment in hydrogen projects.

The plethora of different support mechanisms is welcome but raises the problem of bureaucratic overlap, and confusion for investors seeking support. There is a risk that different programmes with different criteria may lead to inefficient use of limited funds if, for example, the most promising hydrogen projects are not eligible for support in a programme with spare funds. Revising and developing coordinated investment criteria across the different funding mechanisms to ensure hydrogen receives sufficient funding will also be challenging, particularly where hydrogen is competing for funds with other political priorities.

2.2.3 Incentivising supply of, and demand for, hydrogen

The Strategy says that the policy focus should be on creating incentives for supply of, and demand for, hydrogen. A key hurdle is 'the cost gap' between renewable and low carbon hydrogen, and either current fossil fuel-based hydrogen without carbon capture or natural gas. The figures provided by the EU illustrate the gap (Table 1).

Table 1: EU estimates of current hydrogen production costs

Production costs	€/kg	€/MWh
Fossil fuel hydrogen	1.5	44.9
Low carbon hydrogen	2.0	59.9
Clean hydrogen	2.5 – 5.5	74.9 – 164.7
TTF Natural gas price	-	11.0

Source: EU Hydrogen Strategy, TTF Gas Year 20 30th July 2020 ICIS Gas in Focus 31st July 2020.

Renewable hydrogen is significantly more expensive than low carbon hydrogen, and both are much more expensive than current natural gas prices. The EU expects renewable hydrogen to become

[30] EU Cohesion Fund. "The Cohesion Fund is aimed at Member States whose Gross National Income (GNI) per inhabitant is less than 90 % of the EU average. It aims to reduce economic and social disparities and to promote sustainable development." EU Commission website.

[31] Financing the green transition: The European Green Deal Investment Plan and Just Transition Mechanism. "The Just Transition Mechanism (JTM) . . . provides targeted support to help mobilise at least €100 billion over the period 2021-2027 in the most affected regions, to alleviate the socio-economic impact of the transition." EU Commission website.

[32] EU Innovation and Networks Executive Agency (INEA). Connecting Europe Facility. "The Connecting Europe Facility (CEF) is a key EU funding instrument to promote growth, jobs and competitiveness through targeted infrastructure investment at European level." Between 2014 and 2020 €5.35 billion has been made available for energy infrastructure projects, €4.6 billion in the form of grants managed by the INEA. EU Commission website.

[33] CEF Transport is the "funding instrument to realise European transport infrastructure policy. . . (It) supports innovation in the transport system in order to improve the use of infrastructure, reduce the environmental impact of transport, enhance energy efficiency." Between 2014 and 2020 €24.05 billion has been made available for energy infrastructure projects, €23.7 billion in the form of grants managed by the INEA. EU Commission website.

[34] The Sustainable Finance Strategy aims to provide a roadmap with new actions to increase investment in sustainable projects, as well as providing an enabling framework for the Green Investment Plan. A consultation on the strategy closed on 15th July.

[35] The Taxonomy Regulation establishes criteria for determining the degree to which an investment is environmentally sustainable. It entered into force on 12th July 2020. 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

gradually cost competitive with low carbon hydrogen by 2030. However, this will depend not just on the capital costs of electrolysers but also on their load factors (i.e. availability of renewable electricity), and the cost of renewable electricity. Since the EU expects up to one quarter of renewable electricity to be used for electrolysis by 2050, this implies a massive build-up of renewable generation, to meet growing demand due to electrification of the economy and demand for electrolysis. Also, the hydrogen production costs quoted do not include the cost of transmission infrastructure or the cost for consumers of switching to hydrogen.

Uncertainty about demand and supply makes it difficult for both producers and consumers to commit to hydrogen. The cost gap makes it unlikely that consumers will switch or that producers will produce without financial support, or compulsion to use hydrogen, or a mix of the two. The Strategy notes that support schemes are 'likely to be required for some time' in order to scale up renewable and low carbon fossil-based hydrogen (while adding that these schemes must be compliant with competition rules), and makes a number of proposals to boost supply and demand.

Development of appropriate State Aid rules

Both renewable and low carbon hydrogen would be eligible for State aid, where Member States would be willing to provide such support. A majority of member states are supportive of renewable hydrogen. As far as low carbon hydrogen (and specifically methane reforming with CCS) is concerned, some member states have much more positive attitudes towards it (e.g. the Netherlands) than others (e.g. Germany). Several non-EU countries, connected to the EU by existing gas infrastructure – most importantly Norway but also the UK – are also supportive of low carbon hydrogen, and their policy choices could potentially have a significant impact on the EU hydrogen market.

Regulatory Carbon Contracts for Difference (CCfD)

The Strategy proposes tenders for **carbon contracts for difference (CCfD)**. It notes that a CO_2 price of between €55 and €90 per tonne would be needed to make low carbon hydrogen competitive with fossil fuel-based hydrogen. (The CO_2 price to make renewable hydrogen competitive, or to make low carbon hydrogen competitive with natural gas would therefore be much higher). The current EU Emissions Trading Scheme (ETS) price is around €25 per tonne. CCfD would be 'a long term contract with a *public* counterpart' which would 'remunerate the investor by paying the difference between the CO_2 strike price and the actual CO_2 price in the ETS' thereby bridging the cost gap, and providing 'initial support for early deployment'. As low carbon hydrogen is significantly less expensive than renewable hydrogen, it could be the main beneficiary of the CCfD scheme until the cost of renewable hydrogen decreases significantly or ETS prices rise above the strike price. (The Strategy does not specify what entity would act as a public counterpart of the CCfD but presumably it would have to be a state-owned or a state-backed entity.) The Strategy does not provide costings for such support. Based on emissions of 70 to 100 Mt of CO_2 existing hydrogen production in the EU,[36] and the strike and ETS prices quoted above, the cost would range from €2.1 billion to €6.5 billion per year to decarbonise current EU hydrogen production alone. The true cost will be higher as sectors at risk of carbon leakage such as current hydrogen production and steel are granted free ETS allowances. (See revision of the ETS below).

The EU expects that potential beneficiaries of the CCfD would be replacement of existing fossil fuel hydrogen production, low carbon steel and chemicals, and the deployment of hydrogen in marine and aviation sectors.[37] As such the CCfD scheme could help retrofit CCS to existing fossil fuel production, and also support the industrial clusters where hydrogen demand is likely to develop first. Notably the Strategy states that the CCfD scheme could be implemented 'at EU, or national level', acknowledging potential support from the ETS innovation fund.[38] The proportionality of these measures and their

[36] EU Commission, A Hydrogen Strategy for a climate neutral Europe.

[37] Note that only aviation between airports within the European Economic Area is currently covered by the ETS.

[38] The Innovation Fund is one of the funding instruments supporting the European Commission's strategic vision for a climate neutral Europe by 2050 as outlined in its communication 'A Clean Planet for All' of 28 November 2018. The Fund will support the demonstration of low-carbon technologies and processes in energy intensive industries (including products substituting carbon intensive ones), environmentally safe carbon capture and utilisation and storage of carbon dioxide (CCU and CCS), innovative renewable energy and energy storage technologies. The Innovation Fund is established by the EU ETS Directive for

impact on the market will need to be assessed to ensure their compliance with State aid guidelines for energy and environmental protection.[39]

Revision of the ETS

Whilst welcome, the CCfD is only helpful in sectors where the ETS is applied. The utility of the CCfD approach depends therefore in part on the design of the ETS.[40]

Only 45% of EU greenhouse gas (GHG) emissions are covered by the ETS and a number of industries have free allowances because of the problem of carbon leakage.[41] Whilst most EU fossil fuel hydrogen is covered by the ETS, the sectors concerned, refineries and fertiliser production, receive 100% free allowances. Applying CCfD to these sectors would therefore represent an additional subsidy but would at least have the benefit of reducing GHG emissions. The EU is revising the ETS for Phase 4 which covers the period 2021 to 2030 including the eligibility for free allowances, and is also considering a Carbon Border Adjustment tax to deal with the carbon leakage issue. The Commission has said that as part of the forthcoming revision of the ETS it "may consider how the production of renewable low-carbon hydrogen could be further incentivised."

Further expansion of the ETS to cover sectors not currently covered (which include transport and buildings) would create greater scope for the promotion of hydrogen via CCfDs, as well as create greater incentives for end use sectors to decarbonise, and hence use hydrogen where economic to do so. However, this is not part of the planned Phase 4 revisions.

Direct support schemes (DSS)

Only renewable hydrogen would be eligible for **direct support schemes (DSS)**. Allocation of such schemes will be made through competitive tenders, coordinated 'within a transparent, efficient and competitive hydrogen and electricity market', which provides price signals 'rewarding electrolysers' for services provided to the energy system such as flexibility or 'reducing the burden of renewable incentives.' There are no further details on how such schemes would be structured, the level of financial support or the criteria for eligibility. The link with electricity markets will require clever design of the mechanisms to avoid unforeseen consequences and ensure compatibility with State Aid rules.[42] Although the Strategy does not specify sources of financing for DSS, it can be presumed that funding would come from the range of EU financing instruments listed above, possibly in combination with government support from Member States.

Boosting demand in end use sectors

The Strategy identifies two main lead markets for boosting demand, industrial applications and mobility, but is vague on how this will be achieved. It notes the need for demand side measures and says the Commission will 'consider' various options for incentives at the EU level, including quotas for renewable hydrogen in specific end use sectors. This includes the possibility of virtual blending where users can benefit from the overall share of hydrogen in the energy mix even if they do not use it directly themselves.

The use of hydrogen in transport will be addressed in the Sustainable and Smart Mobility Strategy due before the end of 2020. As well as considering hydrogen fuel cell trains, heavy goods vehicles, and marine uses, the strategy mentions use in commercial fleets such as taxis. This appears odd given that Battery Electric Vehicles are considered more cost effective for light passenger vehicles.

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the period 2021 to 2030, and is endowed with at least 450 million allowances, which is around €11 bn based on a carbon price of €25/tCO_2e.

[39] Communication from the Commission — Guidelines on State aid for environmental protection and energy 2014-2020

[40] For a summary of the ETS and other policy mechanisms relevant to decarbonisation of gas see Alex Barnes "Can the current EU regulatory framework deliver decarbonisation of gas?" Oxford Institute for Energy Studies, Chapter 2 and Annex 2.

[41] Carbon leakage is where carbon emitters move their business out of the EU to other jurisdictions, and then import goods or services into the EU instead, thereby avoiding EU limits on emissions.

[42] For example, the UK electricity market capacity mechanism incentivised higher emitting diesel generation and was investigated by the EU under State Aid rules. "State aid: Commission approves the British Capacity Market scheme." EU Commission Press Release 24th October 2019.

2.2.4 Development of hydrogen infrastructure

There are several provisions in the Strategy enabling regulatory and financial support for networks by which both renewable and low carbon hydrogen could benefit, including: Project of Common Interest (PCI) status;[43] the IPCEI State aid instrument; exemptions and application of the existing rules for closed distribution systems and direct lines to hydrogen networks (as specified in the Gas Directive).

The Strategy states that the need for infrastructure will depend on the pattern of hydrogen production and demand, as well as transportation costs, and is linked to the different phases of hydrogen production. Notably, all three stages, mentioned in the Strategy – 2020-2024, 2025-2030, 2031-2050 – are linked to the development of *renewable* hydrogen only (6 GW of electrolyser capacity by 2024, 40 GW by 2030, and 500 GW by 2050).[44] Consequently, the Strategy views the infrastructure – network and non-network, gas and electricity – requirements mostly in connection with renewable hydrogen. Although the Strategy acknowledges that 'infrastructure to support carbon capture use and storage may be needed for the production of low carbon hydrogen', it lacks a clear vision for low carbon hydrogen beyond possible retrofitting the existing high carbon production capacity, and does not appear to take into account the infrastructure needs that may arise *as and if* low carbon hydrogen develops at scale.

During **the first stage (2020-2024)**, 'infrastructure needs for transporting hydrogen will remain limited' as demand will be met initially by production close to or on site (from local renewables or methane) in industrial clusters and coastal areas through existing connections. Replacement of fossil fuel hydrogen with low carbon hydrogen by adding CCS would require construction of CO_2 transportation pipelines as well as CO_2 storage. The location and the length of such pipelines will depend on the location of the facilities where captured CO_2 could be stored, which in turn would be determined by geology as well as public acceptance. CO_2 can be stored in a variety of geological formations but in many countries (for example Germany) there is opposition to onshore storage of CO_2 which has so far proved impossible to overcome despite the lack of scientific justification. This makes offshore storage the only realistic possibility, in which case offshore pipelines for CO_2 transport would be required.[45]

According to the Strategy, planning of 'medium range and backbone transmission infrastructure' should also begin during the first stage,[46] with policy focus being on establishing 'the regulatory framework for a liquid and well-functioning hydrogen market'.

For regulation of hydrogen infrastructure during the first phase, the Strategy suggests **the existing rules for closed distribution systems, direct lines or exemptions in the gas and electricity markets** 'may provide guidance'. These enable eligible infrastructure to avoid some of the regulatory burden such as ownership unbundling or regulated third party access. Such mechanisms have been used where regulation is not appropriate, or to enable investments to go ahead which otherwise would have been too risky.[47] It is therefore welcome that the Commission recognises their relevance.

The Strategy envisages 'the further retrofitting of existing fossil-based hydrogen production with carbon capture' during **the second phase (2025-2030)**. It confirms that during this phase 'the need for an EU-wide logistical infrastructure will emerge', building on the national and regional infrastructure, characteristic of the first phase. It also notes that local hydrogen networks would accommodate additional industrial demand, and with increasing demand, optimisation of hydrogen production, usage and transportation will be required thus necessitating longer-range transportation to ensure efficiency of the whole system.

[43] PCIs were established as part of TEN-E Regulation in 2013, currently under review. A revised text is expected by the end of 2020.
[44] Current electrolyser capacity in Europe is 1 GW.
[45] To the best of our knowledge all the low carbon hydrogen projects under consideration are based on offshore storage: Northern Lights (Norway), N21 North of England and HyNet North West of England (UK), H-Vision Rotterdam (the Netherlands).
[46] Gas for Climate, a group of EU gas network companies, has just published the "European Hydrogen Backbone: How a dedicated hydrogen infrastructure can be created." July 2020.
[47] For more details on this see Chapter 3 and Annex 3 of Alex Barnes "Can the current EU regulatory framework deliver decarbonisation of gas?" Oxford Institute for Energy Studies, June 2020.

The main regulatory instruments envisaged during the second phase are as follows:

- **revision of the TEN-E Regulation;**[48]
- **establishment of common hydrogen quality standards and/or cross border operational rules** to ensure interoperability of markets for pure hydrogen;
- **review of the Alternative Fuels Infrastructure** and **revision of the Trans-European Transport Network (TEN-T)** with a view of meeting the transport demand through a network of refuelling stations;
- **review of the internal gas market legislation for competitive decarbonised gas markets**.[49]

As demand for natural gas is expected to decline after 2030,[50] some parts of the existing European gas infrastructure could be repurposed to enable large-scale cross-border transport of hydrogen. The Strategy argues such repurposing 'may provide an opportunity' for a cost-effective energy transition, being much less expensive, as repurposed pipelines are often 'already at a large extent depreciated' whereas 'relatively limited' newly built hydrogen infrastructure would be required.[51]

Revision of the TEN-E Regulation appears to be one of the main building blocks contributing towards establishing a regulatory framework for hydrogen infrastructure. A public consultation was held during 18 May – 30 July 2020, and the revised Regulation is expected in Q4 of 2020. It is envisaged inter alia to ensure eligibility of hydrogen infrastructure projects for a Project of Common Interest (PCI) status, thus making it eligible for Connecting Europe Facility (CEF) funding.[52] For the period 2021-2027, the Commission proposed the CEF total budget of €31.7 billion, of which €7.7 billion are earmarked for energy infrastructure, focusing on 'cross-border renewable energy projects, interoperability of networks and better integration of the internal energy market'. The revised TEN-E Regulation is also understood to allow for retrofitting existing gas (methane) infrastructure and building new infrastructure, primarily for transportation of *renewable* hydrogen.[53] It is understood that low carbon hydrogen projects would also be eligible but most likely would only constitute a very small share (e.g. for demonstration projects).

The revised TEN-E Regulation is also expected to prioritise sustainability criteria in the PCI selection process (currently sustainability is a sufficient but not a necessary criterion for selection) as well as shifting focus to large scale cross-border projects. Also, the revised TEN-E Regulation is aimed at ensuring 'full integration' of hydrogen in the infrastructure planning process, including through changes to the Ten Year Network Development Plans (TYNDP) development process. (Notably, ACER and CEER in their joint report on the TEN-E Regulation revision called for more powers for ACER, including a right to issue binding amendment requests to draft TYNDPs to ensure coordinated development of hydrogen networks alongside gas and electricity networks.[54])

Blending

While the Strategy acknowledges that transportation of a methane and hydrogen blend through the existing natural gas network 'may enable decentralised renewable hydrogen production in local networks in a transitional phase', it is largely dismissive of cross-border transportation of hydrogen-

[48] Expected at the end of 2020. The OIES will publish a follow up comment on the revised TEN-E Regulation later this year.
[49] Previously referred to as 'Gas Package', 'Gas Decarbonisation Package', and most recently 'Decarbonisation Package'. The Package was originally expected to be unveiled in late 2019 but this has since been moved to 2020/2021, and at present there is a lack of clarity about its proposals.
[50] Post-2030 decline in European gas demand is envisaged in all scenarios (IEA Sustainable Development, IEA Stated Policies, BP Energy Outlook, Shell Sky, Equinor Rivalry, Equinor Renewal), the disagreement only being about at what rate this decline will occur. No scenario envisages an increase in demand post 2030.
[51] For example, it is expected that up to 90% of the hydrogen network in Germany and the Netherlands may consist of repurposed natural gas infrastructure. The European Hydrogen Backbone report, prepared by 11 European TSOs, suggests that ~75% of the hydrogen network will consist of retrofitted methane pipelines whereas ~25% will consist of new hydrogen pipelines. Gas for Climate 'European Hydrogen Report: how a dedicated hydrogen infrastructure can be created?' July 2020.
[52] See footnote 33 for details on CEF.
[53] Klaus-Dieter Borchardt, Florence School of Regulation "Online Workshop on Renewable Hydrogen." April 2020.
[54] ACER/CEER, 'Position on Revision of the Trans-European Energy Networks Regulation (TEN-E) and Infrastructure Governance', 19 June 2020.

methane blends. The Strategy states that blending is 'less efficient and diminishes the value of hydrogen' as well as 'changes the quality of the gas' thus potentially affecting the design of gas infrastructure, end user applications, and cross border system interoperability. It is also concerned that blending might cause 'fragmenting' of the internal market if adjacent member states accept different levels of blending thus hindering cross border flows. It stresses the need to update the current gas quality standards[55] and suggests addressing the technical feasibility of adjusting the gas quality and the cost of handling its differences. It also notes that the existing regulation on interoperability may need to be revised to ensure cross-border coordination and system interoperability between different Member States.

3. EU Energy System Integration Strategy

The EU Energy System Integration Strategy is aimed at "powering a climate neutral economy" and sets out a vision "on how to accelerate the transition towards a more integrated energy system" which supports "a climate neutral economy at the least cost." Energy system integration is defined as "the coordinated planning and operation of the energy system 'as a whole' across multiple energy carriers, infrastructures and consumption sectors." Three "complementary and mutually reinforcing" concepts form the basis of energy system integration:

- A more circular energy system "with energy efficiency at its core" including greater use of waste energy and synergies across sectors.
- Greater electrification of end use sectors based on renewable electricity generation.
- "The use of renewable and low-carbon fuels, including hydrogen, for end-use applications where direct heating or electrification are not feasible, not efficient or have higher costs."

This represents a significant move forward in the debate as it means that the Commission has formally recognised the challenges associated with an "all-electric" solution for decarbonising the EU economy which relies on natural gas for about a quarter of its energy supply. This has been the subject of much debate in recent years with a number of studies showing that decarbonisation can be achieved at lower cost using hydrogen, including hydrogen from natural gas.[56]

The Energy System Integration Strategy identifies hydrogen's benefits as follows:

- As fuel in certain transport sectors such as heavy-duty road transport, buses, non-electrified rail transport, captive bus fleets, and maritime and inland waterways.
- As fuel or feedstock for industrial processes such as steel, refining, chemical industries including the production of 'green fertilisers'
- As an input for synthetic fuels such as kerosene by combining hydrogen with carbon dioxide. This would aid the decarbonisation of aviation where energy density of fuels and weight are crucial issues. (For such fuels to be carbon neutral the carbon dioxide would need to be sourced from the atmosphere or biomass.)

As well as its role as a fuel in hard to decarbonise sectors, the Strategy identifies an important "nodal role" for hydrogen in the integrated energy system. Hydrogen produced via electrolysis of renewable electricity "can help integrate large shares of variable renewable generation, by offloading grids in times of abundant supply, and providing long term storage to the energy system."

The Energy Integration Strategy also highlights the importance of carbon capture and storage to support deep decarbonisation. This is important for the production of low carbon hydrogen from natural gas

[55] Gas Quality standards are currently determined by Member States, and the Commission has failed in the past to set a single pan-European gas quality standard.
[56] For more discussion on this see Alex Barnes "Can the current EU regulatory framework deliver decarbonisation of gas?" Oxford Institute for Energy Studies, June 2020.

using methane reforming or for potential continued use of natural gas as a fuel, as in both cases CCS is required to capture CO_2 emissions. However, the main focus of the strategy is on the potential for CCS to address hard to abate emissions in certain industrial processes, and also its potential for the capture of carbon dioxide from biomass or from the air to be combined with hydrogen for the creation of synthetic fuels. The strategy notes the slow uptake of CCS in Europe due to high investment and operational costs, and political opposition in some countries.

The next steps proposed in the Strategy which are relevant for hydrogen include the following (dates indicate publication of proposals):

- Propose a comprehensive terminology and European system of certification for all renewable and low carbon fuels based on full life cycle greenhouse gas emissions savings, based on existing provisions e.g. in the Renewable Energy Directive. (June 2021).
- Consider additional measures to support renewables and low carbon fuels including quotas in specific end use sectors such as aviation or maritime. (2020 and 2021).
- Promote the financing of "flagship projects of integrated, carbon-neutral industrial clusters producing and consuming renewable and low-carbon fuels." (From 2021).
- "Stimulate first-of-a-kind production of fertilisers from renewable hydrogen." (From 2021).
- Demonstrate and scale up the capture of carbon for production of synthetic fuels. (From 2021).

In line with its key theme of better integration of different energy sectors, the Energy System Integration Strategy notes the need to update electricity and gas market regulation to make them fit for decarbonisation. The Strategy notes that the Clean Electricity Package [57] has "already laid the foundation" for the integration of renewables but now needs to be fully implemented. It has identified the problem that taxes on electricity are higher than coal, gas or oil in many Member States, and that levies on electricity used to finance renewables have increased.

The Strategy also notes that the gas market regulatory framework needs to be "re-examined" to enable the uptake of renewable gases whilst ensuring "an integrated liquid and interoperable EU internal gas market." It identifies the following issues:

- Infrastructure connection and market access for distributed production of renewable gases
- Gas quality changes as a result of diversification of supply sources and injection of renewable gases (e.g. hydrogen) into the networks. The EU wants to avoid this leading to market segmentation and trade restrictions, which requires consideration of how to ensure interoperability across gas systems and Member State borders.

Proposed actions which impact energy markets and therefore hydrogen include the following (dates indicate publication of proposals):

- Ensuring State Aid rules (currently being revised) support cost effective decarbonisation of the economy. (By 2021).
- More consistent carbon price signals across energy sectors through a "possible proposal for the extension of the ETS to new sectors." (By June 2021).
- Issuance of guidance to Member States "to address the high charges and levies borne by electricity and to ensure the consistency of non-energy price components across energy carriers" (By 2021).

[57] For details see Electricity Market Design. EU Commission.

- Alignment of taxation of energy products and electricity with climate policies and ensuring "a harmonised taxation of both storage and hydrogen production, avoiding double taxation" via revision of the Energy Taxation Directive.[58]

Whilst the Hydrogen Strategy can therefore be seen as a tool to enable energy system integration, it is also clear that many of the other policy proposals will also affect take up of hydrogen and the evolution of EU gas markets. The Integration Strategy implies a very ambitious regulatory workload as all the proposed action areas are complex and sometimes controversial (for example State Aid rules, taxes). Developing these on a stand-alone basis will be challenging; ensuring coordination across different initiatives will make this more so. There is relatively little time for the detail to be agreed, let alone implemented.

4. EU Industrial Strategy

The EU Industrial Strategy has a much broader scope than both the Hydrogen and the Energy System Integration Strategies, but decarbonisation is an important element. It notes that all industrial sectors will have a role to play, not just energy intensive ones. As well as the supply of clean and affordable energy, the strategy stresses the opportunities for EU industry to become leaders in clean technologies.

Elements relevant to hydrogen and EU gas markets include:

- Support for clean steel breakthrough technologies leading to a zero-carbon steel-making process. This could include use of hydrogen as a reduction agent for iron ore in place of coke.[59]
- "A more strategic approach to renewable energy industries" and the supply chains supporting them.
- A focus on sustainable mobility including automotive, rail, aerospace and ship building.
- Proposal for a Carbon Border Adjustment Mechanism in 2021 to reduce the risk of carbon leakage.

As with the Integration Strategy and Hydrogen Strategy, developing the detailed rules whilst ensuring coordination and coherence across the various initiatives will be challenging.

5. Development of a hydrogen market in the EU: regulatory revolution or evolution?[60]

The Strategy implicitly acknowledges that the regulatory challenges facing the development of a hydrogen market are very different from those facing the liberalisation of natural gas markets, namely the need to develop a whole value chain of supply, infrastructure and demand.[61] The current small hydrogen market is not regulated. Whilst the Hydrogen, Smart Energy System and Industrial Strategies have all set out proposals to help a hydrogen market develop, there is little detail on how the mechanisms would work. Moreover, the Hydrogen Strategy does not address some important issues which will impact the development of an EU hydrogen market.

[58] Initial Impact Assessment for the revision of the Energy Taxation Directive. EU Commission.
[59] See for example Thyssenkrupp "Climate Strategy for sustainable steel production" and Thyssenkrupp and RWE "Green hydrogen for steel production: RWE and thyssenkrupp plan partnership." 10th June 2020
[60] The authors would like to acknowledge that the phrase 'regulatory revolution' for describing the necessary changes in the EU regulatory framework for successful decarbonisation of gas, was first used by Jonathan Stern.
[61] For further discussion on this see Chapter 5 of Alex Barnes "Can the current EU regulatory framework deliver decarbonisation of gas?" Oxford Institute for Energy Studies, June 2020.

The strong support for the development of a hydrogen market gives stakeholders a clear idea of the Commission's aim for hydrogen. The vision of a liquid traded market with third party access to EU wide infrastructure illustrates the scale of the Commission's ambition. The inclusion of different mechanisms to boost supply and demand, ranging from investment support to market mechanisms, should give the Commission and Member States the tools they need to help a market to develop. Furthermore, although the Commission shows a clear preference for renewable hydrogen, it has not ruled out low carbon hydrogen from other sources. The use of certification criteria, coupled with the ETS or other carbon pricing mechanisms, will help enable competition between different sources of hydrogen based on their cost and carbon footprint. This should help meet the Energy System Integration Strategy's goal of 'a climate neutral economy at the least cost.' The recognition that a system of exemptions may be helpful to develop infrastructure in the early stages is also useful.

Despite these positive steps the Hydrogen Strategy does not provide the regulatory roadmap needed to ensure that its vision becomes a reality. This Insight argues that there are three key areas, outlined below, that need to be addressed.

5.1 Coordination of development of supply, demand and infrastructure

The Strategy rightly notes that the availability of infrastructure connecting supply and demand for hydrogen is 'a condition for a widespread use of hydrogen'. But the reverse is also true, namely that the availability of sufficient volume of hydrogen is a condition for maintaining and retrofitting the existing, and investing in the new, transmission networks. Potential for lack of coordination arises from the different tools and funding mechanisms which the Strategy proposes, both within each segment of the value chain (e.g. infrastructure) and across them i.e. supply, demand and infrastructure. Investors may need to line up several different mechanisms to make a project viable.

In addition, the current natural gas regulatory framework, which the Strategy appears to use as its blueprint for its vision of the end state of the hydrogen market, is not appropriate for a market which does not yet exist. For example, the Directive's ownership unbundling requirement preventing vertical integration of supply, demand and infrastructure activities could hinder coordinated management of risk in developing hydrogen markets, by preventing coordinated investment by producers, pipeline companies and customers. It would, for example, prevent a consortium of a hydrogen producer, pipeline company and large industrial users from establishing a hydrogen industrial cluster, which could also supply other users, unless they obtained an exemption. However, the exemption process gives national regulators and especially the Commission – which has the power to approve, deny, or request a change in the exemption granted by a national regulator – considerable discretion, which creates uncertainty.

The Strategy acknowledges shortcomings of the existing regulatory framework, noting that the TSOs, which own the existing gas pipelines, are 'often not allowed to own, operate and finance hydrogen pipelines', and calls for 'a review of the regulatory framework for competitive decarbonised gas markets' which could lead to allowing financing and operation of hydrogen pipelines by the gas TSOs and enable repurposing of the existing networks. However, it stops short of calling for structural changes based on a re-bundling approach, such as allowing network operators to produce hydrogen, which would require amendment of current ownership unbundling rules.

Lastly the Strategy does not have any detailed analysis of sectors which could benefit from hydrogen, but which are not covered by the ETS or the sectors targeted, such as transport or industry. This includes hydrogen in the residential heating sector where dwellings may be unsuitable for heat pumps. Without either major subsidy or compulsion it is not clear how such end users will decarbonise using hydrogen, despite its obvious potential.

5.2 Adapting the regulatory framework to economic conditions

Although the Hydrogen Strategy is clear that the hydrogen market will develop in stages, and that the development of the market is not certain, it does not provide any detail of an adaptive regulatory framework which would be suited to the prevailing state of the market.

Instead, the EC appears to believe that minor changes to the existing natural gas and electricity acquis, provision of EU funds for selected (mostly renewable) hydrogen projects as well as exemptions would be sufficient to create an internal market for hydrogen, modelled in the image of the gas and electricity internal markets. The Strategy states that '[e]xisting rules that have been developed for gas and electricity markets could be considered for a hydrogen market under the review of the gas legislation for competitive decarbonised gas markets'. And further that '[n]ot to distort the level playing field for market-based activities, network operators must remain neutral. TPA rules, clear rules on connecting electrolysers to the grid and streamlining of permitting and administrative hurdles will need to be developed to reduce undue burden to market access […] [p]roviding clarity now will avoid sunk investments and the costs of ex-post interventions later'.

However, while the existing rules for gas and electricity were introduced to regulate already *existing* mature markets aimed at strengthening competition and encouraging new companies to enter the market, a renewable and low carbon hydrogen market is only in its very early stage. The Strategy's intention to treat it as a mature market by declaring 'fostering liquid markets and competition' as the main focus, has limited relevance today and may hinder its development. The Strategy argues that such an approach would 'facilitate entry of new producers and be beneficial for further integration with other energy carriers' as well as 'create price signals for investment'. However, the Strategy itself acknowledges that for some time both renewable and low carbon hydrogen are not price competitive and require financial support. The Strategy is vague on how it will adapt regulation during the transition from a nascent to mature market.

5.3 Creating a hydrogen market alongside existing gas and electricity markets

Although the System Integration Strategy highlights the importance of hydrogen in managing renewable dependent electricity systems, there is little consideration of how electricity market mechanisms need to be adapted to ensure that any system balancing uses hydrogen with a low carbon footprint. It would, for example, make no sense to use low priced electricity to make hydrogen if that electricity is partly fossil fuel based.

The Hydrogen Strategy does not consider how to decide between keeping pipelines available for existing but diminishing natural gas demand, or repurposing for hydrogen, or how to ensure a level playing field for natural gas and hydrogen using the same network as a blended stream.

The design of market rules is time consuming, and the introduction of a new variable such as hydrogen increases the complexity and time required. The Commission does not appear to consider this when setting out its ambitious timetable.

6. Conclusions

The EU Hydrogen Strategy sets a vision for establishing hydrogen as an important part of the decarbonisation of the EU energy system, based mostly on renewable hydrogen in the long term (for which €180-470 billion of investment is envisaged), while also acknowledging a role for low carbon hydrogen in the short and medium terms (for which only €3-18 billion of investment is envisaged). Thus, while acknowledging the importance of both renewable and low carbon hydrogen, the Strategy views the former as a 'teacher's pet' and the latter as an underdog. It also expects significant imports of renewable hydrogen from outside the EU, without providing any detail on how this will be achieved.

The EU expects €382 billion of investment is needed for renewable hydrogen by 2030. But this will result in very modest hydrogen production of only 10 Mt/y (334 TWh) and this may not be realistic as it assumes very high load factors for electrolysers. This means that in the transition period large scale hydrogen will have to come from low carbon hydrogen (including reformed methane with CCS). For this to happen, large scale CCS projects will have to be developed in the 2020s. Yet, an expected investment of €3-18 billion by 2050 for low carbon hydrogen appears woefully insufficient, especially as private investors are reluctant to invest even in pilot projects, given the lukewarm attitude of the EC and the lack of (promise of) an articulate policy/regulatory framework. While the Strategy enables low carbon

hydrogen to benefit from some of the support schemes, designed primarily for renewable hydrogen, such as inter alia CCfD, the IPCEI State aid instrument, PCIs, low carbon hydrogen will only be able to make rapid progress if Member States – whose attitude towards it differs widely across the EU – provide government support. For governments to do so and for private investors to contribute, a regulatory framework that facilitates a cooperative value chain would be required. Such a framework would consist of both support mechanisms to enable supply and demand for hydrogen to develop, but also regulation of hydrogen and CCS infrastructure. The criteria for qualifying for the various support mechanisms, and the way in which these mechanisms will operate, all need to be developed, as does the appropriate form of regulation of infrastructure. This will inevitably take time and makes the challenge of meeting targets all the more difficult.

Whilst the ambition and vision for the Hydrogen Strategy is a very positive development, there is insufficient clarity on how a key challenge is to be overcome, namely the support for and coordination of the development of supply, demand and infrastructure. During the development of the natural gas market from the 1960s to the 1980s, this problem was addressed through vertical integration between infrastructure and supply to customers, and long-term contracts with natural gas producers. The current regulatory framework prevents such vertical integration via the requirements of ownership unbundling and the encouragement of short-term contracts, both for capacity and supply. Moreover, there was an economic case for natural gas without the need for subsidy or market intervention.

The Hydrogen Strategy acknowledges the need to develop a whole new value chain, and the difficulties posed by the existing acquis for the development of a hydrogen market, calling for 'a review of the regulatory framework for competitive decarbonised gas markets' which would allow financing and operation of hydrogen pipelines by the TSOs. But it falls short of proposing structural changes, for example allowing cooperation between networks and producers/suppliers, while suspending unbundling and competition requirements. Indeed, it assumes that the market and infrastructure will develop in such a way that the current rules for natural gas will apply. This suggests that at present the EC is not considering the coordination issues sufficiently – especially the possibility of a revolutionary re-bundling approach.[62] It appears to believe that relatively minor changes to the existing acquis, provision of EU funds for selected (mostly renewable) hydrogen projects, State aid, as well as possible exemptions would be sufficient to create a large scale cross border hydrogen market in the EU, modelled in the image of gas and electricity markets. Should this belief prove unjustified, it could lead to a failure of large-scale gas decarbonisation in the EU.

Whilst the Hydrogen strategy has moved the proposed framework forward considerably, it remains the case that although the desired end point for a hydrogen market is clear, there is much work to be done on the mechanisms by which this will be achieved. The transition period will be as important, or even more important than the end state, since without successful development of the markets during the former, the EU will fail to achieve the latter.

[62] See for example Jonathan Stern "Narratives for Natural Gas in Decarbonising European Energy Markets." Oxford Institute for Energy Studies, February 2019.

Annex: EU Hydrogen Strategy Key Actions (Source: EU Commission: A hydrogen strategy for a climate-neutral Europe. July 2020.)

An investment agenda for the EU

- Through the **European Clean Hydrogen Alliance,** develop an investment agenda to stimulate the roll out of production and use of hydrogen and build a concrete pipeline of projects (by end of 2020).
- Support **strategic investments** in clean hydrogen in the context of the Commission's recovery plan, in particular through the **Strategic European Investment Window of InvestEU (from 2021)**.

Boosting demand for and scaling up production

- Propose measures to facilitate the use of hydrogen and its derivatives in the transport sector in the Commission's upcoming **Sustainable and Smart Mobility Strategy**, and in related policy initiatives (2020).
- **Explore additional support measures, including demand-side policies in end-use sectors,** for renewable hydrogen building on the existing provisions of Renewable Energy Directive (by June 2021).
- Work to introduce a common low-carbon threshold/standard for the promotion of hydrogen production installations based on their full life-cycle GHG performance (by June 2021).
- Work to introduce **a comprehensive terminology and European-wide criteria for the certification** of renewable and low-carbon hydrogen (by June 2021).
- Develop a pilot scheme – preferably at EU level – for a **Carbon Contracts for Difference programme**, in particular to support the production of low carbon and circular steel, and basic chemicals.

Designing an enabling and supportive framework: support schemes, market rules and infrastructure

- **Start the planning of hydrogen infrastructure**, including in the Trans-European Networks for Energy and Transport and the Ten-Year Network Development Plans (TYNDPs) (2021) taking into account also the planning of a network of fuelling stations.
- Accelerate the **deployment of different refuelling infrastructure** in the revision of the Alternative Fuels Infrastructure Directive and the revision of the Regulation on the Trans-European Transport Network (2021).
- Design enablin**g market rules to the deployment of hydrogen**, including removing barriers for efficient hydrogen infrastructure development (e.g. via repurposing) and ensure access to liquid markets for hydrogen producers and customers and the integrity of the internal gas market, through the upcoming legislative reviews (e.g. review of the gas legislation for competitive decarbonised gas markets (2021).

Promoting research and innovation in hydrogen technologies

- Launch a 100 MW electrolyser and a Green Airports and Ports call for proposals as part of the European Green Deal call under Horizon 2020 (Q3 2020).
- Establish the proposed Clean Hydrogen Partnership, focusing on renewable hydrogen production, storage, transport, distribution and key components for priority end-uses of clean hydrogen at a competitive price (2021).
- Steer the development of key pilot projects that support Hydrogen value chains, in coordination with the SET Plan (from 2020 onwards).

- Facilitate the demonstration of innovative hydrogen-based technologies through the launch of calls for proposals under the ETS Innovation Fund (first call launched in July 2020).
- Launch a call for pilot action on interregional innovation under cohesion policy on Hydrogen Technologies in carbon-intensive regions (2020).

The international dimension

- Strengthen EU leadership in international fora for technical standards, regulations and definitions on hydrogen.
- Develop the hydrogen mission within the next mandate of Mission Innovation (MI2).
- Promote cooperation with Southern and Eastern Neighbourhood partners and Energy
- Community countries, notably Ukraine on renewable electricity and hydrogen.
- Set out a cooperation process on renewable hydrogen with the African Union in the
- framework of the Africa-Europe Green Energy Initiative.
- Develop a benchmark for euro denominated transactions by 2021.

Acknowledgements

The authors are grateful to their OIES colleagues Jonathan Stern, James Henderson, Ralf Dickel and Martin Lambert for their comments, to John Elkins for his editing, and to Kate Teasdale for her administrative support. All views expressed and errors which may remain are solely the authors alone.