Rialtas na hÉireann
Government of Ireland

Consultation on Developing a Hydrogen Strategy for Ireland

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Prepared by the Department of the Environment, Climate and Communications
gov.ie/decc

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1 Purpose of this Consultation

The Department of the Environment, Climate and Communications has stated in the National Energy Security Framework, published on 13th April 2022, that the development of an integrated hydrogen strategy for Ireland is to be prioritised, in line with the Climate Action Plan. This consultation is accordingly being held to gather the views of stakeholders and interested parties which will inform the development of this strategy. Submissions are invited on the potential role and opportunities for green hydrogen in Ireland. In particular, stakeholder views are sought on the specific areas of interest and the questions highlighted in this paper, as set out in section 12 at pages 31-34.

2 Overview of Hydrogen in the Energy System Including Potential Benefits and Challenges

Hydrogen has many possible applications as a feedstock, a fuel for transport or an energy carrier. As it does not emit carbon dioxide (CO2) when used, hydrogen could become a zero carbon substitute for fossil fuels in the coming years to decarbonise industrial processes and economic sectors where reducing carbon emissions is difficult to achieve. There have been many recent advances regarding the potential use of hydrogen as a fuel for transport, as a suitable replacement for natural gas for heat in industrial processes, and the early development of hydrogen powered electricity generation plants. Hydrogen can be produced through a number of processes from a wide range of sources including fossil fuels, nuclear energy, biomass and renewable energy sources. The energy source, the production process, and the by-products influence how carbon-intensive hydrogen is. Different colours are used to indicate how the hydrogen is produced, the energy sources used and the carbon intensity of the hydrogen (see Figure 1 below).

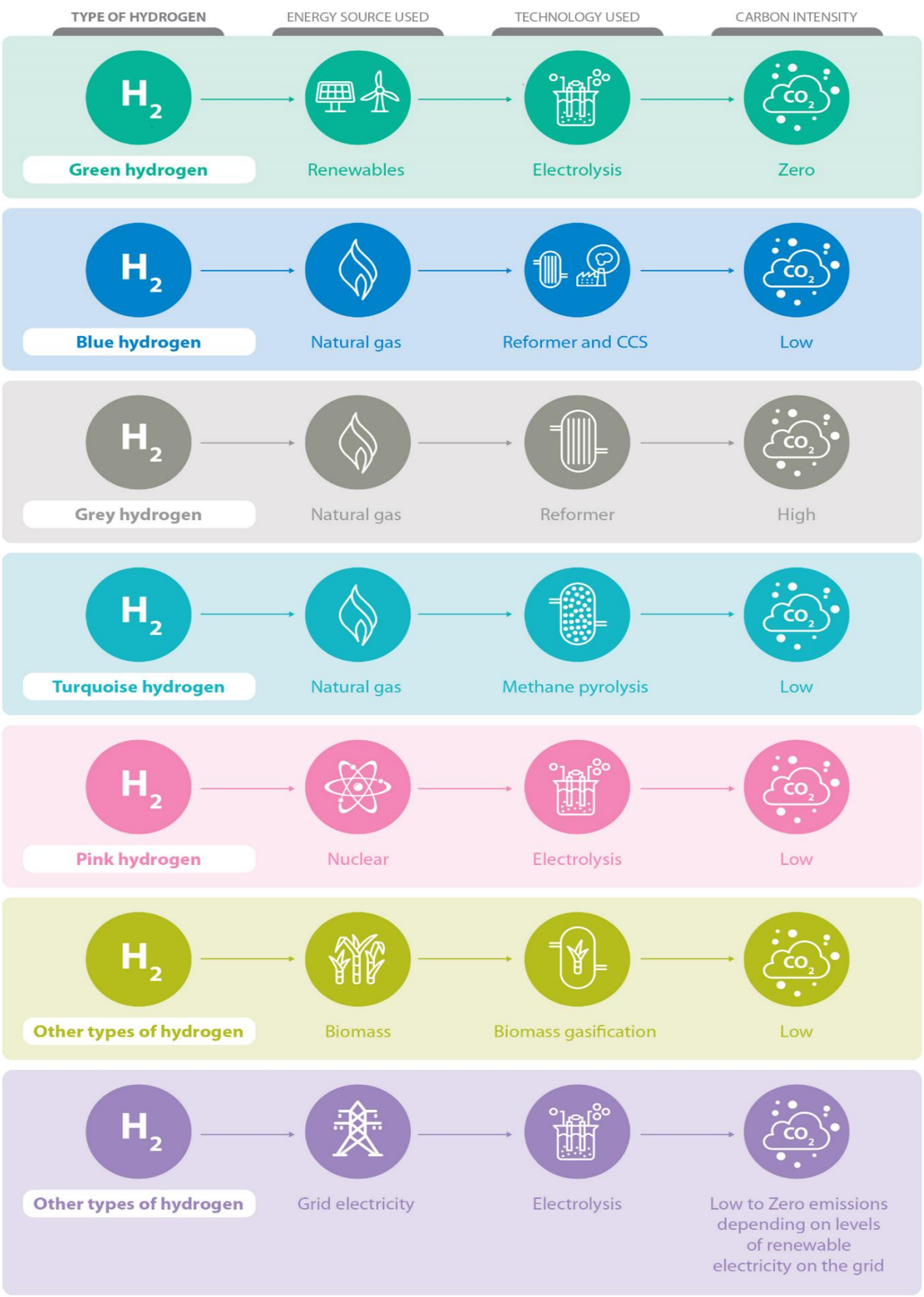

Figure 1: Types of hydrogen, source, technology & carbon intensity

Hydrogen has the potential to support decarbonisation in difficult-to-decarbonise sectors where energy efficiency, electrification and direct use of renewables are not feasible solutions, including heavy goods transport, high-temperature heat for industry and in electricity generation as a back-up for intermittent renewables. In addition, domestically produced green hydrogen would reduce reliance on imported fossil fuels, enhancing Ireland's energy security of supply. There is also revenue-generating potential for Ireland through exporting green hydrogen in the medium to long term if developed in parallel with domestic demand.

Hydrogen can be used very safely as a fuel with residual risks managed to a level that is as low as reasonably practicable when all necessary standards and safety regulatory frameworks and enabling legislative requirements are in place (see section 11).

However, hydrogen is currently not well developed in Ireland for energy applications and supply is likely to be both limited in the early years and comparatively expensive. One of the main challenges to the supply of green hydrogen is the availability of renewable energy to produce it; current analysis indicates that green hydrogen production can be expected to feature in the Irish energy system by 2030 and to expand significantly post-2030, as significant scale offshore wind and other renewable electricity sources are developed. Also, while hydrogen burned for power generation does not produce carbon dioxide emissions, it does produces other air emissions such as nitrogen oxide (NOx), which will need to be carefully considered as part of the overall environmental impact.

Hydrogen accounts for less than 2% of the EU's current energy consumption and is mostly used as feedstock in industrial processes, notably oil refining, ammonia and methanol production. Current hydrogen use in the transport and power generation is negligible, accounting for less than 1% of energy consumed globally in those sectors. Most hydrogen used today is "grey" hydrogen, meaning it has been produced from fossil fuels without any emissions abatement. There are around 5000 km of hydrogen pipelines today, mainly in the US (2600 km), Belgium (600 km) and Germany (400 km), compared with some 3 million km of natural gas pipelines. For hydrogen to contribute to decarbonisation, it needs to achieve a far larger scale and its production must become fully decarbonised.

3 Irish Policy Context

Programme for Government

gov.ie - Programme for Government: Our Shared Future (www.gov.ie)

A key aspect of the Programme for Government is a commitment to reduce overall greenhouse gas emissions, committing to an average reduction of 7% per year from 2021 to 2030, a 51% reduction over the decade, and to achieving net zero emissions by 2050. The Programme for Government recognises the importance of researching and developing green hydrogen for use as a zero-emission energy source in difficult-to-decarbonise sectors such as transport and industry.

National Energy and Climate Plan

gov.ie - Ireland's National Energy and Climate Plan 2021-2030 (www.gov.ie)

The National Energy & Climate Plan, which was published in July 2020 and took account of the Climate Action Plan 2019, states that the production and use of green hydrogen is expected to have a key role to play in Ireland's transition to a low carbon economy and society – in particular as a means to maximise the potential of offshore wind generation. In order to meet our 2030 emissions reduction target, the Climate Action Plan 2021 commits to carrying out a work programme to identify a route to deliver 1 to 3 TWh of zero emissions gas (including green hydrogen) by the end of the decade. Climate Action Plan 2022 will require an increased ambition in terms of the overall delivery of emissions reductions, including the potential for an increased ambition on zero emissions gases in the period to 2030. A green hydrogen strategy will need to expand upon the role of hydrogen in Ireland's energy mix and the actions needed for its development. The work underway for the security of supply review of Ireland's electricity and natural gas systems will be done in parallel with the development of the hydrogen strategy to ensure that long-term security needs take account of future hydrogen technologies.

Climate Action Plan

gov.ie - Climate Action Plan 2021 (www.gov.ie)

Green hydrogen has been identified in the Climate Action Plan as having the potential to support decarbonisation across several sectors including heavy goods transport, high-temperature heat for industry and electricity generation. The Plan envisages that green hydrogen could play a significant role in sector coupling (the increased integration of energy

supply and end-use sectors), and in minimising the overall cost of decarbonisation across all sectors. Specific actions relating to hydrogen set out in the Annex of Actions include testing the technical feasibility of safely injecting green hydrogen blends in the gas grid, assessing the potential for system integration between the electricity and gas networks, which will include the production, storage and use of green hydrogen, and progressing research and pilot studies regarding the use of hydrogen in the transport sector. There are a number of other actions, such as those concerning renewable energy in the heat sector, where hydrogen is a relevant factor. Further measures set out in the Plan include incentivising electrolyser production, developing storage capacity for long duration and seasonal storage of renewable energy, and co-location of electrolysers with renewable energy production infrastructure. In accordance with the Climate Action and Low Carbon Development (Amendment) Act 2021, the Climate Action Plan will be updated on an annual basis to reflect ongoing developments and targets achieved.

Renewable Fuels for Transport Policy Statement

gov.ie - Renewable Fuels for Transport Policy Statement (www.gov.ie)

The Renewable Fuels for Transport Policy Statement establishes an ambitious pathway for transport fuels to achieve our target of a 51% reduction in emissions by 2030. The Policy Statement sets out a roadmap for the supply and use of renewable fuels in transport for meeting the targets set out in the Climate Action Plan 2021 and for European obligations for renewable energy supply and use in transport. Further commitments include incentives to develop the supply of renewable fuels including advanced biofuels and alternative transport fuels such as green hydrogen and biomethane, while ensuring the maintenance of the highest standards of sustainability of biofuel supply from source. Green hydrogen and synthetic fuels produced from green hydrogen are anticipated to be eligible for credits under the Biofuels Obligation Scheme from 2023, as per the Renewable Fuels for Transport Policy Statement.

National Marine Planning Framework

gov.ie - National Marine Planning Framework (www.gov.ie)

The National Marine Planning Framework provides the overarching framework for consistent, evidence-based decision making in the maritime area. All applications for activity or development in Ireland’s maritime area, including hydrogen production, will be considered in terms of consistency with the objectives of the Plan.

National Smart Specialisation Strategy 2022-2027

National-Smart-Specialisation-Strategy-Consultation-Paper-.pdf (enterprise.gov.ie)

The forthcoming National Smart Specialisation Strategy 2022-2027 identified hydrogen generation as an important opportunity for green transformation, notably in the Northern and Western regions and in the Southern region.

Regional Enterprise Plans

Nine Regional Enterprise Plans (REPs) were launched throughout February and March 2022, with a common theme around the enterprise potential of both onshore and offshore wind energy. As part of this, the North-West, West and Mid-West regions have jointly commissioned research on routes to market for the offshore wind energy potential in the Atlantic. The Climate Action Plan contains a target of at least 5 GW of offshore wind energy by 2030 based on competitive auctions, and there is a longer-term plan to install at least 30GW of offshore renewable energy, as reflected in the Policy Statement on the facilitation of Offshore Renewable Energy by Commercial Ports in Ireland, December 2021. There is also the expectation that this research will examine Green Hydrogen potential.

Shannon Estuary Economic Taskforce

gov.ie - Call for Expression of Interest - Shannon Estuary Economic Taskforce (www.gov.ie)

A particular focus of the Shannon Estuary Economic Taskforce will be on the offshore wind energy potential. The report of the Taskforce will likely contain actions to be assigned across the Government system and the realisation of the offshore wind energy potential from the Estuary, which would include green hydrogen (production, seasonal storage, manufacture & assembly of electrolysis platforms, use in heavy industry and gas turbines, routes for export, etc.), is likely to be included. It is expected that a final report will be delivered by end-November 2022.

4 EU Policy Context

EU Hydrogen Strategy

Hydrogen is an important part of the overall EU strategy for energy system integration: EU strategy on energy system integration (europa.eu). The EU hydrogen strategy, "A Hydrogen Strategy for a Climate Neutral Europe': EUR-Lex - 52020DC0301 - EN - EUR-Lex (europa.eu) was published in July 2020 and sets out a pathway for hydrogen to become an intrinsic part of an integrated EU energy system. Green hydrogen is a key focus of the strategy, as it has the biggest decarbonisation potential and is therefore the most compatible option with the EU's climate neutrality goal. The strategy examines the role of hydrogen over three phases:

- From the present to 2024, the EU will support the installation of at least 6GW of renewable hydrogen electrolysers, and the production of up to 1 million tonnes of renewable hydrogen across Member States.
- From 2025 to 2030, it recognises that hydrogen needs to become an intrinsic part of an integrated energy system, with at least 40GW of renewable hydrogen electrolysers and the production of up to 10 million tonnes of renewable hydrogen in the EU.
- From 2030 onwards, it sets out that renewable hydrogen will be deployed at a large scale across all hard-to-decarbonise sectors.

Ireland welcomed the EU hydrogen strategy, in particular the need to support the deployment of green hydrogen produced from renewable sources.

EU Hydrogen and Decarbonised Gas Market Package

Published on 15th December 2021, the hydrogen and gas market decarbonisation package is a set of legislative proposals to decarbonise the EU gas market by facilitating the uptake of renewable and low carbon gases, including hydrogen, and to ensure energy security for all citizens in Europe: New EU framework to decarbonise gas markets (europa.eu). The proposals aim to create the conditions for a shift from fossil natural gas to renewable and low-carbon gases, in particular biomethane and hydrogen, and to strengthen the resilience of the gas system. One of the main aims is to establish a market for hydrogen, by creating the right environment for investment, and enabling the development of dedicated infrastructure, including that for trade with third countries.

REPowerEU

On 18th May 2022, the European Commission published "REPowerEU – A plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition": https://ec.europa.eu/commission/presscorner/detail/en/ip_22_3131. Building on the "Fit for 55" package of proposals and the actions on energy security of supply and storage, the REPowerEU plan puts forward an additional set of actions to reduce greenhouse gas emissions and strengthen the security and competitiveness of energy supplies through energy savings, diversification of energy supplies, and accelerated roll-out of renewable energy to replace fossil fuels in homes, industry and power generation. The plan sets out a number of measures proposed by the Commission to help Europe achieve this ambition, including accelerating the replacement of natural gas, coal and oil in hard-to-decarbonise industries and transport with fossil-free hydrogen, an increased target of 10 million tonnes of domestic renewable hydrogen production and a new target of 10 million tonnes of renewable hydrogen imports by 2030.

EU and UK hydrogen Strategies - Brief Synopsis

There are a number of hydrogen strategies that have already been published across Europe and the world. Three that are particularly useful to include as policy context are the German Hydrogen Strategy (based on potential cooperation), the UK hydrogen strategy (based on interconnection), and the Portuguese hydrogen strategy (based on similarities: wind resource, export potential).

Germany

The German hydrogen strategy was published in June 2020 and is targeted at the following future hydrogen markets: (i) hydrogen production (ii) the industrial sector (iii) transport and (iv) heat. The German government estimates green hydrogen production of up to 14 TWh with funding and subsidies totalling €1.4 bn. There is also a plan to establish hydrogen partnerships with countries having cost-effective green hydrogen production potential.

Portugal

Portugal published its hydrogen strategy in July 2020 with a budget of €7bn and a number of key actions which are set out in the table below.

UK

The UK launched its hydrogen strategy in August 2021 and set out three phases to reach 5GW of low carbon hydrogen production capacity by 2030 (equivalent to the amount of gas consumed by over 3 million households in the UK each year), with a possibility of 1GW by 2025. The UK has adopted a 'twin-track approach' encompassing both green hydrogen and CCUS-enabled blue hydrogen. In addition, Northern Ireland's energy strategy, the Path to Net Zero Energy, was published in December 2021 and outlines a roadmap to 2030 aiming to deliver a 56% reduction in energy-related emissions, which includes the delivery of a Hydrogen Centre of Excellence.[1] In 2020, Scotland, a peer nation to Ireland in terms of offshorerenewable potential, developed a detailed assessment of the economic benefits of Scotland becoming a major Green H2 exporter.[2]

Country	Pre - 2025	2025 - 2030	Post - 2030
Germany		Electrolysers with a total capacity of up to 5GW, for both offshore and onshore. Targeted hydrogen demand of about 90 to 110 TWh by 2030.	A further 5 GW of hydrogen by 2035 (or 2040 at the latest).
Portugal		Installation of 2 GW of electrolyser capacity. Aims to have the share of hydrogen in the final energy consumption increased to 5% by 2030.	Increased electrolyser capacity to 5 GW by 2050. Have up to 20% hydrogen consumption in the road transport sector by 2050.

[1] The supporting study, "Hydrogen-Exploring opportunities in the Northern Ireland Energy Transition", is available here: https://www.nweurope.eu/media/13425/hydrogen-exploring-opportunities-in-the-northern-ireland-energy-transition-march-2021.pdf

[2] https://www.gov.scot/binaries/content/documents/govscot/publications/research-and-analysis/2020/12/scottish-hydrogen-assessment-report/documents/scottish-hydrogen-assessment/scottish-hydrogen-assessment/govscot%3Adocument/scottish-hydrogen-assessment.pdf

UK	Launch the Net Zero Hydrogen Fund. Phase 1 of the CCUS cluster decision. Finalise low carbon hydrogen standard.[3] Finalise business model. Heat neighbourhood trial. Value for money case for blending by Q3.	Aiming for 1GW production capacity with at least two CCUS clusters by 2025. Heat village trial by 2025. Hydrogen heating decision by 2026. Decision on the role of H2 in HGVs, mid-2020s. Ambition for 5GW production capacity and four CCUS clusters by 2030. Establishment of a potential pilot hydrogen town by 2030 and an ambition for 40GW offshore wind by 2030.	

Figure 2: Key actions within the Hydrogen Strategies for Germany, Portugal and the UK

European Clean Hydrogen Alliance

The European Clean Hydrogen Alliance: European Clean Hydrogen Alliance (ech2a.eu) brings together industry, public authorities, civil society and other stakeholders. Alliance members meet twice a year in the Hydrogen Forum to discuss the large-scale deployment of clean hydrogen technologies and what this requires.

Important Projects of Common European Interest (IPCEIs) in the Hydrogen Sector

Important Projects of Common European Interest are large-scale, multi-country projects for global state-of-the-art innovation to solve market or systemic failures in particular sectors. Favourable State aid rules apply to IPCEIs, allowing Member States to provide capital grants to companies to incentivise them to participate in these projects. The State aid framework for IPCEIs is without the limitations of some of the other State aid tools and this allows for much

[3] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1067392/low-carbon-hydrogen-standard-guidance.pdf

higher levels of State aid to be provided. In addition, the eligible costs set out in the IPCEI State aid communication are broader than for many other State aid tools. A number of IPCEIs in the area of hydrogen are in development, with several waves in the first stage of the IPCEI State aid process (pre-notification): IPCEIs on hydrogen (europa.eu)

Under the REPowerEU plan, the Commission will accelerate the evaluation of proposals received through the Hydrogen IPCEI and will complete the process by summer 2022. This is a very notable signal from Commission about the importance it is putting on hydrogen as part of the energy transition.

EU Regulation on Guidelines for Trans-European Energy Infrastructure (TEN-E)

The EU Regulation on Guidelines for Trans-European Energy Infrastructure, known as the TEN-E Regulation: EUR-Lex - 32022R0869 - EN - EUR-Lex (europa.eu) provides the legislative basis for the “Project of Common Interest” designation, which refers to key cross border energy infrastructure projects that link the energy systems of EU countries. Benefits associated with Project of Common Interest status include accelerated planning and permitting, preferential regulatory treatment and, in most instances, the ability to apply for EU grant funding via the Connecting Europe Facility (CEF). To reflect the increased climate ambition introduced under the European Green Deal, TEN-E was the first of the EU energy and climate legislative files scheduled for amendment under the “Fit for 55” Package. Some key points in the new Regulation include establishment of Project of Common Interest status for hydrogen infrastructure (pipelines, storage, electrolysers) and the establishment of Projects of Mutual Interest for energy infrastructure projects between the EU and third countries

EU Alternative Fuels Infrastructure Regulation

The Commission has published the proposed Alternative Fuels Infrastructure Regulation (AFIR): resource.html (europa.eu) and: Fit for 55 package: Council adopts its position on three texts relating to the transport sector - Consilium (europa.eu) which sets out refuelling requirements for hydrogen infrastructure. Under the AFIR proposal, Ireland would be required to provide publicly available refuelling points of 350 bars and 700 bars every 200km on the core TEN-T network.

5 Hydrogen in Ireland

At present, Ireland has no dedicated hydrogen networks and current uses of hydrogen are relatively limited and dispersed. The Whitegate refinery in Co. Cork produces hydrogen for internal use; BOC, a provider of industrial, medical and special gases, produces hydrogen which is used by a range of industry sectors, such as aerospace, electronics, pharmaceutical and medical. BOC also supplies the green hydrogen used for the three Bus Éireann hydrogen buses. Intel is one of the biggest users of hydrogen in Ireland with a sizable internal hydrogen network to supply hydrogen to various processes.

There are a number of hydrogen-related projects underway in Ireland: Indaver has been granted planning permission for a 10MW hydrogen generation unit, Bord Na Mona & BOC are building a 2MW electrolyser and Mercury are applying for planning permission for an 80MW electrolyser.

In the transport sector, the National Transport Authority and Bus Éireann are using three hydrogen-fuel-cell-electric double-deck buses on commuter services in the Greater Dublin Area as part of the Department of Transport's Low Emission Bus Trial: gov.ie - Ireland takes next step in testing hydrogen buses in transport fleet (www.gov.ie). The final report of Phase Two of the Low-Emission Bus Trial, published on 23rd May 2022 provides findings relating to testing of two hydrogen fuel-cell buses and makes recommendations on actions that could be taken in the coming years to comply with policy requirements and improve the performance of the national bus fleet: https://www.gov.ie/en/publication/e2cd8-low-emission-bus-trial-final-report/

Ireland has considerable potential to produce green hydrogen from renewable electricity given our offshore and onshore wind potential. With a sea area approximately seven times the size of our landmass, Ireland has one of the best offshore renewable energy resources in the world. Due to our location in the Atlantic, Ireland's coast is one of the most energy productive in Europe. The Climate Action Plan 2021 commits to achievement of 5GW of installed offshore wind capacity by 2030 and includes a suite of actions to realise the potential of Ireland's offshore renewable energy potential, while the Programme for Government commits to a long-term plan to take advantage of a potential of at least 30GW of floating wind thereafter. It is anticipated that most of the first phase of offshore renewable energy will be located off Ireland's east coast and that second and later phases will also see deployment in southern and western costs and the applications of such power supplies in a planned way, such as for electricity, transport and industry uses.

Ireland’s gas network is one of the most modern in Europe. The distribution network is comprised of polyethylene pipes and early indications are that it is already capable of transporting hydrogen or hydrogen/natural gas blends. The transmission and distribution system operator, Gas Networks Ireland, is currently carrying out a technical assessment in relation to how levels of hydrogen could be accommodated in the gas network in line with Climate Action Plan 2021.

Ireland sources around one-quarter of its gas from the Corrib gas field, and three-quarters via the UK, which has diverse sources of supply. From 2025 it is possible that natural gas imported via the UK could contain hydrogen blends (including blue or low-carbon hydrogen), which could be a factor in the deployment of hydrogen in the Irish energy system if imported from the UK.

6 Research and Development

There is significant research underway concerning hydrogen and its future role in Ireland's energy mix. The Sustainable Energy Authority of Ireland (SEAI) is developing a number of initiatives on the role of green hydrogen in decarbonisation. The annual SEAI Research, Development and Demonstration (RD&D) Call contains targeted topics, formulated with policy makers to address known gaps. This continues to be available to include specific research challenges for the Irish research community to address. Following the 2021 SEAI National Energy RD&D (Research, Development & Demonstration) Funding Programme Call, a number of projects related to green hydrogen have been awarded and are in the early stages. Details of relevant ongoing energy research projects can be searched for within the National Energy Research Database at: https://www.seai.ie/data-and-insights/seai-research/research-database/.

The SEAI's National Heat Study, published in February 2022, examines options to decarbonise the heating and cooling sectors in Ireland to 2050, including options for green hydrogen.

Climate Action Plan 2021 includes a number of actions related to research including a study reviewing the profile, sustainability and supply of renewable transport fuels in Ireland, including green hydrogen, testing the technical feasibility of safely injecting green hydrogen blends in the gas grid, and assessing the potential for energy system integration between the electricity and gas networks including the production, storage and use of green hydrogen.

Irish academic institutes and businesses are involved in a number of hydrogen research projects. Researchers from the University College Dublin Energy Institute (UCDEI) are working with Gas Networks Ireland on a project investigating the potential use of hydrogen in the distribution network, which involves testing the operation and performance of household appliances (such as boilers, cookers, radiators) with varying levels of hydrogen and natural gas blends using the testing facilities at both UCDEI's Integrated Energy Lab and Gas Networks Ireland's hydrogen innovation facility in west County Dublin: Hydrogen-Research-Collaboration-Final.pdf (ucd.ie)

There is an ongoing testing programme for 20% hydrogen blends in existing gas appliances. Initial tests have been completed on 2% and 5% hydrogen blends and will progress up to 20% hydrogen blends to understand the impact of imported blended hydrogen and methane mixes.

HyLIGHT is a project funded by Science Foundation Ireland (SFI) and a 25-strong industry consortium through MaREI (the SFI Research Centre for Energy, Climate and Marine), University College Cork, Dublin City University and the National University of Ireland Galway. The overall aim of the project is to provide the knowledge, data and the necessary tools to guide decarbonisation via the cost-effective and sustainable large-scale implementation of hydrogen technologies in Ireland: HyLIGHT - MaREI

The GenComm project funded by Interreg North West Europe aims to address the energy sustainability challenges of North West Europe, by technically and commercially validating renewable hydrogen technologies. The project will develop three pilot plants, in Northern Ireland (wind power), Scotland (bioenergy) and Germany (solar power), linking the three main renewable sources, solar power, wind power and bioenergy, with energy storage and the main forms of demand - heat, power and transportation fuels. Based on the pilot plants, technical and financial models will be developed, with the overall aim of developing a decision support tool. This tool will then provide a roadmap for communities to transition to renewable, hydrogen-based energy: GENCOMM - MaREI

Dublin City University published a report on the first hydrogen bus trial on the island of Ireland, which travelled 3000km on urban & rural routes in Dublin in November 2020.: Exploring Low Emissions Public Transport; Analysis of Ireland's first Hydrogen Bus Trial - 2020 (hydrogenireland.org)

Dublin City University and partner colleges across Europe are involved in a Erasmus+ project, HySkills, aiming to develop a modular training course enhanced with a practical

element focused on green hydrogen technical & safety skills: EIfI-Tech - Europäisches Institut für Innovation-Technologie | EIfI-Tech's latest approved Erasmus+ project, HySkills

Nexsys, a research partnership based in University College Dublin will be exploring energy system decarbonisation and investigating hydrogen with respect to offshore renewables & transport: Minister Simon Harris announces €16m NexSys Partnership to decarbonise energy sector | UCD Research

Under the HWind project, SFI MAREI & University College Cork are seeking to support the development of green hydrogen as the means of more efficiently providing energy by bringing the electricity network and gas network together to make optimal use of Ireland's offshore wind resources. The project will seek to identify new markets for green hydrogen and ensure that Ireland delivers on EU strategy in energy system integration: https://www.marei.ie/new-h-wind-project-to-advance-development-of-hydrogen-energy-in-ireland/

The "Extending the European Hydrogen Backbone" study suggests that a hydrogen valley network could emerge around the city of Cork, on Ireland's south coast. In addition, groups like Wind Energy Ireland and Hydrogen Mobility Ireland have produced papers on the potential for hydrogen in Ireland: EHB_one-pager_210624.indd (gasforclimate2050.eu)

"Impact 2030: Ireland's Research and Innovation Strategy" puts research and innovation at the heart of addressing Ireland's social, economic and environmental challenges. The strategy highlights a number of emerging sectoral opportunities for Ireland, including hydrogen and other cleantech areas, as well as sustainable industries and technologies, as identified by Enterprise Ireland and the Industrial Development Authority (IDA). Research, development and innovation are essential areas for supporting the efforts of Irish enterprises to decarbonise and creating new opportunities in technologies and sectors that will support Ireland's future: gov.ie - Impact 2030: Ireland's Research and Innovation Strategy (www.gov.ie)

Other noteworthy research projects include Seafuel (Interreg, led by NUI Galway): Home - SEAFUEL; HUGE (Interreg, involves NUI Galway): Home - HUGE Project (huge-project.eu) and GreenHysland (Major project, FCHJU, involves NUI Galway): Green Hysland - Deployment of a H2 Ecosystem on the Island of Mallorca

Further research will be required to effectively and efficiently deploy hydrogen in Ireland's energy mix. Ireland has several State agencies that are well placed to help accelerate developments in innovation across the academic, public and private sectors.

Stakeholder views are sought on:

- Which areas of hydrogen research require further examination?
- What can an Irish hydrogen strategy could do to drive innovation?
- What are the research priorities for the development of each hydrogen end-use (demand) in Ireland?

7 Hydrogen Demand

Ireland's strategic approach to decarbonisation is to concentrate first on energy efficiency, and then to proceed to electrification of sectors, particularly heating and transport. Green hydrogen can play a role in hard-to-abate sectors, in particular those identified in the Climate Action Plan 2021 such as the electricity generation, industry (including industrial heat) and transport sectors (heavy-duty vehicles, maritime and aviation). The Climate Action Plan 2021 includes actions relating to green hydrogen demand in transport, as well as setting out a vision for how green hydrogen could address some of the challenges faced by the energy sector, such as providing a back-up for variable renewables. A green hydrogen strategy will need to expand upon the production of green hydrogen and its use in each of these sectors.

It will also be important to recognise the sectors for which green hydrogen use will not be a priority. There are a number of H2 “Pyramids” or “Ladders” that have been produced internationally, see Figure 3 as an example. Ireland has its own unique landscape for hydrogen and it is critical that the use of zero-emissions gases is directed towards sectors that will maximise emissions’ abatement, particularly in those that would be otherwise difficult to decarbonise. In order to progress and inform the development of the strategy, there will be a specific examination of each end use (demand) sector. A hydrogen strategy will need to examine the challenges and synergies associated with the combined deployment of green hydrogen across multiple sectors. This potential vector of development is reflected in the EU’s approach to funding Hydrogen Valleys and Hubs that include both producers and users -- linking hydrogen production, transportation, and various end-uses such as mobility or industrial feedstock.

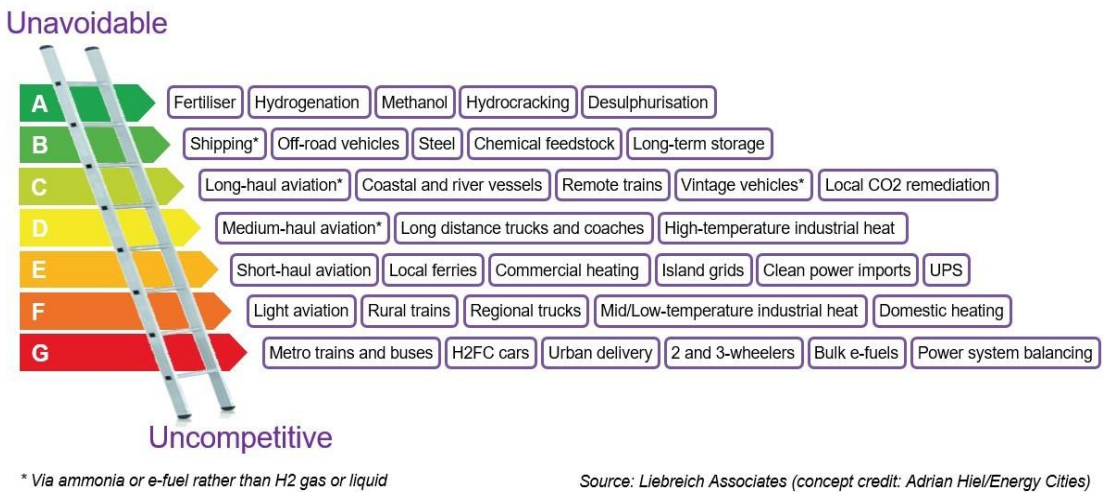

Figure 3: The Clean Hydrogen Ladder, Version 4.0

Stakeholder views are sought on:

- What end-uses are there for hydrogen in Ireland (i.e. where hydrogen will be used)?
- How much hydrogen would be anticipated for use in each (in low, medium and high demand scenarios)? At what rate might that increase? What current evidence supports these projections?
- What specific end-uses should be high, medium and low priority for green hydrogen use?
- What are the potential policy options for incentivising for each of these end-uses?
- How might the combined deployment of green hydrogen across multiple sectors synergies facilitate the development of hydrogen in Ireland?
- How does hydrogen compare to competing technologies (direct electrification and other decarbonisation options) for each of these end-uses?
- What are the competing fossil fuels that are sought to be displaced?
- How can Ireland avoid hydrogen use that increase the overall level of energy used in the economy versus other decarbonisation pathways?
- How should green hydrogen be incentivised in the electricity market?

7.1 Hydrogen Demand – Heat

The National Heat Study: National Heat Study | SEAI has modelled several routes to net zero in the heat sector by 2050, in all scenarios the industry sector uses hydrogen fuel, primarily to produce high grade and medium grade heat in industrial manufacturing processes. In contrast, the use of hydrogen for space heating is limited, with only the "Decarbonised Gas" scenario seeing significant uptake, with other technology options like heat pumps being widely used in all scenarios to decarbonise space and water heating in buildings and low-temperature heat at industrial sites. Therefore the role for hydrogen in the heat sector will be as an option to decarbonise the medium and high-temperature heat use in the industrial sector, as opposed to use for low-temperature heat use in the built environment. There will also be other competing technologies to meet medium and high-temperature heat use, including electric technologies, biomass and carbon capture, utilisation and storage (CCUS) on sites with significant process emissions.

7.2 Hydrogen Demand – Transport

Hydrogen can be used as a fuel by most types of vehicles either by using hydrogen in a fuel cell to power electric motors or by burning hydrogen (or hydrogen-based fuels such as ammonia) in an internal combustion engine. The Climate Action Plan sets out targets for battery electric vehicles as the most commercially advanced solution for decarbonising passenger cars and other lightweight vehicles. Direct electrification (via battery-electric vehicles) has significant efficiency advantages over hydrogen use due to the energy conversion losses in producing and using hydrogen in fuel cell electric vehicles (FCEVs). Therefore, direct electric technologies are preferable where they are technically feasible. However, full electrification may remain a challenge for heavy, long-range vehicles, particularly maritime, aviation and long-haul road freight. While FCEV options for trucks and coaches aren't yet commercially available, it is anticipated that these vehicles will become commercially available in the second half of this decade.

A green hydrogen strategy will need to consider the potential demand for hydrogen across the transport sector and how hydrogen could complement electricity as a zero-carbon transport fuel for vehicles where battery electric vehicles may not be a viable decarbonisation solution. Decarbonisation targets in sectors such as maritime and aviation will create a demand for hydrogen-based renewable or carbon-neutral fuels. This will be a focus of the Shannon Estuary Task Force which will examine the potential for the Shannon Region to develop sustainable aviation fuels availing of potential offshore renewable energy.

In the aviation sector, hydrogen can be used to develop e-fuels such as e-kerosene which are carbon neutral drop-in fuels. In addition to this, companies such as Airbus are developing hydrogen fuel cell airplane technologies while the aviation industry is also working on solutions to develop lighter cryogenic chambers for storing larger quantities of liquefied hydrogen on-board aircraft. In the maritime sector, hydrogen can be used to produce green ammonia which is a renewable maritime fuel that will help the maritime sector reach net-zero by 2050. Green Hydrogen fuel cell technology can complement battery electric technology for the heavy-duty vehicle sector, particularly for longer distance freight movements where there may be an advantage over electrification.

While electric-power trains will be the primary means to decarbonise the commuter rail sector and plans are underway under the DART+ Programme to this effect, hydrogen fuel cell trains are now commercially available as evidenced by the Alstom trains in Germany, France and other countries. Hydrogen powered trains could potentially be substituted for conventional trains without the need for infrastructure upgrades and they can also work on overhead catenary lines when the network is fully electrified. This also provides a redundancy in case of overhead electrical failure.

7.3 Hydrogen Demand – Electricity

The National Heat Study has modelled several routes to net zero in the power sector by 2050, including the deployment of green hydrogen fuel with hydrogen-ready gas turbines. The use of hydrogen could decarbonise the conventional generation required at times when variable renewable electricity is less plentiful, as well as enhancing energy security by diversifying supply. Hydrogen as a method of storing electricity from variable renewable generation may be needed to address the challenges associated with system stability, seasonal wind variability and curtailment in order to achieve the 2030 target of up to 80% of electricity demand to come from variable renewable sources (which will be increased even further beyond 2030). Identifying the opportunities and challenges of decarbonising the conventional generation asset base is a pressing policy area given the scale of electricity demand growth expected over the coming years and decades. Further investigation is also needed to understand how current market and grid operation rules would need to change to facilitate such systems and market interactions, and the impacts on energy consumers. The full decarbonisation of data centres via RES-E (electricity from renewable sources) and green hydrogen is a major potential end use in Ireland. In addition, green hydrogen is expected to have an important role in the inter-seasonal storage of electricity (as per B in the Hydrogen Ladder above) as part of decarbonising the power system on the pathway to net zero emissions.

The utilisation of excess renewable electricity, that would otherwise be curtailed due to 'over-supply' of renewables relative to electricity demand in a particular hour or due to network or system wide constraints, must also be considered. There is a question as to the business case and financeability of a co-located electrolyser in these circumstances, and whether revenue from the lost curtailed energy would be sufficient to cover the capital and operational expenditure required. The Department is carrying out further analysis in this regard and welcomes the views of stakeholder on the commercial case for such projects pre-2030.

Network constraints in specific locations may mean that onshore wind projects, for example, could become viable through physical co-location with an electrolyser. Similarly, offshore wind projects co-located with electrolysers could serve domestic or international demand for green hydrogen.

Financial support and route-to-markets for green hydrogen should be targeted at maximising the overall output of renewable energy and minimising emissions across the economy. Ireland has ambitious renewable electricity targets (up to 80% by 2030) which require that onshore wind, solar and offshore wind projects in the period deliver electricity. Efficiency losses through converting that energy into hydrogen should only be contemplated where this does not reduce the supply of renewable electricity in the power sector to meet domestic demand.

8 Hydrogen Supply

Hydrogen ought to be produced and deployed in a way that is coherent with our decarbonisation goals, in particular to avoid any potential lock-in of non-green/non-renewable hydrogen use that fails to align with Ireland's target of achieving net zero by 2050. Therefore, our priority is green hydrogen sustainably produced from renewable sources. The production of green hydrogen relies on the availability of renewables, both offshore and onshore. Ireland plans for up to 80% of our electricity to come from renewable sources by 2030 and has considerable potential to produce renewable hydrogen from renewables, particularly from offshore wind. Ireland has a massive offshore wind potential and the production of green hydrogen from variable renewable electricity could help Ireland to fully utilise its renewable resources to decarbonise, reducing significant levels of curtailed renewables and improving energy security. The Climate Action Plan 2021 commits to facilitating the development of at least 5 GW of offshore wind by 2030. In addition, the Programme for Government commits to developing a long term plan setting out how Ireland will take advantage of the massive potential of offshore renewable energy on the Atlantic

Coast. There will be a major opportunity for green hydrogen production using the electricity generated from floating offshore wind in particular. The integration of offshore wind with the production of green hydrogen can help address some of the wider challenges of decarbonisation of the wider energy sector.

Further work is needed to understand how using wind for hydrogen production interacts with the electricity system's needs, and if the capacity can be deployed quickly enough to meet the total requirements. There is also a need to identify the locational signals for where electrolysis stations ought to be developed and to understand how they are scheduled and dispatched, as they could place large loads/demands on the system if they are producing hydrogen using grid electricity. In relation to production from renewable energy, a number of possibilities for electrolysers will need to be explored including:

- Grid connected and running on grid electricity with a high capacity factor.
- Grid connected and running on curtailed RES from the grid only (however this would need to comply with the EU definitions of green hydrogen, which currently require 90% RES-E, and related greenhouse gas emissions-saving criteria).
- Grid connected with dedicated on-site RES to supply power for the electrolysis. Potentially providing system services and excess generation back onto the grid.
- Non-grid connected with dedicated on-site RES and storage.

The ability for all of the above, and other options, to generate renewable/green hydrogen will need to be examined in the context of the proposed changes to the Renewable Energy Directive (recast as RED III as part of the EU's 'Fit for 55' package), particularly any requirements around co-location with new/existing generation and additionality. Certification will need to be examined to ensure the sustainability of hydrogen produced in Ireland.

In this context, the draft EU Delegated Act on Renewable Fuels of Non-Biological Origin (RFNBOs) sets out three cases for green hydrogen production with strict limitations:

1. Physical colocations of renewables and electrolysis
2. Grid based electrolysis with PPAs including monthly corelation to 2026 and hourly corelation from 2027.
3. Grid-based electrolysis with average grid power.

Production of renewable transport fuels – share of renewable electricity (requirements) (europa.eu)

Feedback is requested on these proposals set out by the Commission in the Delated Acts.

Interconnection with the UK

The UK's National Grid intend to have a Hydrogen Regulatory Framework established for injection of blends into their gas transmission pipeline network from 2025. This may open the opportunity for hydrogen blends to be imported through the Ireland-UK gas interconnector pipelines. The certification of any such hydrogen (i.e. which jurisdiction gets credited with the emission saving) would need to be explored, particularly given that such blends may be blue or grey hydrogen. The proposed regulation[4] regarding the EU Hydrogen and Gas Markets Decarbonisation Package states that Transmission System Operators shall accept gas with a hydrogen content of up to 5% at interconnection points between Member States from 1st October 2025. While Ireland is not directly connected to a Union Member State, it is connected indirectly via the UK (which has confirmed that it will align with this ambition).

Stakeholder views are sought on:

- What is the renewable electricity potential that does not have a route to market from conventional grid connections? Could this be used for green hydrogen production?
- What are the most cost-effective ways of utilising potentially curtailed renewable electricity output for hydrogen production?
- What should government do to de-risk efficient investment in green hydrogen production to supply Ireland's demand?
- What is the expected minimum capacity factor of grid connected hydrogen electrolysers that would be financially viable?
- What policy mechanisms could be used to avoid green hydrogen production competing with direct electrification?
- Where would it be best to locate hydrogen production? Should there be specific government policy to locate hydrogen production facilities where too much energy being generated for the electricity grid to manage (i.e. grid constraints)? What spatial planning considerations should be factored into this? What role might ports play in the production and transportation of hydrogen?
- What minimum sustainability criteria should apply to hydrogen produced in Ireland?

[4] https://eur-lex.europa.eu/resource.html?uri=cellar:0c903f5a-5d8b-11ec-9c6c-01aa75ed71a1.0001.02/DOC_1&format=PDF

- What policy mechanisms could be used to ensure that competition between green hydrogen production and other direct uses of renewable electricity is managed such that there are no negative impacts on emissions reductions or consumer costs?
- What contribution could domestic green hydrogen supply make towards Ireland's energy security?
- What strengths does Ireland have in hydrogen supply chains?
- What potential uses are there for the oxygen by-product of hydrogen production?

9 Hydrogen Transportation and Storage

Hydrogen can be transported by pipeline, either through localised and dedicated hydrogen grids or injecting blended hydrogen into the natural gas network. Compressed hydrogen can also be transported by road in gas cylinders using trucks, BOC and Energia already transport hydrogen by truck in Ireland. There is also the potential to transport by rail as Irish Rail have connections to most ports in Ireland. How hydrogen is transported from the point of production to the point of end-use will be an important area for consideration in the hydrogen strategy, particularly where it is produced using renewables off the west coast and moved to meet east coast demand or export. End-users of hydrogen will have different requirements, challenges and opportunities when it comes to how hydrogen is transported (e.g. blended hydrogen that is delivered by the gas grid will arrive at its end use in a blended state) and this will need to be carefully considered alongside the value of pure hydrogen use.

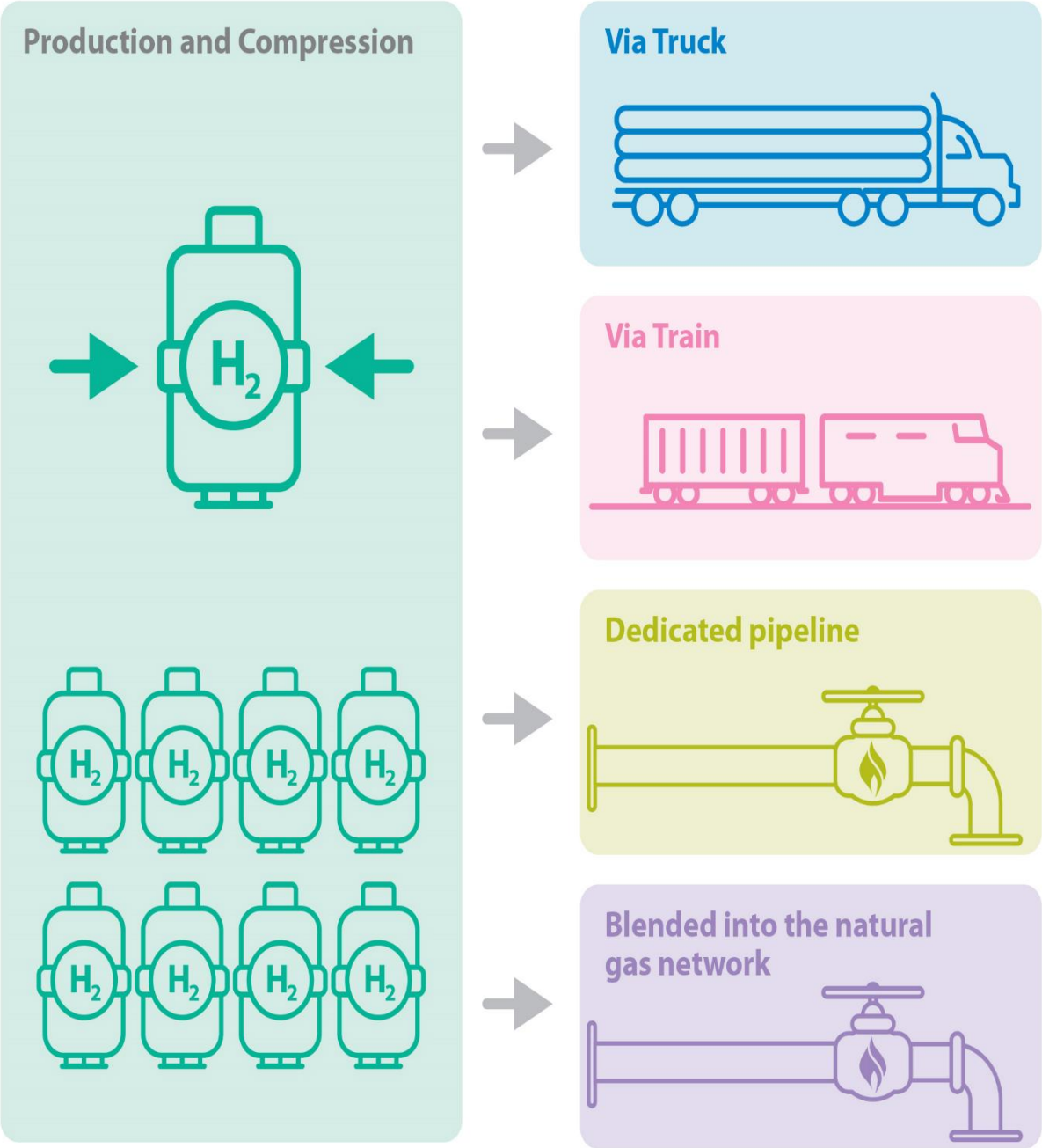

Figure 4: Methods for transporting hydrogen

The Climate Action Plan 2021 sets out a number of actions for developing renewable gas in the gas grid, including testing the technical feasibility of safely injecting green hydrogen blends in the gas grid, developing a policy/regulatory roadmap for green hydrogen use in the natural gas grid, and assessing the potential for energy system integration between the electricity and gas networks (including the production, storage and use of green hydrogen). Under the EU proposals mentioned in section 8, Ireland's gas network will need to be capable of accepting a level of hydrogen blending. However, it is not necessarily the best

use of hydrogen to blend directly with natural gas, as a 20% blend rate yields only a 7% reduction in natural gas demand.

Hydrogen can be stored as a gas or liquid for long periods of time using high pressure storage tanks, salt caverns, salt aquifers and depleted gas fields. Further work is also required to examine geological storage options and what impact ammonia storage may have on the emissions ceilings for these gases. Hydrogen storage could have a significant role to play as a form of long-term electricity storage, where hydrogen would be used as a backup to renewables to generate electricity during periods of low renewable availability.

There is currently no legislative or regulatory regime in place regarding investigation of the potential for storage of hydrogen (as opposed to the regulatory framework in place in respect of gas exploration and extraction), onshore or offshore Ireland.

There is the possibility of storing hydrogen either as a gas or as a liquid for extended periods using high pressure tanks for storage, as well as salt caverns, salt aquifers and depleted gas fields. However, underground storage of hydrogen systems and associated knowledge are still in their infancy. The potential use of geological formations for largescale underground hydrogen storage would require careful examination and further research and development. Up-scale pilot projects would be required to fully investigate the challenges and opportunities of such a new pathway, including the need to undertake technical investigations and studies on the geological nature of subsurface reservoirs.

Determining factors in identifying economic solutions include the available volume of hydrogen and the extent to which it could meet demand, the length of time it would need to be stored for, site location, whether any existing infrastructure can be used or adapted, and the potential end use application, in addition to the need to satisfy any regulatory and statutory criteria which may be put in place.

Stakeholder views are sought on:

- What methods of transporting hydrogen are best suited to meet the needs of hydrogen end-use in each sector?
- Whether hydrogen blends injected into the gas network is considered to be a good use of green hydrogen?
- Would hydrogen blends in the gas network be a viable way to underpin investment and ensure lack of demand risk is mitigated in the event that hydrogen demand fails to adequately materialise in end-use sectors?

- Should there be a long-term plan for a transition of the natural gas network to 100% green hydrogen? How much of the network should be repurposed (should it be the transmission pipelines only or include some of the distribution network? Should the existing gas grid will be broken up into smaller segregated sections to carry 100% hydrogen in some areas? How would this meet needs of end-use sectors? What should be the timeline for this?
- What role could hydrogen storage play in Ireland's energy system?
- What level of hydrogen storage should Ireland have? Where would it be best to locate hydrogen storage?
- What is the potential acceptance of or resistance to hydrogen storage facilities in communities? What public engagement might be required?
- What regulatory and statutory framework should be put in place to allow for geoscientific investigation of the potential for geological storage of hydrogen in the future?
- What specific aspects would be needed for any research and development to test the feasibility of storing hydrogen underground, particularly in respect of depleted gas fields?
- Are there any predefined geographical areas of interest in relation to potential hydrogen storage?
- What types of technologies, including any existing infrastructure, could be put in place to facilitate hydrogen storage?
- What would be the major challenges and opportunities presented by the possibility of storing hydrogen underground for the long term, particularly so to be able to effectively balance consumer demand and supply during peak periods and to address seasonal demand?
- What new environmental considerations should be considered in relation to hydrogen storage?

10 Export Opportunity

Given Ireland's substantial offshore wind resource, there is the potential for Ireland to export as a net producer of green hydrogen. As the National Agency tasked with the development and growth of Irish enterprises in world markets, Enterprise Ireland already has a good overview of the potential export opportunities arising from the green hydrogen market, including the export of green hydrogen itself and industrial products produced using green hydrogen as an input such as ammonia, methanol, green plastics, and sustainable aviation fuels (SAFs). It is important that green hydrogen produced in Ireland is used for the decarbonisation of the Irish energy system and other sectors of the Irish economy. Parallel development of both the indigenous and export markets could lead to lower costs and bigger decarbonising impact than "indigenous first, export later" approaches. Export to a readily available European market could stimulate the scale of production and storage required for cost-effectiveness, while co-investment with an export market might be useful to unlock the economies of scale required where domestic demand will initially be limited.

The drafting of an enterprise policy White Paper later this year will consider what domestic opportunities and value-adding activities industrial policy might promote in Ireland and in proximity to this potentially significant and decarbonised energy resource.

Stakeholder views are sought on:

- What is Ireland's potential opportunity to export green hydrogen? What are the impacts of this on consumers and the economy?
- How does export of green hydrogen compare with the direct export of renewable electricity through electricity HVDC interconnection?
- What methods and volumes of exportation are likely to be viable by 2030 and in the period to 2035?
- How should Ireland support the development of green hydrogen exports?

11 Safety and Regulation

At present, the regulation of natural gas networks from a safety perspective is carried out under The Gas safety Framework which is developed from The Electricity Regulation Act 1999 (as amended). Blends of hydrogen can be safety regulated in these networks currently

without the need for legislative change. This remit excludes points of 100% hydrogen generation pre-injection into the national grid.

Legislative change would be required to support the development of a hydrogen safety framework to ensure that the public safety risks associated with the generation, pipeline transportation and utilization of hydrogen are managed to a level that is as low as reasonably practicable. Currently this is not in place and will take time and a suitable evidential base to implement. Hydrogen standards will be key in this evidential base.

Hydrogen, if used to displace natural gas, will be a fully decarbonized fuel which, due its different characteristics as compared to natural gas, will pose new risks and should be treated as such. This new risk profile due to using hydrogen as a fuel would mandate a new safety framework which is bespoken to its unique risks.

A safety regulatory system for hydrogen fuel risks would allow for regulatory framework development, ensuring end-to-end and consistent application of safety parameters for the emerging hydrogen sector and providing stakeholder clarity around public safety expectations. This would ensure practical and efficient regulation rather than the challenge of implementation of safety regulation around matured projects/processes. The Department of Transport has recently gone to tender on a co-funded study with the Department of the Taoiseach under the Shared Island Fund. It will be looking at international best practice on safety regulation for hydrogen refuelling infrastructure and how it may be best deployed to inform the infrastructure rollout required by the Alternative Fuels Infrastructure Regulation.

A key aspect of the EU hydrogen and decarbonised gas market package is to establish a market for hydrogen, create the right environment for investment, and enable the development of dedicated infrastructure, including that for trade with third countries. The proposals cover access to hydrogen infrastructure, separation of hydrogen production and transport activities (unbundling), and tariff setting. The view at EU level is that there is a need for a flexible regulatory framework for hydrogen during the market ramp-up phase to accommodate different hydrogen pathways, whilst ensuring clarity about the long-term framework to create investor certainty. A particular key matter would be the adoption of “dynamic regulation” (where the level of regulation is tailored to the development of the market). The Agency for the Co-operation of Energy Regulators (ACER) and the Council of European Energy Regulators (CEER) have produced a white paper on hydrogen, which explores this and other matters in some detail. It is available at: https://www.ceer.eu/white-paper-hydrogen

Stakeholder views are sought on:

- What is the appropriate safety framework for the future hydrogen economy?
- What state body should be nominated as the hydrogen safety regulator, charged with responsibility for the development, implementation and oversight of the hydrogen safety framework for the various elements of the future hydrogen economy?
- What international standards will be necessary for products and processes used in the hydrogen industry, particularly in regard to safety? What standards should be adopted in Ireland and why?

12 Pathways for a Hydrogen Strategy and Key Questions to be Responded To

A green hydrogen strategy for Ireland will need to set out a holistic overview of hydrogen supply and demand in the period to 2030 and beyond, and also set out the pathways to how we envision green hydrogen will be produced and how it will be deployed in our energy mix. In terms of supply, we need to set out how we will ensure sustainability, consider production costs and what means of transport could be used during this period. In terms of demand, we will need to fully identify and expand on the high value applications of green hydrogen, including the potential costs of incentivising uptake and timeframes for deployment. Wider considerations include the costs of different technology options, sources of funding and risks (e.g. risk of stranded assets, timelines, technology readiness, cumulative emissions or failing to stimulate interest from developers).

The potential cost and how this could be funded/supported is a crucial consideration for the hydrogen strategy. These pathways will need to be set out in phases to ensure clarity of policy progression as we move from the research and development stage to the latter stages of implementation of policy tools and supports. Opportunities for Irish companies to lead in the hydrogen economy will also be explored. Stakeholder views are sought on the broad landscape of potential hydrogen supply, transport, storage and demand in Ireland.

The key questions to which we are seeking responses, with evidence demonstrated, are set out below.

Key Questions to be Responded to

Hydrogen Research

- Which areas of hydrogen research require further examination?
- What can an Irish hydrogen strategy could do to drive innovation?
- What are the research priorities for the development of each hydrogen end-use (demand) in Ireland?

Hydrogen Demand

- What end-uses are there for hydrogen in Ireland (i.e. where hydrogen will be used)?
- How much hydrogen would be anticipated for use in each (in low, medium and high demand scenarios)? At what rate might that increase? What current evidence supports these projections?
- What specific end-uses should be high, medium and low priority for green hydrogen use?
- How might the combined deployment of green hydrogen across multiple sectors synergies facilitate the development of hydrogen in Ireland?
- How does hydrogen compare to competing technologies (direct electrification and other decarbonisation options) for each of these end-uses?
- What are the competing fossil fuels that are sought to be displaced?
- How can Ireland avoid hydrogen use that increase the overall level of energy used in the economy versus other decarbonisation pathways?

Hydrogen Supply

- What is the renewable electricity potential that does not have a route to market from conventional grid connections? Could this be used for green hydrogen production?
- What are the most cost-effective ways of utilising potentially curtailed renewable electricity output for hydrogen production?
- What should government do to de-risk efficient investment in green hydrogen production to supply Ireland's demand?
- What is the expected minimum capacity factor of grid connected hydrogen electrolysers that would be financially viable?
- What policy mechanisms could be used to avoid green hydrogen production competing with direct electrification?
- Where would it be best to locate hydrogen production? Should there be specific government policy to locate hydrogen production facilities where too much energy being generated for the electricity grid to manage (i.e. grid constraints)? What spatial planning considerations should be factored into this? What role might ports play in the production and transportation of hydrogen?
- What minimum sustainability criteria should apply to hydrogen produced in Ireland?
- What policy mechanisms could be used to ensure that competition between green hydrogen production and other direct uses of renewable electricity is managed such that there are no negative impacts on emissions reductions or consumer costs?
- What contribution could domestic green hydrogen supply make towards Ireland's energy security?
- What strengths does Ireland have in hydrogen supply chains?
- What potential uses are there for the oxygen by-product of hydrogen production?

Hydrogen transportation and storage

- What methods of transporting hydrogen are best suited to meet the needs of hydrogen end-use in each sector?
- Whether hydrogen blends injected into the gas network is considered to be a good use of green hydrogen?
- Would hydrogen blends in the gas network be a viable way to underpin investment and ensure lack of demand risk is mitigated in the event that hydrogen demand fails to adequately materialise in end-use sectors?
- Should there be a long-term plan for a transition of the natural gas network to 100% green hydrogen? How much of the network should be repurposed? Should it be the transmission pipelines only or include some of the distribution network? Should the existing gas grid be broken up into smaller segregated sections to carry 100% hydrogen in some areas? How would this meet needs of end-use sectors? What should be the timeline for this?
- What role could hydrogen storage play in Ireland's energy system?
- What level of hydrogen storage should Ireland have? Where would it be best to locate hydrogen storage?
- What is the potential acceptance of or resistance to hydrogen storage facilities in communities? What public engagement might be required?
- What regulatory and statutory framework should be put in place to allow for geoscientific investigation of the potential for geological storage of hydrogen in the future?
- What specific aspects would be needed for any research and development to test the feasibility of storing hydrogen underground, particularly in respect of depleted gas fields?
- Are there any predefined geographical areas of interest in relation to potential hydrogen storage?
- What types of technologies, including any existing infrastructure, could be put in place to facilitate hydrogen storage?
- What would be the major challenges and opportunities presented by the possibility of storing hydrogen underground for the long term, particularly so as to be able to effectively balance consumer demand and supply during peak periods and to address seasonal demand?
- What new environmental considerations should be considered in relation to hydrogen storage?

Export opportunity

- What is Ireland's potential opportunity to export green hydrogen? What are the impacts of this on consumers and the economy?
- How does export of green hydrogen compare with the direct export of renewable electricity through electricity HVDC interconnection?
- What methods and volumes of exportation are likely to be viable by 2030 and in the period to 2035?
- How should Ireland support the development of green hydrogen exports?

Safety and regulation

- What is the appropriate safety framework for the future hydrogen economy?
- What state body should be nominated as the hydrogen safety regulator, charged with responsibility for the development, implementation and oversight of the hydrogen safety framework for the various elements of the future hydrogen economy?
- What international standards will be necessary for products and processes used in the hydrogen industry, particularly in regard to safety? What standards should be adopted in Ireland and why?

Supports and targets

- What scale of ambition is right for Ireland regarding hydrogen production targets? What timelines should set for these targets?
- How should the deployment of hydrogen in Ireland be funded/supported?
- What are the potential policy options for incentivising for hydrogen end-uses?
- How should green hydrogen be incentivised in the electricity market?
- What policies should be put in place to develop further hydrogen based enterprises?
- How could supports and targets account for cross sectoral deployment of hydrogen?

Energy security

- What contribution could domestic green hydrogen supply make towards Ireland's energy security?
- What role could hydrogen storage play regarding security of supply?

Figure 5: Key questions to be responded to

13 Submissions

The closing date for submissions is **5.30pm on Friday 2nd September 2022**.

In cases where responses exceed five pages, respondents are requested to include a concise executive summary.

Submissions should include **"Hydrogen Strategy Consultation**" in the subject field and be sent by email to hydrogenconsultation@decc.gov.ie or by post to:

Wholesale Electricity and Gas Policy Division
Department of the Environment, Climate and Communications
29-31 Adelaide Road
Dublin D02 X285