Sectoral Analysis Of Future Hydrogen Demand & End Use In Ireland

JAN 2026

Report Prepared by **HyEnergy® Consultancy**

for the **Department of Enterprise, Tourism and Employment**

Foreword

The exact nature of hydrogen's role in a future net-zero or zero emissions economy, particularly in Ireland, is not yet widely understood. To advance understanding, the Department of Enterprise, Tourism and Employment, commissioned a broad sectoral analysis across the primary areas of economic activity where there is likely to be a future demand for green hydrogen, with a focus on the industries that are likely to be powered by green hydrogen in the future.

The study has undertaken an extensive sector stakeholder consultation exercise to derive an understanding of current plans, future goals and expectations for hydrogen within Ireland based on existing policies and progress to achieving publicly stated renewables targets. Such targets, especially those for offshore wind, are particularly relevant given hydrogen's reliance on the availability and cost of renewable energy. The stakeholder consultation exercise has also been supported by a high-level literature review and desktop analysis. Due to the macro nature and limited scope of this study, potential areas for future investigation not covered in this work have also been identified.

As part of the stakeholder engagement, experts from over 35 different companies, organisations, government departments and universities were interviewed. The output from such meetings, including expert opinions, research data and analysis results were compiled and analysed. To enable this work to best reflect the latest thinking, many organisations have openly shared state-of-the-art and commercially confidential data. As such, much of the data is as yet unpublished (academic work in preparation or under review) or commercially sensitive, and is not publicly available. Therefore, there is a limit to the level of detail that can be shared within this report and its appendices.

The pathways and estimates developed are based on this wide array of data compiled and is informed by the opinions shared by relevant experts, as well as existing internal HyEnergy expertise and analysis. As such the work outlines three potential pragmatic pathways or scenarios for future hydrogen demand growth whilst accounting for the considerable uncertainty that surrounds hydrogen in Ireland and the energy transition more broadly.

Executive Summary

It is now widely understood that hydrogen has a strategically important role to play in the energy transition. While electrification and energy efficiency will deliver the majority of emissions reductions, certain sectors face operational and infrastructural constraints that limit their abatement potential, necessitating complementary solutions such as hydrogen, sustainable biofuels, and other emerging technologies.

The exact nature of hydrogen's role in a net-zero or zero emissions economy, particularly in Ireland, is not yet widely understood. With some of Europe's most abundant wind resources, particularly offshore, Ireland is uniquely positioned to capitalise on the opportunity for hydrogen to drive sustainable economic growth, improve energy security for citizens, and achieve legally binding climate targets. This work identifies key hydrogen demand sectors, and estimates the scale and timelines for development of the industry in Ireland. This is achieved through extensive market engagement with key stakeholders from government, industry, and academia, as well as a comprehensive literature review and desktop analysis, building on existing policy including the *National Hydrogen Strategy* and *Powering Prosperity – Ireland's Offshore Wind Industrial Strategy*.

The work first assesses the role for hydrogen in a zero emissions economy, before setting out three pathways for the development of hydrogen demand in Ireland: Insufficient Progress, Delayed Growth, and Committed Action.

Despite hydrogen's smaller role relative to electrification in achieving a zero emissions economy, the energy security and economic growth that can be enabled by hydrogen in the long-term requires timely and focused action. Hydrogen offers unique long-duration energy storage opportunities to support a secure, zero emissions power system, and is a key feedstock for the production of clean fuels for transport. There is also a smaller but important role for direct hydrogen usage in heavy-duty mobility and high-temperature industry.

Based on the pathway analysis, in absence of committed early action to scale renewable energy and infrastructure and anchor hydrogen demand, Ireland risks higher long-term emissions and import dependencies, losing competitiveness in sectors expected to drive future global economic growth. By contrast, a proactive approach ensures the hydrogen sector is primed and ready to scale, growing to 11–34 terawatt-hours (TWh) of demand by 2050, with hydrogen used to supply up to 18% of electricity demand, and used to produce over 630 kt clean fuels for aviation. Early projects in mobility, cement, e-fuels, and off-grid power are important to demonstrate that hydrogen can already provide value in strategic applications, helping to build the skills, public awareness, and infrastructure required for later scale-up.

In practice, Ireland needs to move quickly to deliver renewable energy capacity, especially from offshore wind, as this is the foundation of any domestic hydrogen supply. As such, polices which aid in the timely delivery of renewables at scale, reducing the cost of electricity, will have a positive effect on the hydrogen industry. Demand-side incentives, however, are also critical to encourage uptake where suitable, such as industrial decarbonisation or heavy-duty mobility, as hydrogen is unlikely to be cost-competitive in the short term without targeted policy support.

Therefore, facilitating the delivery of a coordinated hydrogen value chain is crucial. A focus on clusters, valleys, and energy parks where low-cost renewable energy and hydrogen supply are co-located alongside hydrogen storage and demand can reduce costs and catalyse demand in key regions. Such locations can also act as critical hubs from which to expand hydrogen and other clean solutions.

Once scaled, hydrogen can also play a crucial role enhancing Ireland's energy security, increasing Irish energy sovereignty by reducing the need for imported biofuels or natural gas. This can help protect Irish consumers from high electricity prices caused by spikes in global energy markets.

To realise the long-term economic and security benefits of hydrogen, it is necessary for Ireland to leverage existing resources. This includes its existing industry, expertise, and research and innovation base, to identify and maximise its value-addition for clean energy, from data and clean fuels to microbial food products.

Crucial to this is flexible policy support that encourages the development of first-mover projects as they build skills, create early offtake and facilitate long-term industry development. The opportunity for Ireland is significant, with the potential to develop world leading industries based on its abundance of clean energy. From provision of power to large energy users, to the production of high-value products such clean fuels, hydrogen can serve as a catalyst for emissions reductions, improved energy security, and sustainable economic growth. However, the scale of Ireland's domestic hydrogen sector could be limited without timely intervention across several key areas. These include acceleration of the deployment of low-cost renewables at scale, a co-ordinated development approach across the hydrogen value chain that reduces first mover risk and incentivises demand, and a clear long-term strategic direction for hydrogen within key sectors.

H_2 in Ireland Today

PRIMARILY
Refining
FOSSIL FUELS

SMALL H2 USE
Electronics
SEMI CONDUCTOR MANUFACTURING

Next Phase Projects

H_2 in a Zero Emissions Ireland

5 - 15 GW
ELECTROLYSER PRODUCTION CAPACITY

0.5 - 1.4 Mt
15 - 46 TWH
H2 DEMAND PER YEAR

Key Sectors

Off-Grid
On-Grid

Industry
Mobility
Fuels
Power

Cement
Metals

HGVs
Buses

Bio Fuels
E-Fuels

Future H_2 Demand Pathways

Insufficient

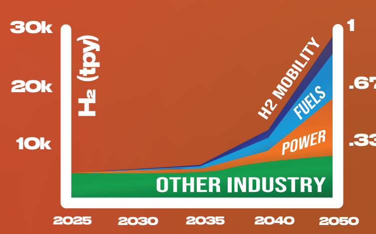
Energy Transition Slows

Delays Offshore Wind

H_2 Industry Fails To Take Off

Emissions Reduction
30 - 40%

0.5 - 2 TWh H_2



Delayed

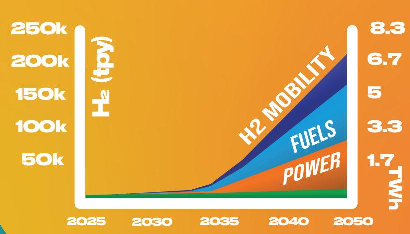
Clear Vision, Slow Progress

H_2 Scales Late 2030s

Missed Economic Opportunity

Emissions Reduction
50 - 70%

3 - 10 TWh H_2



Committed

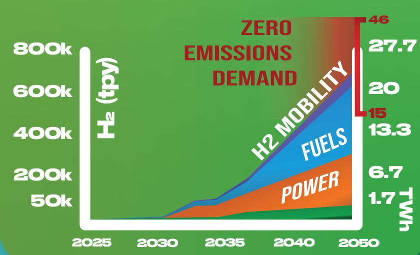
Step-Change

Off-Shore Wind At Scale

Zero Emissions Power & Clean Fuels Industry

Emissions Reduction
80 - 95%

12 - 34 TWh H_2



Policy Focus Areas

1. Deliver low-cost renewables at scale, including offshore wind
2. Develop coordinated hydrogen value chains including storage and demand
3. Provide a long-term vision for Ireland's key value-add hydrogen-based products

Contents

1 - Introduction

Project and Deliverable Overview

This report is the final deliverable of a body of work undertaken by HyEnergy® Consultancy for the Department of Enterprise, Tourism, and Employment (DETE) which aims to quantify potential future hydrogen demand across the Irish economy. The work has identified key sectors likely to require hydrogen to achieve zero emissions, with a particular focus on the industrial sector.

Engaging key stakeholders from across industry, government, and academia, the work builds on existing research and policy, such as the *National Hydrogen Strategy* and *Powering Prosperity – Ireland's Offshore Wind Industrial Strategy,* to deliver a pragmatic analysis on the scaling of national hydrogen demand. As such, this study aligns with the Hydrogen Strategy Implementation Plan under actions 8 and MC5.

Close cooperation with and guidance from multiple government departments and key organisations from the energy and industrial sectors via the project's steering committee has been essential in ensuring delivery within the workplan's tight timeline. This report outlines the key project results and findings from an extensive market engagement exercise and comprehensive high-level sectoral demand analysis.

Emissions Reduction and Hydrogen

With the effects of climate change, its growing impact on energy and wealth inequality, and the increasing regularity and impact of extreme weather events, the need for meaningful and committed action has never been more urgent. Although global greenhouse gas emissions continue to rise, the transformation of our energy system has begun. For instance, during the first half of 2025, renewables overtook coal as the world's leading source of electricity for the first time across a six-month period[1], whilst in Europe, solar became the dominant source of EU electricity for the first time in June 2025[2]. This is the result of a concerted effort by governments around the world, from the signing of the Paris Agreement in 2015 to the widespread setting of targets for renewables deployment and emissions reduction for the coming years and decades. Having initially relied on generous government subsidies and preferential policies for support, the cost of solar and onshore wind has plummeted in the last 10 years. The cost of solar power has fallen by 82%, and onshore wind by 37% from 2010 to 2019[3] with solar now recognised as the cheapest form of electricity in history by the IEA[4].

---

[1] Ember. Global Electricity Mid-Year Insights 2025. 2025.
[2] Eurostat. Solar: main source of EU electricity in June with 22%. 2025.
[3] Our World in Data. Why did renewables become so cheap so fast? 2020 (updated in 2025).
[4] IEA. World Energy Outlook 2020. 2020.

However, progress must accelerate to achieve the levels of climate change mitigation envisaged by established climate targets. The EU aims to be climate neutral by 2050 whilst Ireland is currently on track to exceed its legally binding carbon budgets to 2030, which mandate emissions reduction of 7% per year[5]. The government's Climate Action Plan sets out how this is to be achieved with targets of 9 GW of onshore wind, 5 GW of offshore wind, and 8 GW of solar to be deployed by 2030[6]. Failure to achieve these targets could result in significant economic implications for Ireland. A joint report by the Climate Change Advisory Council and the Irish Fiscal Advisory Council, stated Ireland could face between €3-26bn of incurred costs[7]. This will depend on how much Ireland misses its 2030 51% emissions reduction target by and the cost of carbon credits from programmes such as the EU Emissions Trading Scheme (ETS). This is in addition to the escalating costs of climate inaction including the impact of increasingly severe weather on infrastructure, homes, nature, and agriculture.

Deep decarbonisation of the Irish economy will require the penetration of renewable energy wider than the power sector. Currently, electricity only accounts for 22.4% of Ireland's final energy demand, with the majority of the remainder met by liquid and gaseous fossil fuels for transport (43.2%) and heat (34.4%). A step-change in deployment of sustainable technologies is needed to seize the opportunity presented by the falling costs of renewables and batteries, alongside other clean technologies that can accelerate the penetration of renewables into hard-to-abate sectors (e.g. heat pumps, district heating). Although progress so far has been slower than required to achieve targets, much of the pathway to zero emissions is clear: build renewables at scale, implement energy efficiency measures, and electrify heat and transport as much as possible.

Achieving zero emissions however, will require a multi-technology approach. For certain sectors, there is a limit to the emissions reductions that can be achieved by electrification and energy efficiency measures due to operational requirements or infrastructural limitations. As such, alternative decarbonisation options, such as hydrogen, biofuels, and carbon capture and storage (CCS), alongside other novel technologies, will be required to tackle unique obstacles presented by such sectors. These solutions each present different challenges including cost, technological maturity, and resource availability. For example, biofuels can be an effective solution with high similarity to existing fossil fuels, but there are practical limitations given global scarcity of sustainable feedstocks. This, therefore, limits the potential production capacity for biofuels, highlighting the transitionary nature of biofuel

[5] Climate Action And Low Carbon Development (Amendment) Bill. 2021
[6] Government of Ireland. Climate Action Plan. 2025
[7] Irish Fiscal Advisory Council and Climate Change Advisory Council. A colossal missed opportunity: Ireland's climate action and the potential costs of missing targets. 2025

use in sectors where alternative solutions exist. Similarly, whilst CCS seems an attractive solution for point source emissions at industrial sites and power plants, experts warn that the technology remains unproven at scale and requires large amounts of energy, suggesting it is best reserved for residual emissions with no alternative solution, such as cement and incineration plants.

When produced via sustainable pathways, hydrogen has been widely acknowledged as a potential alternative to fossil fuels. Existing hydrogen production today, which is primarily utilised as a chemical feedstock or as a desulphurisation agent in refineries, is predominantly made from fossil fuels contributing 2% to global carbon dioxide emissions. However, hydrogen has significant potential to offer unique benefits to the energy system, including:

- Production – Electrolysers, which produce hydrogen by splitting water with renewable electricity, can increase overall system resilience and accelerate deployment of renewables. This occurs by minimising curtailment and providing alternative routes to market for renewables.
- Storage – Hydrogen can enable storage of renewable energy at large scale for long-periods. Unlike batteries which typically offer energy storage on an hourly basis, hydrogen can provide long-duration energy storage (LDES) on a seasonal basis.
- End-use – Hydrogen can enable the penetration of renewables into hard-to-electrify sectors, such as heavy-duty transport and high-temperature industrial heat.

Internationally, governments now recognise these benefits and have accordingly positioned hydrogen as a key component of their future energy systems, as reflected in the adoption of ambitious policy targets. Within REPowerEU[8], for instance, following on from the European Green Deal[9], which includes the EU's Hydrogen Strategy, targets were set to realise 10 million tonnes of domestic clean hydrogen production by 2030 alongside an equivalent quantity of imports. Mandatory targets for hydrogen usage in transport and industry have also been set. Renewable hydrogen and hydrogen-derived fuels, referred to collectively as renewable fuels of non-biological origin (RFNBOs), must supply 1.2% of European Union aviation fuel (ReFuelEU Aviation), 42% of existing industrial hydrogen consumption, and 1% of road & rail transport energy demand (RED III) respectively by 2030. It should be noted that progress to achieve these overarching European targets has been slower than expected, with ACER reporting that the EU has only achieved 308 MW of installed capacity, and 1.8GW under construction by the end of 2024[10] (40GW expected by 2030 as part of RePowerEU).

[8] European Union, REPowerEU. 2022
[9] European Commission, The European Green Deal. 2019
[10] ACER. European hydrogen markets 2025 market monitoring report. 2025.

Nevertheless, hydrogen remains a key aspect of Europe's future competitiveness strategy, as highlighted in the Draghi report[11], prompting the European Court of Auditors to call for a strategy revision at the end of 2025 to address current market challenges.

This recognition has now been seen within the Irish context with the release of the Irish National Hydrogen Strategy in 2023. The document confirms the nation's ambition to develop a domestic sector highlighting the strategic benefits hydrogen can provide. The strategy sets out several key actions to instigate sector development, such as a target for 2GW of offshore energies for hydrogen production and non-grid uses to be in development by 2030 and a suite of measures aimed at supporting end-user offtake. Alongside this strategy, the Irish government has recently released the National Hydrogen Programme (NHP) Development Plan, to further accelerate development of the domestic sector and implement the actions of the national strategy. This plan will be executed by the NHP Taskforce – a cross-departmental group also featuring direct collaboration with industry and relevant regulation, codes, and standards bodies.

One key action the Development Plan will address is the initialisation of a Hydrogen Demonstrator Fund, expected to be in place by 2027, to incentivise first movers across the value chain. However, it should be noted that progress to achieve supply targets both in Ireland and many other European locations are progressing slower than expected. This is due to the slow pace of renewable energy deployment, technical scaling difficulties across materials, engineering, manufacturing and integration, as well as persistent high costs of both equipment and electricity, the primary input to electrolysis[12].

The National Hydrogen Strategy, and its intended measures are seen as crucial by domestic stakeholders to setting direction whilst helping the sector to overcome initial barriers. This is particularly relevant within the mobility sector, where Ireland must sufficiently accelerate demand development to meet the requirements of Europe's Alternative Fuels Infrastructure Regulation[13] (AFIR) which requires that five hydrogen refuelling stations along the TEN-T road network are operational by 2030.

Whilst the government has clearly signalled an intent to develop a domestic hydrogen sector, much uncertainty remains regarding how this sector, particularly hydrogen demand, will develop over the coming decades. The country currently exhibits a low industrial base, featuring minimal use of hydrogen today, but has a large potential for hydrogen production

[11] Draghi, M. The Future of European Competitiveness. 2024.
[12] Power accounts for ~70% of the final cost of green hydrogen.
[13] AFIR requires the development of publicly accessible HRSs in urban nodes and every 200km along the TEN-T core network by 2030 (min. 1t/d capacity and 350 & 700 bar refuelling capabilities for TEN-T stations).

from its considerable offshore renewable resource. As such, this work sets out to answer the following questions:

- Which sectors of the Irish economy are likely to require hydrogen to achieve decarbonisation ambitions?
- When is demand for hydrogen in these sectors likely to materialise?

More specifically the objectives of this study are to

1. Assess the role of hydrogen in achieving Ireland's climate targets
2. Set out a number of potential pathways for the hydrogen industry in Ireland from today to mid-century
3. Estimate potential demand for hydrogen across these pathways by compiling data from existing analysis and literature, and extensive market engagement

In addition, insights into key actions required to enable the scale up of the industry and maximise Ireland's opportunity to use hydrogen as an enabler for economic growth are also discussed.

2 - Snapshot: Hydrogen in a Zero Emissions Ireland

While it is not known when we will achieve zero emissions or climate-neutrality, it is known that this must be achieved as quickly and as equitably as possible to minimise the impacts of catastrophic climate damage and to position Ireland for future economic development in several sectors. As part of the Climate Action and Low Carbon Development (Amendment) Act 2021, Ireland has a legally binding target to achieve a climate-neutral economy by 2050. Given the depth of research, including detailed modelling of the energy system, that has been carried out on climate-neutral and 'net-zero' scenarios, this end-goal is, in many ways, clearer than the path to achieving it. Therefore, before exploring the many potential pathways that Ireland and the global community may pursue in the coming decades regarding energy and hydrogen, it is helpful to first define the desired end-state and clarify hydrogen's anticipated role based on current knowledge and expertise. Given the ever-changing and increasingly uncertain geopolitical landscape we find ourselves in, making predictions or estimates of the future of any kind is challenging and imperfect. This is also the case for estimating future hydrogen demand in Ireland or progress on climate and the energy transition more broadly.

Based on a wide variety of sources, including the National Hydrogen Strategy[14], and EirGrid's Tomorrow's Energy Scenarios[15], SEAI's National Heat Study[16], research from University College Cork[17], University of Galway, Trinity College Dublin, Dublin City University and multiple industry sources, in addition to internal expertise, a range of estimates for hydrogen demand in different sectors of a zero emissions Irish economy is presented in Table 1.

Table 1: Estimated demand for hydrogen by sector in a zero emissions Ireland.

Sector	Low (TWh)	High (TWh)
Power Generation	4	12
Clean Fuels	9	23
Other Industry	1	6
Road and Rail Mobility	1	5
Total	15	46

[14] Government of Ireland, National Hydrogen Strategy. 2023
[15] EirGrid and SONI, Tomorrow's Energy Scenarios. 2023
[16] Sustainable Energy Authority of Ireland, National Heat Study. 2022
[17] Mehigan and Deane, Our Zero e-Mission Future. 2020

Many of the analyses used as the basis for the estimates assume net zero emissions is achieved in 2050. Although this work does not assume or predict zero emissions or 'net zero' emissions is achieved in a specific year, the underlying assumption for this zero emissions snapshot is that it occurs sometime around mid-century. For more detailed information on assumptions and methodology see Appendix A.

Power Generation

As mentioned previously, there is a clear need for reliable long-term and large-scale clean energy storage, which hydrogen and hydrogen-derived fuel can provide. A key sector for hydrogen demand is power generation, with between 5 and 18% of electricity supplied by hydrogen-powered generators in a zero emissions Irish power system. Specifically, hydrogen is produced in times of electricity oversupply, when renewable energy generation exceeds electricity demand, and can be stored in tanks, pipes, and underground formations (salt caverns, depleted gas fields, and lined rock caverns), or in liquid form as e-fuels. Hydrogen or e-fuels can then be used to produce power using gas turbines, engines, or fuel cells when wind and solar is not sufficient to meet electricity demand, balancing electricity supply. Key uncertainties that will influence the level of hydrogen demand include overall growth in electricity demand, the level of interconnection between Ireland and neighbouring electrical grids, and potential development of new innovative technologies which could displace some of hydrogen's role.

Clean Fuels

If Ireland is to strive for increased energy security and independence alongside zero emissions, the use of hydrogen to produce clean fuels, primarily for aviation and maritime applications, is critical. Hydrogen is used to upgrade bio-feedstocks to produce biofuels such as hydrogenated vegetable oil (HVO) and sustainable aviation fuel (SAF) as well as being combined with biogenic carbon dioxide to produce synthetic fuels or e-fuels such as e-SAF. In the assumed zero emissions snapshot, Ireland produces enough e-fuels from hydrogen to comply with 2050 EU mandates[18] and some of its own SAF, although much of the bio-feedstocks required are imported due their limited availability domestically.

Whilst maritime fuels are also produced in Ireland, these are in relatively smaller quantities compared to aviation as many vessels bunker (refuel) elsewhere. In addition, aviation is likely to serve as the initial market for fuel producers due to EU mandates for SAF, summarised in Table 2, and the strong presence of the aviation industry in Ireland. The use of hydrogen in maritime, however, may be important in the future for Ireland to achieve its global IMO and EU emissions targets. The scale of this role will likely be shaped by port-

[18] European Union. Regulation (EU) 2023/2405 of the European Parliament and of the Council of 18 October 2023 on ensuring a level playing field for sustainable air transport (ReFuelEU Aviation). 2023

based hydrogen deployment, with ports expected to serve as critical onshoring hubs for offshore renewable energy. Greater investigation is required to more precisely quantify the role of hydrogen and hydrogen-based derivatives across maritime areas, for instance vessel bunkering and supporting onshore power requirements.

Table 2: Overview of emissions reduction measures included within ReFuelEU Aviation and FuelEU Maritime.

Legislation	Metric	2025	2030	2032	2035	2040	2045	2050
ReFuelEU Aviation[19]	*Share of SAF in EU Airports*	2%	6%	6%	20%	34%	42%	70%
	Share of e-SAF in EU Airports	-	0.7%	1.2%	5%	10%	15%	35%
FuelEU Maritime	*Annual average carbon intensity reduction*[20]	2%	6%	-	14.5%	31%	62%	80%

A Note on ReFuelEU Aviation Mandates

ReFuelEU Aviation sets strong strategic ambitions for the decarbonisation of the EU's aviation sector. This includes aligning with the sector's internationally recognised global goal of achieving net-zero carbon emissions by 2050, as well as accelerating SAF production and uptake. It is also worth noting that there is no guarantee that e-SAF produced in Ireland would have to be used domestically within currently policy and legislative frameworks. ReFuelEU Aviation requires supply to be present at member state airports but does not stipulate production by location.

Theoretically, Ireland has the potential to produce excess clean fuels from offshore wind for export, as has been explored within projects such as HYreland, a collaboration between Fraunhofer ISE and ESB, but this is outside of the scope of the zero-emissions snapshot.

Alternatively, depending on the pace at which the domestic clean fuels sector develops, Ireland could continue to import some or all of its requirements from other countries, as it

[19] ReFuelEU aviation features a ten-year transitionary period until the end of 2034 where fuel suppliers can average SAF blending obligations across all Union airports.
[20] In comparison to 2020 average. Obliges vessels >5000 gross tonnes calling at European ports.

does today. This position is reflected in the Sustainable Aviation Fuel Policy Roadmap[21] which states a need to develop SAF import routes to satisfy interim targets, whilst simultaneously investigating domestic production opportunities to increase security of supply. However, domestic fuel production, and therefore its associated hydrogen demand, is highly dependent on feedstock supplies and technology development. Consequently, these will be influenced by several factors including the cost and geographic availability of renewable power and biomass or biogenic carbon dioxide required to produce these fuels.

Other Industry

Unlike countries such as Germany and the Netherlands, Ireland does not have an existing heavy industrial sector on which to base its hydrogen development. Much of Ireland's industrial sector is comprised of industries such as pharmaceuticals and medtech, where energy efficiency and electrification delivers most, if not all of the required emissions reductions in the zero emissions snapshot. However, there are some companies in Ireland that already use hydrogen for semiconductor manufacturing and others will require hydrogen, biofuels, and CCS to eliminate emissions from their manufacturing processes. Hydrogen is only used for applications where electrification is not possible or too challenging. For example, some cement plants in Ireland will require hydrogen for co-firing with solid recovered fuel (SRF) and biomass to maintain high temperatures in the cement kiln. This is due to the lower flame temperature of SRF in comparison to traditional fossil fuels such as coking coal. Other companies require temperatures of over 1000ºC for their processes, including one of Ireland's largest gas consumers. Such temperatures are necessary for part of the process of alumina production, which accounts for approximately one-third of the site's energy consumption. As a result, hydrogen demand for the industrial sector (outside of power and fuels production) is estimated to be between 1 and 6 TWh in this zero-emission snapshot. The key uncertainties here relate to the limits of electrification and sustainable biofuel production. Electrification technologies such as heat pumps, electrode boilers and thermal storage continue to push the boundaries of what can be electrified whilst the use of biofuels will likely be dictated by policy (at both national and EU level) around import and sustainability rules which will in turn influence their cost and availability.

Road and Rail Mobility

Although the vast majority of road transport is likely to be electrified with battery electric vehicles (BEVs), there is a requirement for hydrogen vehicles for some applications in the zero-emissions snapshot. From the findings of the stakeholder engagement, the majority of these vehicles are heavy duty trucks (HDTs), which due to factors such as

[21] Department of Transport. Ireland's Sustainable Aviation Fuel Policy Roadmap. (2025).

recharging/refuelling times, payload or operational requirements, are unsuitable for electrification via BEVs. Though making up a relatively small market share (between 5-15% of HDTs), this is equivalent to up to 12,000 vehicles. Other niche transport applications where there is likely a role for hydrogen vehicles include buses, coaches, off-road vehicles as well as construction and agricultural vehicles and machinery. Rail applications which cannot be easily electrified such as freight, which is set to be expanded under the All-Island Rail Strategy, also require hydrogen or similar solution to achieve zero-emissions.

This sector is perhaps one of the most contentious and often-debated in relation to the use of hydrogen, with some claiming that there will be no role for hydrogen in road or rail transport. The rationale is often that there will be a breakthrough in battery technology to a point where it outcompetes hydrogen for all applications, with biofuels playing an intermediary role in facilitating decarbonisation of the sector until that point. However, given current understanding of operational requirements and technology limitations, this is not reflected in the zero-emissions snapshot. Hydrogen is assumed to play a small but important role in road and rail transport, particularly in the heavy-duty sector. This assumption is informed by existing analysis [22] and extensive stakeholder engagement carried out as part of the study, including from vehicle operators, OEMs, and academia. Furthermore, the EU have also placed a firm direction on the role of hydrogen-based fuels within these transport modes, with member states required to meet 1% of energy demand with RFNBOs by 2030 as part of a wider 5.5% advanced biofuels target within RED III.

Non-Priority Sectors and Novel Applications

There are other sectors and applications which may also use small quantities of hydrogen in a zero emissions Ireland, but have not been included within the scope of the snapshot. In particular, the use of hydrogen in passenger vehicles and home heating is deemed inefficient and costly in comparison to other available and more mature solutions for example.

There is also the possibility of hydrogen use in novel applications that are technologically immature as of 2025. One such opportunity is the use of hydrogen as a feedstock for the production of microbial foods. The process of precision fermentation, for example, can use microorganisms to produce a biological molecule from hydrogen-derived feedstocks and has been used for decades for the manufacture of food products and insulin. Recent research has focused on the technology's potential to produce novel products such as proteins and polymers in a more sustainable and cost-effective way than conventional routes. This is of particular relevance to Ireland given its strong research, bioeconomy, and

---

[22] Aryanpur, V., Rogan, F. Decarbonising road freight transport: The role of zero-emission trucks and intangible costs. *Sci Rep* **14**, 2113 (2024). https://doi.org/10.1038/s41598-024-52682-4

agricultural expertise, which could be leveraged to build on its already world-leading food sector.

There is also the potential for hydrogen to be used as a catalyst to increase domestic industrial activities. This could attract new manufacturing processes, such as steel and chemicals. However, with an absence of such industries in 2025 it is deemed that they are unlikely to materialise by mid-century, if at all. One potential area of interest would be the production of ammonia from hydrogen to produce fertiliser, given the significance of the agricultural sector in the country. The development of these industries is only likely to occur currently if there is commercial benefit to establishing operations in Ireland, which is highly dependent on access to large-scale, low-cost renewable energy. Within the current energy landscape, with more bankable affordable renewable energies in European locations such as Spain, this is deemed unlikely. Alternatively, strategic policy support could attract particular industries to Ireland for economic purposes such as job creation or food security.

As mentioned previously, this snapshot does not aim to predict the future but estimates potential hydrogen demand in a zero emissions Ireland that occurs sometime around mid-century. This is based on existing analysis and extensive consultation with industry and academic experts, but current understanding of net zero and what it will entail is likely to change, as evidenced many times in the past. Plummeting costs of onshore renewables and batteries that have occurred over the last decade were not expected by many reputable and sector leading organisations, including the International Energy Agency (IEA). This inherent uncertainty is reflected insofar as it is possible, in the range of values outlined for the zero-emissions snapshot presented above, as well as for the three pathways described in the subsequent chapters. For reference, to meet the total demand of 15 to 46 TWh in the zero-emissions scenario snapshot described, an estimated hydrogen production capacity of between 5 and 15 GW would be required (50% electrolyser capacity factor powered by renewables). This indicates that Ireland's 2050 target for offshore renewable energy capacity of 37 GW would provide more than enough electricity for hydrogen production in a zero emissions Ireland, even when accounting for increased domestic electricity demand.

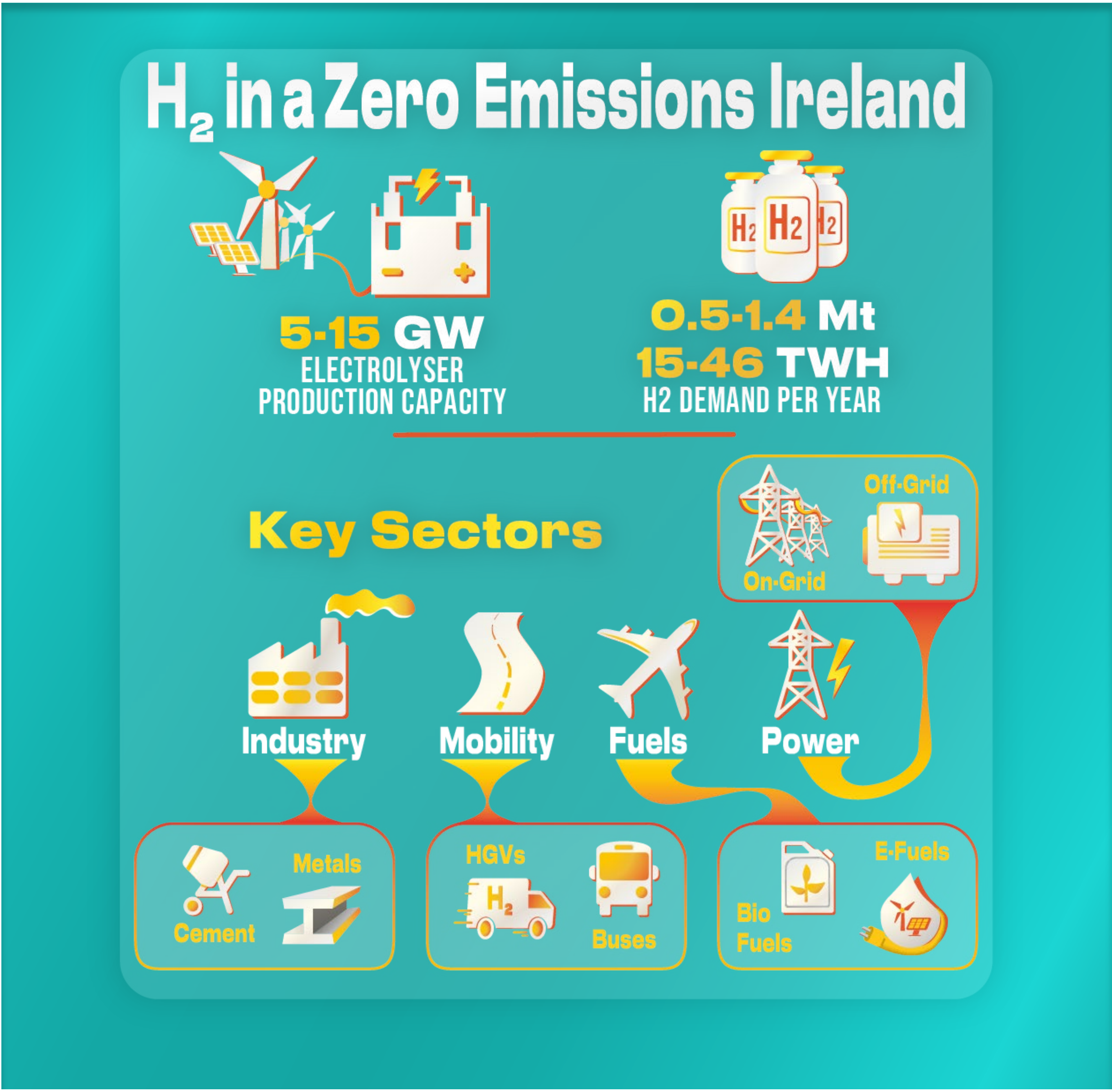


Figure 1: Hydrogen in a zero emissions Ireland.

3 - Hydrogen in Ireland Today

Despite the large requirement for hydrogen to achieve zero emissions, this is a far cry from the industry as it stands today. Current demand for hydrogen in Ireland is negligible in comparison (0.15-0.2 TWh per year), and the vast majority of this hydrogen (90-95%[23]) is produced (as a refinery byproduct) and consumed on-site at Ireland's only oil refinery at Whitegate, Co. Cork. This hydrogen is primarily used for desulphurisation in the production of diesel but is also used for hydrogenation of bio-feedstocks in the production of hydrotreated vegetable oil (HVO). Policies and associated targets such as EU's Fit-for-55 package, RED III, and Ireland's Renewable Transport Fuel Obligation (RTFO) are driving emissions reductions plans at Whitegate, with Irving Oil a key partner in the Celtic Hydrogen Cluster, and the Cork based GLEANNCELT Hydrogen Valley proposal.

Outside of oil refining, industrial use of hydrogen in Ireland is limited with smaller quantities of hydrogen being used in electronics manufacturing by companies such as Intel and Analog Devices, and for power plant cooling at natural gas power plants in multiple locations around the country. This demand is supplied by BOC gases via their 500kW grid-powered electrolyser in Dublin, and supplemented by tube trailers from the UK, as well as via liquid hydrogen imports (ex Rotterdam) from Air Products.

More recently, some green hydrogen has been used in fuel cells to supply stationary power to events and an off-grid military base trial via ESB's partnership with GeoPura. Their Hydrogen Power Units (HPUs) have supplied power to events such as the Irish Open (golf) and film productions, using green hydrogen produced by GeoPura in the UK, with plans to use green hydrogen from ESB's 1MW Lighthouse Project in Cork to meet future demand.

In mobility, Bus Éireann currently operates 3 double-decker hydrogen city buses in Dublin from their Broadstone depot. The first-generation prototypes from Wrightbus, in Ballymena, Northern Ireland, have been operational since 2021.

Key Projects in Development

There are a number of hydrogen projects in development in Ireland. The following list showcases those which will play an important role in the initialisation of Ireland's hydrogen sector out to 2030. Representatives from the key projects outlined have been interviewed as part of the market engagement process for this study.

[23] European Hydrogen Observatory. Hydrogen Demand. (2024).

SH2AMROCK Hydrogen Valley

Status – Planning granted, FID yet to be taken.

The SH2AMROCK Project is Ireland's first EU-funded hydrogen valley. Coordinated by the University of Galway, the project will connect hydrogen production from wind power at Mount Lucas wind farm in the Midlands to multiple end-uses in Galway, centred around the port. The 2MW electrolyser at Mount Lucas is a joint venture between BnM and BOC, with BOC distributing the hydrogen to the port. Colas will serve as the baseload industrial demand, using hydrogen in their industrial burners for heating bitumen, whilst BOC will also build a hydrogen refuelling station (HRS) to supply hydrogen to 10 coaches, 5 trucks and 4 vans which are planned to be deployed by Bus Éireann and HIVE Hydrogen. The project aims to be operational by end of 2027. The HRS has the potential to meet the urban node HRS requirements of the Alternative Fuels Infrastructure Regulation (AFIR) for Galway.

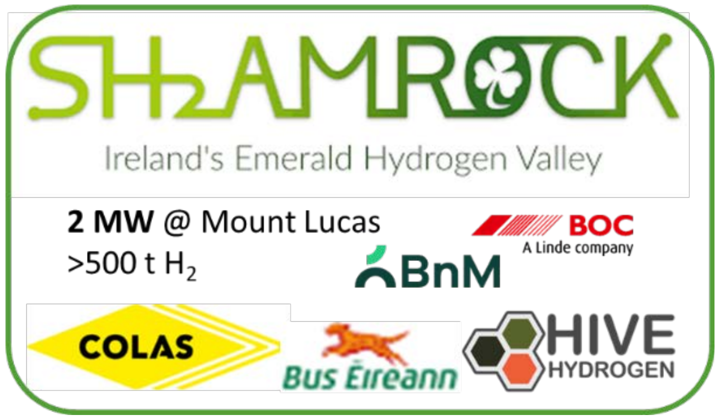


Figure 2: SH2AMROCK Project

ESB's Hydrogen Ambitions

Status – GeoPura on-site power deployments ongoing. Lighthouse project conditional planning granted. H2FUELS in pre-planning and seeking funding.

Semi-state energy utility company ESB are showing considerable leadership in the nascent Irish hydrogen market through a variety of projects underway or in planning. Through their collaboration with GeoPura they have supplied clean on-site power through fuel cell power units to a number of events and off-grid applications in Ireland. There are plans to continue to grow this market and supply clean hydrogen from ESB's Lighthouse Project which will deploy a 1MW electrolyser in the Cork lower harbour area. Some of this supply is earmarked for the H2FUELS project, a collaboration

Figure 3: ESB Hydrogen Projects

with Zero Petroleum and academic partners including Trinity College Dublin. The project aims to pilot e-fuels technology, with plans for scaling to larger plants in Phase II and III to maximise value from Ireland's offshore wind to produce e-fuels for aviation.

Collaborative Cluster-Focused Approaches in Cork

Status – Pre-planning – Celtic Hydrogen Cluster & Kestrel projects both assessing European funding opportunities.

Wider hydrogen centric industrial collaboration in the Cork region is under development that includes Irving Oil, Bord Gais, GNI, ESB, Simply Blue and the Port of Cork. The GLEANNCELT project is a Hydrogen Valley concept, which involves a wider group of hydrogen interested organisations with the cluster partners at its centre. Currently it is on the reserve list for Clean Hydrogen Partnership funding. The project aims to develop a cluster of hydrogen production, storage, and demand based on the strong nearby offshore wind resource, potential for hydrogen demand in industry and power, and the potential for geological storage off the coast as part of the Kestrel Project. Kestrel – a joint venture between ESB, Bord Gaís (owned by Centrica), and dCarbonX (50% owned by SNAM) – is investigating the redevelopment of the Kinsale gas field for natural gas with plans to transition to hydrogen when the need and market develop. It is estimated that the Kestrel Project could hold 4 TWh of usable hydrogen gas once operational.

Figure 4: GLEANCELT Project Map

Mannok Cement

Status – Pre-planning - Assessing European & national funding opportunities.

Located on the Cavan-Fermanagh border, Mannok, formerly Quinn Cement, has developed an energy valley concept centred around the use of hydrogen, in combination with other technologies, to reduce emissions from their operations. They plan to deploy a 10 MW electrolyser to produce hydrogen from a local wind farm that experiences curtailment of up to 30%. The hydrogen will be used to decarbonise their distribution fleet and quarry trucks as well as for testing hydrogen co-firing with solid refuse fuel (SRF) in their cement kilns.

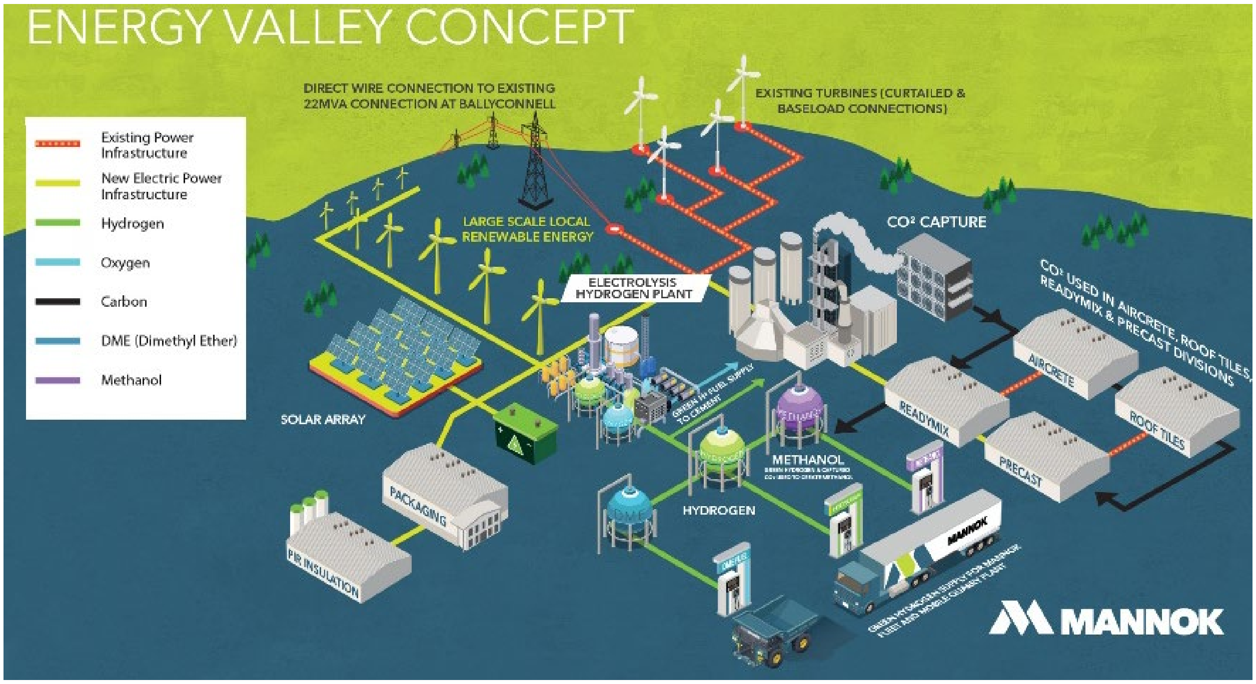


Figure 5: MANNOK Energy Valley Concept

Indaver

Status – Planning permission granted.

Indaver, a waste management specialist, have had a non-recyclable waste treatment centre based in Duleek, County Meath, since 2011. The company, as part of their strategy to minimise potential long-term curtailment experienced from their waste-to-energy process, have been investigating opportunities to couple hydrogen production to their existing facilities. Waste-to-hydrogen pathways provide greater supply certainty than intermittent renewables as they can achieve reliable, 24-hours-a-day operation. Indaver have subsequently submitted and been awarded planning permission for a 10 MW electrolysis plant adjacent to their existing location. This planning permission also includes a HRS, 2 tonnes of hydrogen storage, and an above ground installation (AGI) point to facilitate on-site blending.

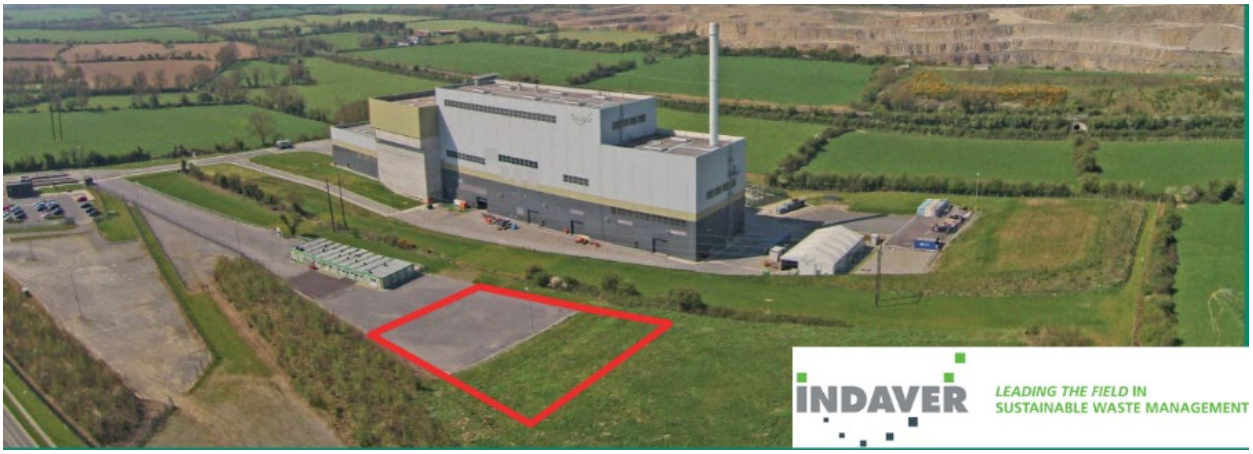


Figure 6: Current view of Meath plant with proposed hydrogen facility location outlined.

Other Projects

There are multiple other hydrogen projects at various stages of development in Ireland, some further along than others. Galetech received planning permission in October 2025 for their e-fuels pilot and test facility in county Cavan, which includes a 1 MW electrolyser. Net Zero Energy are looking to develop multiple hydrogen projects across Ireland for long-duration energy storage, whilst Constant Energy have planning permission (June 2025) to develop a hydrogen production and power generation site in Bellacorrick, County Mayo, that includes nine gas engines capable of generation 106 MW of power. Vermillion Energy, who co-own the Corrib Gas field in Co. Mayo have plans to develop large-scale renewable hydrogen production in the region to maximise the value of existing gas infrastructure, starting with a 1 MW proof of concept electrolyser project.

4 - Future Hydrogen Demand Pathways to 2050

Pathways Description

As part of this study a number of potential pathways for hydrogen demand have been developed. These pathways each correspond to a potential trajectory or scenario that is followed to 2050, effecting the development of the hydrogen industry in Ireland. These have been informed by existing analysis, internal expertise, and the comprehensive market engagement carried out as part of the work, with experts and representatives from across the relevant sectors of the Irish economy interviewed. The three pathways are:

1. Insufficient Progress
2. Delayed Growth
3. Committed Action

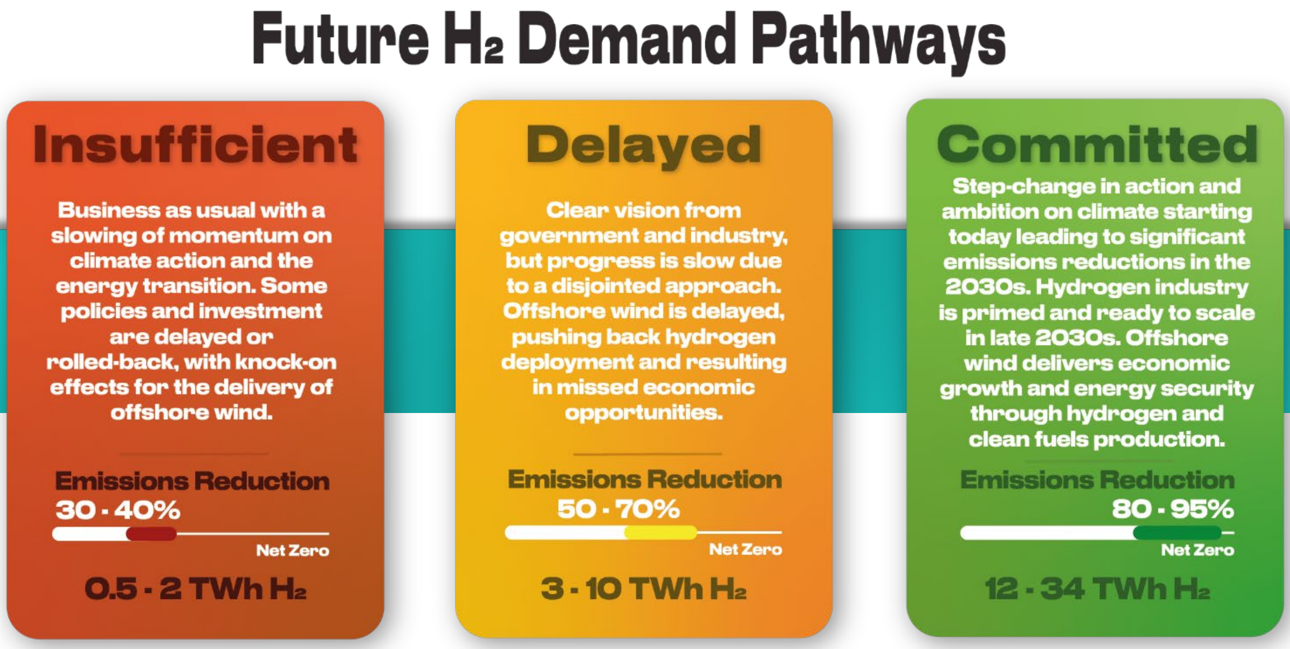


Figure 7: Hydrogen Demand Pathways

Each pathway is summarised below and reflects a different level of action from both government and industry on climate and energy and how this affects progress in renewable energy and more specifically, hydrogen demand. For more detailed sector-specific descriptions and assumptions on each pathway see Appendix A.

Insufficient Progress sees business as usual with slowing of momentum or hesitancy in certain areas of climate action and the energy transition, with some policies and investment delayed or rolled-back. Deployment of mature and cost-effective technologies such as renewables, batteries, and electrification continues but is delayed by a number of factors. These include the persistence of planning issues and perceived grid capacity challenges, ineffective policy levers, a lack of private investment, and an unstable and uncertain geopolitical landscape in the absence of a global consensus on climate action. National targets for 2030 are missed and offshore wind is not realised at >5GW scale until 2040. While there is some policy implementation and investment in hydrogen, electricity and hydrogen prices remain high and potential users are not adequately incentivised or mandated to reduce emissions. This ultimately results in the industry failing to reach the scale required for meaningful emissions reductions. Ireland achieves 30-40% emissions reduction by 2050 from today – including emissions from aviation and maritime – through renewables, limited electrification, and imported biofuels and e-fuels, remaining reliant on imports for much of its energy. All national carbon budgets are exceeded and climate targets missed.

Delayed Growth follows a more optimistic but ultimately delayed pathway in the energy transition. Whilst there is a clear long-term vision and appetite for action in government and industry, progress on climate and the energy transition is slow due to a disjointed and inefficient approach. Planning improvements and policies incentivising electrification drive significant investment and reduction in emissions in the late 2020s and early 2030s with the deployment of wind, solar, batteries, EVs and heat pumps, but the scale of transition is limited by bottlenecks in planning and grid capacity limits. Despite progress, carbon budgets are exceeded and 2030 targets are missed. Some offshore wind begins to come online in the early 2030s but does not reach 5GW+ scale until circa 2035. Policy support sees the development of a nascent renewable hydrogen industry in Ireland by 2030 but this is limited by the persistence of high prices and a lack of incentives for end-users, stifling demand. Scaling of supply is expected to occur significantly circa 2038 due to a number of potential factors. This includes significant scaling of offshore wind and subsequent domestic hydrogen production following delays, alongside connection to the European Hydrogen Backbone via Great Britain, facilitating hydrogen import as an initial or complementary source of supply. Growth in demand uptake across the power, industrial, and mobility sectors to 2050 results in a hydrogen industry an order of magnitude larger than today's, but slow progress means some opportunities have shifted to other geographies. Despite its abundant wind resource, Ireland imports the vast majority of its clean fuels for use in sectors such as aviation and maritime. Ireland achieves 50-70% emissions reduction by 2050 from today – including emissions from aviation and maritime – and is on track to achieve zero-emissions by 2070. There is some production of clean fuels (biofuels and e-fuels) but the country remains reliant on imports for much of its energy. All national carbon budgets are exceeded and most climate targets are missed.

Committed Action assumes a step-change in action and ambition on climate starting today resulting in an accelerated energy transition. There is real progress in implementation of climate and clean energy solutions but due to current limitations significant emissions reductions do not occur until the 2030s. Targets for 2030 are reached a couple of years late with over 5 GW of offshore wind online by 2035, enabled by grid capacity upgrades, efficient auctioning processes, and improved planning timelines. With multiple hydrogen projects already realised by 2030, the availability of low-cost electricity resulting from widespread deployment of renewables helps the industry to scale quickly. High renewable penetration in the electricity sector also results in a significant drop in gas demand, which, contingent on numerous other factors, could enable a quicker transition of parts of the gas grid to hydrogen, unlocking large potential for both hydrogen production and demand. Demand for hydrogen includes the use of hydrogen for power, enabling a 100% renewable and energy secure power system by 2040, as well as for the production of clean fuels at scale. Huge growth in offshore wind in Ireland in the 2040s facilitates deep emissions reductions, the production of clean fuels, and the growth of new industries reliant on clean energy. Ireland achieves 80-95% emissions reduction by 2050, including emissions from aviation and maritime and is on track to achieve zero-emissions in the 2050s.

Key Drivers and Influencing Factors

These three pathways are influenced by a variety of factors and key drivers as summarised in Figure 6. Climate, energy, and hydrogen specific policy at both national and EU level have a significant impact across the scenarios and can act as a catalyst for real action. However, there are many other factors and drivers of change. For instance, positive policy landscapes can substantially accelerate deployment of clean energy solutions, as well as reducing risk for first-mover novel opportunities which are critical to sector initialisation. At the same time sector scaling can be affected by the ability to drive private investment, particularly capital, given many clean technologies, including hydrogen, are characterised by large upfront capital costs. This can be a barrier to deployment but when overcome leads to long-term cost savings and price certainty for energy consumers. Furthermore, both policy and capital investment will be affected by the global geopolitical landscape. Events such as conflicts, invasions and trade-wars, have a large impact on the global economy from the price of food and energy to international relations and global economic policy. The rate of climate breakdown is also expected to be a major driver of climate and energy policy by directly influencing public awareness of climate change and its effects.

Figure 8: Key drivers for hydrogen demand pathways.

Pathway Results

The development of hydrogen demand over time varies significantly between the pathways, as shown in Figure 9. Within the pathways themselves, there is additional uncertainty, with this reflected in the large ranges depicted, increasing in variance to 2050. In **Insufficient Progress**, hydrogen demand has grown by a factor of 11 by 2050 compared to 2025 levels for the higher range estimates. However, in the context of the other pathways, it is clear that the industry has failed to take-off and does not contribute meaningfully to emission reduction. Total demand of between 14,000 and 63,000 tonnes per year (tpy, equiv. 0.46 – 2.09 TWh) represents only 1.6-7% of the hydrogen demand required for a zero emissions Ireland, as set out in 2 – Snapshot: Hydrogen in a Zero Emissions Ireland, using 670 to 3,000 GWh of electricity (equivalent to 2-9% of Ireland's total electricity usage in 2024).

In **Delayed Growth**, despite a delayed start, there is a steady increase in hydrogen demand post 2035. The industry then scales steadily in the 2040s but not sufficiently to achieve zero emissions, reaching 100,000 to 304,000 tpy (3.3-10.1 TWh) by 2050. This is equivalent to 11-35% of hydrogen demand needed to achieve zero emissions. Despite this, 1 to 3.3 GW of renewable powered hydrogen production capacity (50% capacity factor electrolysis) would be required to meet this demand. For context, as of December 2025, current renewable generation capacity in Ireland is approximately 7 GW.

Hydrogen demand scales earlier in the **Committed Action** pathway, reaching over 50,000 tpy (>1.7 TWh) sometime between 2035 and 2037. There is a steady increase throughout the 2030s before rapid scaling begins late in the decade, enabled by abundant renewables and large-scale build out or conversion of hydrogen infrastructure. Domestic hydrogen demand grows to unprecedented levels in the 2040s alongside deep emissions reductions across the economy enabled by renewables and electrification. Hydrogen demand in 2050 is 346,000-1,000,000 tpy (11.6-34.4 TWh). This requires up to 11.2 GW of electrolysis capacity, powered predominantly by offshore wind, but still falls narrowly short of the 15 to 46 TWh industry necessary for zero emissions.

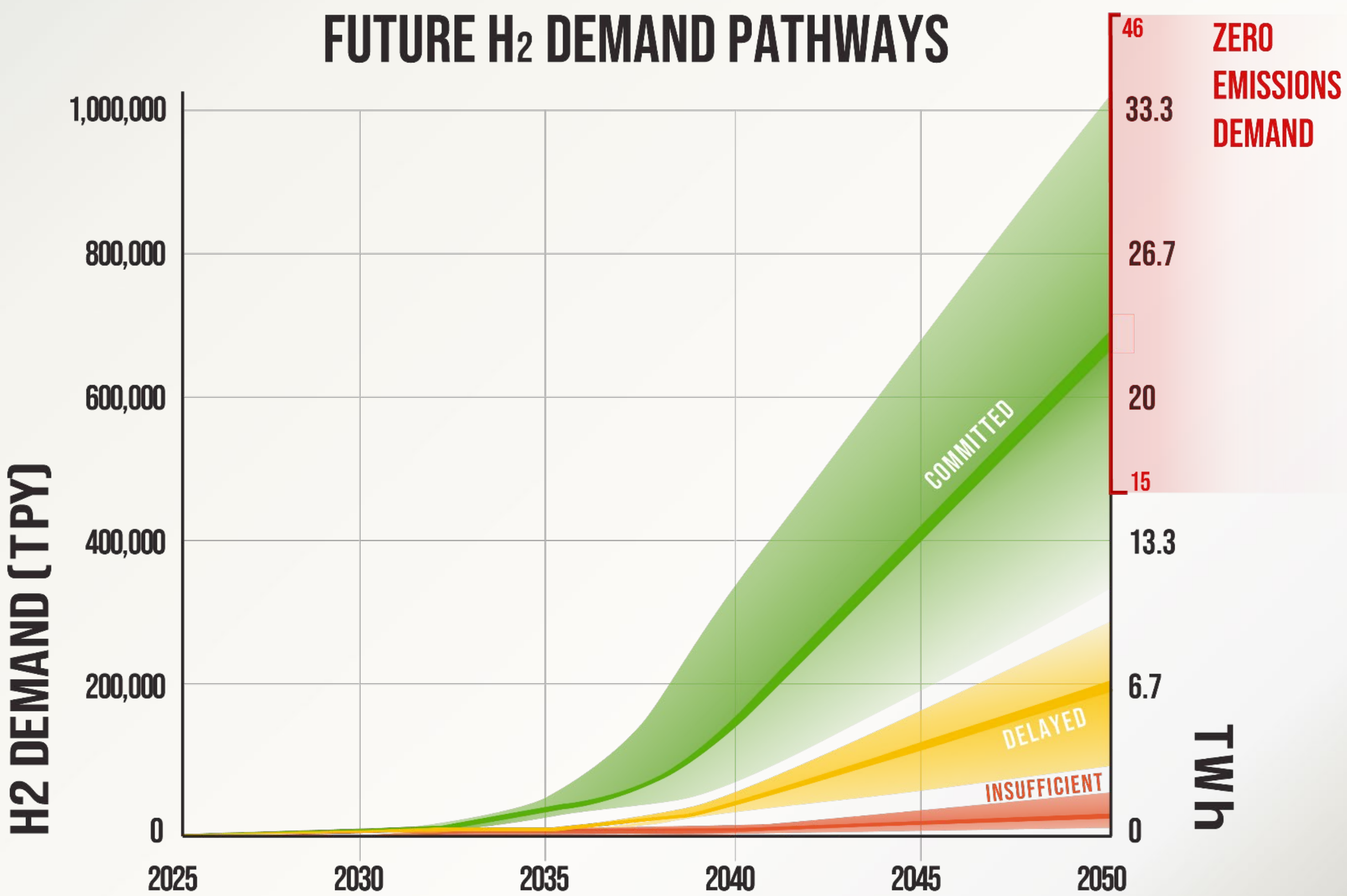


Figure 9: Hydrogen demand estimate ranges for three pathways analysed. Insufficient Progress: hydrogen industry fails to materialise at scale required. Delayed Growth: Delayed scale up of the industry leaves too big a gap to be made up by 2050. Committed Action: Early action primes the industry to scale when the twin pieces of offshore wind and infrastructure fall into place.

Sectoral Breakdown by Pathway

Insufficient Progress

As shown in Figure 10, hydrogen demand to 2040 is dominated by '*Other Industry*', which consists primarily of existing hydrogen production and consumption in oil refining. Hydrogen is also used for diesel and biofuel (HVO) upgrading (630-770 tpy, ~0.02 TWh) – categorised under 'Clean Fuels' in Figure 10 – and in a small number of trucks, buses, and coaches (270-335 tpy, ~0.01 TWh) by 2035. Demand for hydrogen in power generation remains relatively small (325-397 tpy, ~0.01 TWh) with some growth in the use of hydrogen for on-site and off-grid power and in limited blending trials at gas-fired plants. Outside of refining and existing uses, some hydrogen demand develops in industrial settings by 2040 for cement and other processes that require high temperatures. Demand in such sectors increases to up to 6,000 tpy (0.2 TWh) by 2050, representing just a small proportion of sector-level emissions reductions. Demand for hydrogen in road mobility increases to 1,500-4,570 tpy (0.05-0.15 TWh) by 2050 but has largely failed to develop, accounting for less than 1% of heavy-duty trucks in Ireland. The use of hydrogen for power generation (3,600-29,000 tpy, 0.12-0.97 TWh) and upgrading of fuels (5,600-16,800 tpy, 0.19-0.56 TWh) are the largest end use applications by 2050.

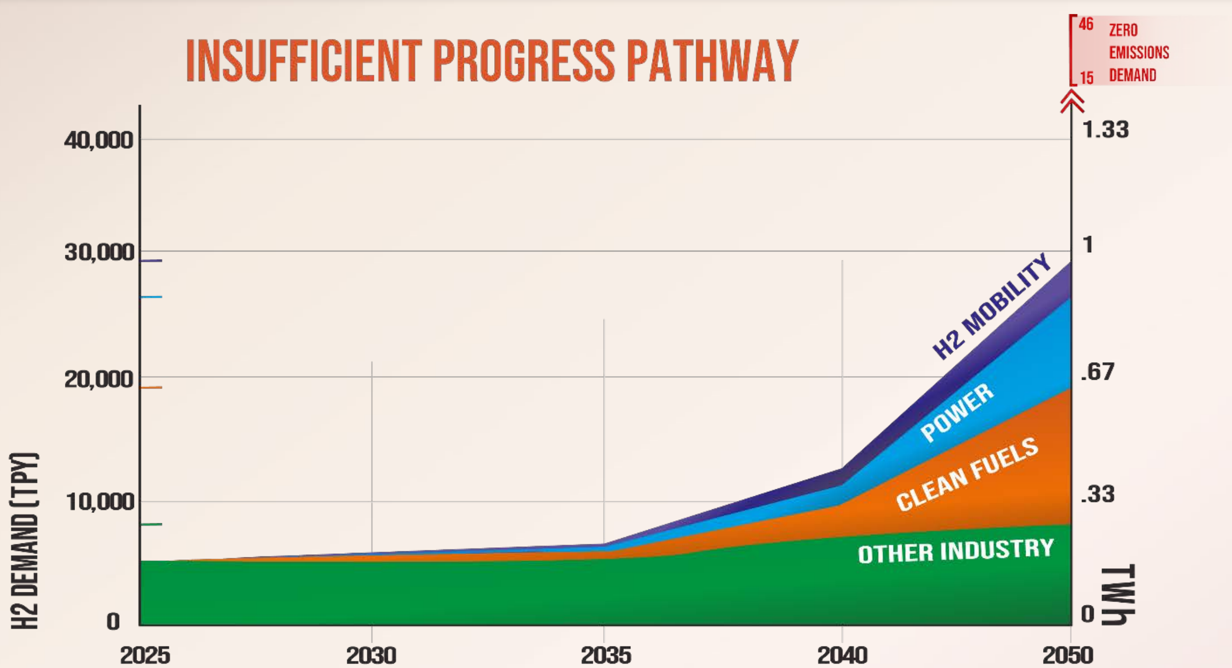


Figure 10: Hydrogen demand by sector over time for the ***Insufficient Progress*** *pathway. Though study estimates use a range of values for each sector to account for uncertainty and variances within pathways, median values have been used above to allow for ease of graphical representation.*

Delayed Growth

For the Delayed Growth pathway (Figure 11), there is some new demand from pilot activities in mobility and cement by 2030 and potentially clean fuels by 2035. Slow uptake persists through the mid-2030s but jumps in the latter part of the decade with total demand at 37,000-67,000 tpy (1.23-2.23 TWh) by 2040, an increase of 6-8 times from 2030. Much of this demand growth is from the power sector (10,000-19,000 tpy, 0.33-0.64 TWh) as the first 100% hydrogen power plant comes online, but the largest demand is from the clean fuels sector – reaching up to 24,000 tpy (0.8 TWh) of demand for biofuel upgrading and e-fuel production. This is facilitated by large growth in renewable power generation, particularly offshore wind, as well as the planned build out or repurposing of gas infrastructure for the transmission of hydrogen in key production and demand clusters/regions. Follow-on growth from initial pilot activities is exhibited from mobility as well as cement in the industrial sector, but throughout the 2040s their shares of the overall market decrease in comparison to power and clean fuels. By 2050, total hydrogen demand is between 100,000 and 300,000 tpy (3.3-10.1 TWh), up to 55 times greater than 2025 demand, but still only 11-35% of the volume needed for zero-emissions.

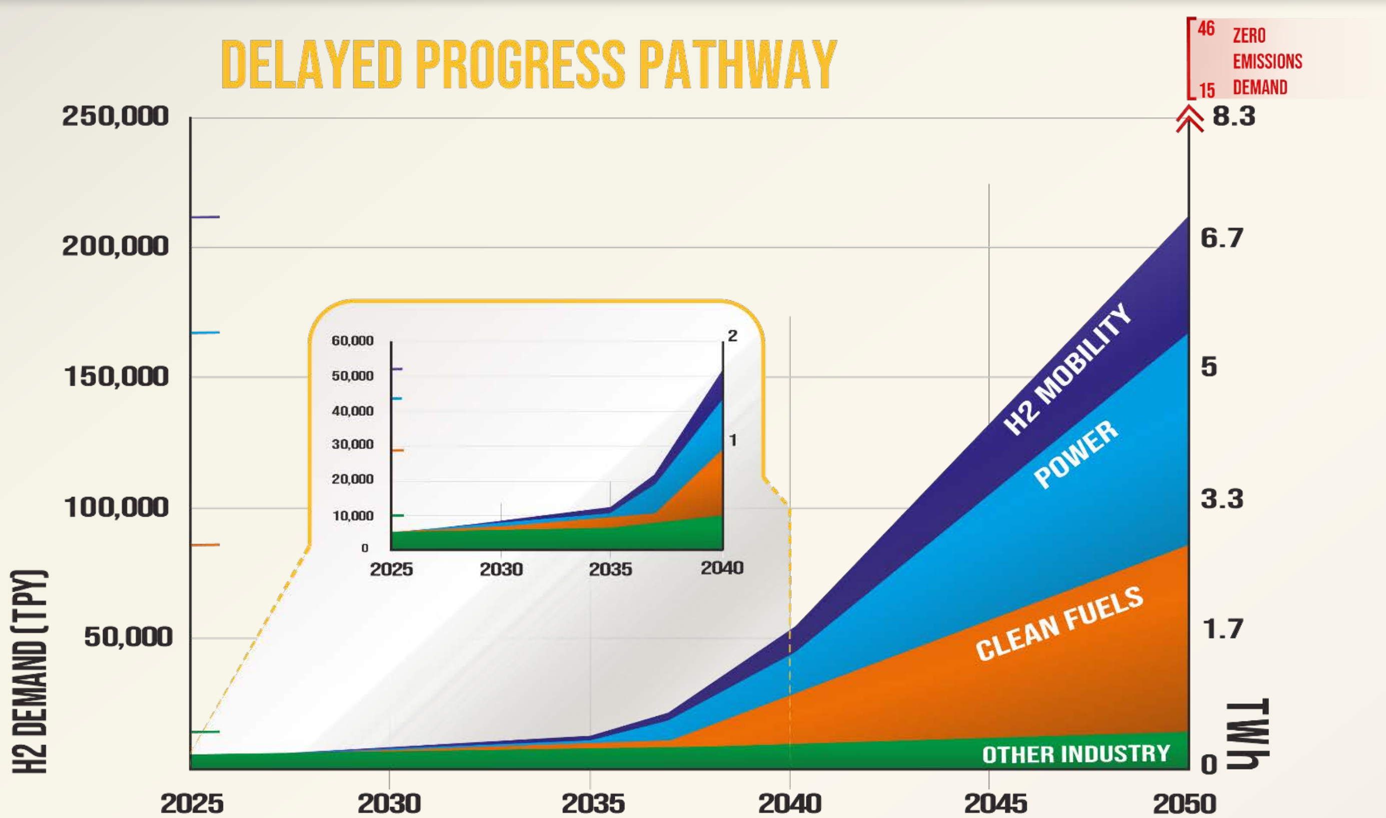


Figure 11: Hydrogen demand by sector over time for the ***Delayed Growth*** *pathway. Though study estimates use a range of values for each sector to account for uncertainty and variances within pathways, median values have been used above to allow for ease of graphical representation.*

Committed Action

In the Committed Action pathway, new demands have already far exceeded traditional hydrogen demand in Ireland by 2035 (Figure 12). Hydrogen for power generation has grown by an order of magnitude from 2030, with a small-medium sized commercial hydrogen power station realised as Ireland moves towards an emissions free power system. Medium-scale commercial e-fuel production plants are also in operation, representing hydrogen demand of up to 19,000 tpy (0.64 TWh). Hydrogen vehicles and refuelling infrastructure are built out but remain a modest part of the overall transport fleet. In Figure 12, demand in other industry increases modestly from 2030 to 2035 as increases in hydrogen usage in cement and other industries is offset somewhat by the ramp down in the production and usage of fossil hydrogen for refining. This is displaced by the increased use of renewable hydrogen for upgrading of biofuels such as HVO and SAF, which is categorised under '*Clean Fuels*'. Hydrogen use in power and clean fuels continues to grow to 2040, with total demand reaching 81,000-361,000 tpy (2.7-12 TWh), but the biggest change in this period is the uptake of hydrogen demand in industry not suitable for direct electrification. This occurs as the delivery of offshore wind at scale helps to bring down the cost of electricity, reducing the cost of hydrogen in turn. As such, hydrogen's role within the power system increases, including high deployments at specific sites with large energy requirements, supporting progress towards sector and national targets.

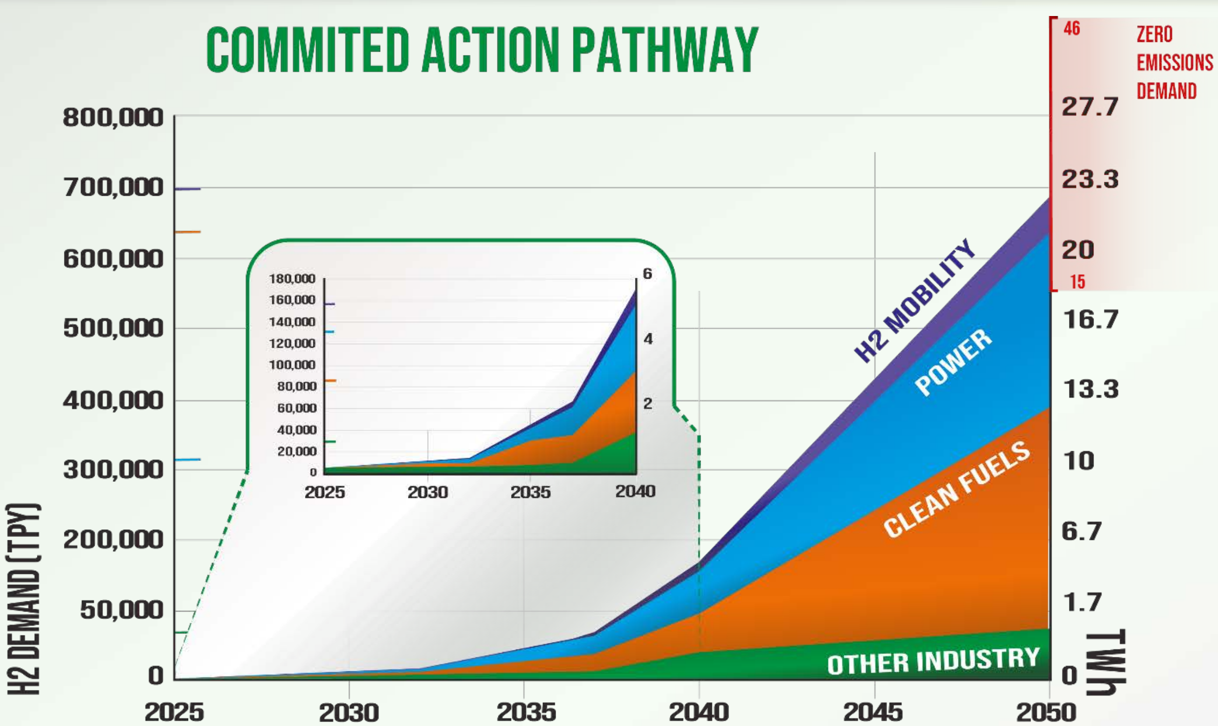


Figure 12: Hydrogen demand by sector over time for the ***Committed Action*** *pathway. Though study estimates use a range of values for each sector to account for uncertainty and variances within pathways, median values have been used above to allow for ease of graphical representation.*

In the 2040s demand for hydrogen in the power sector grows with overall electricity demand, as electrification continues at pace alongside demand from data centres and population growth. By 2050 Ireland produces over 700 kt of clean fuels, primarily SAF and e-SAF. Total hydrogen demand is now 346,000 -1,000,000 tpy (11.6-34.4TWh) as Ireland is on track to achieve zero emissions by the mid-2050s.

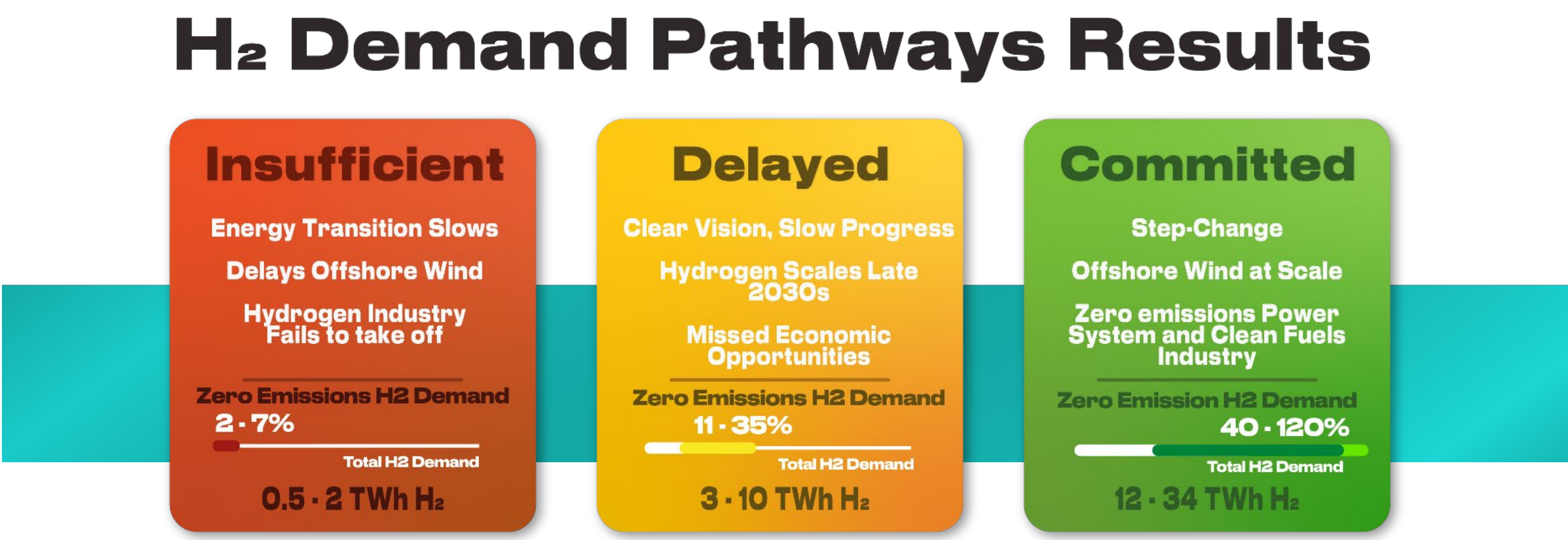


Figure 13: Summary of pathways and result.

Ireland's 2040 and 2050 Offshore Renewable Energy Targets

To meet demand in the Committed Action pathway requires between 0.9 to 3.9 GW of electrolyser capacity (50% capacity factor) supplied by renewables in 2040 with this increasing to between 3.8 and 11.2 GW by 2050. For reference, Ireland's target for renewables capacity in 2040 includes 20 GW of offshore renewable energy in addition to onshore wind and solar. If realised, an estimated production surplus of 40 TWh is predicted to be available from additional generation capacity, indicating adequate electricity supply for hydrogen production from electrolysis in this case. For 2050, the offshore renewables target rises to 37 GW, with a potential 114 TWh of surplus electricity, highlighting how the achievement of such targets would far exceed the capacities required for domestic hydrogen production, representing an opportunity for economic growth and the export of electricity and hydrogen-derived high value products.

Table 3: Comparison of required hydrogen production capacity for Committed Action pathway with national targets for offshore wind deployment.

	2040	2050
National Offshore Renewable Energy Target	20 GW	37 GW
Committed Action Pathway Estimated Electrolysis Capacity	0.9 – 3.9 GW	3.8 – 11.2 GW

Key Takeaways

Given Ireland's lack of progress to date on hydrogen, and low existing demand, hydrogen demand does not reach significant scale until the mid-2030s, even in the Committed Action scenario. As set out in Insufficient Progress, and to some extent the Delayed Growth pathway, there is a distinct possibility that the hydrogen industry in Ireland fails to take off, locking the country into reliance on imports of both volatile fossil fuels and sustainable liquid fuels for decades. However, if primed and ready, the Irish industry stands to make the most of learnings from first-mover projects in Europe and beyond, deploying and scaling mature technologies at pace and taking advantage of cost reductions realised by deployments elsewhere. In particular, hydrogen can help Ireland achieve zero emissions and energy security in the power sector, which has the most ambitious timelines for emissions reductions of any sector of the economy. Beyond this, there is a potential opportunity for the production of clean fuels in Ireland. Initially, hydrogen can be used, with minimal disruption to existing infrastructure, for the upgrading of diesel and biofuels such as HVO. In the longer-term, if the large-scale deployment of offshore wind is achieved, hydrogen, combined with bio-feedstocks and waste biogenic carbon dioxide from biogas plants, can be used to produce clean fuels such as SAF and e-SAF at scale, assuming economic-competitiveness can be achieved.

Although power and clean fuels could dominate long-term demand, the use of hydrogen for other applications in the industrial sector and mobility is not to be neglected. In some cases, these are likely to be the first mover projects in Ireland, enabling initial investment, and crucially, the development of the skills and expertise needed for a hydrogen industry. Such projects are also key for improving public awareness and societal acceptance of the technology. As mandated by the AFIR, 5 hydrogen refuelling stations must be built in Ireland by 2030 and this can help to facilitate some modest uptake of hydrogen vehicles for trucks, buses, and coaches. Though electric vehicles will dominate, the sector will then be ready to facilitate niche but important role of hydrogen vehicles in transport, with between 2,500 and 7,900 vehicles deployed by 2050 as per the Committed Action pathway – 80-90% of which are expected to be road-going heavy-duty vehicles. In relation to industry, applications such as cement can provide the early volume for hydrogen production even when co-fired in relatively small blends.

It is also crucial to note how hydrogen is just one solution that forms part of the wider energy system. Given Ireland's ambition to produce hydrogen from renewable sources the quantity and cost of energy from wind and solar will have an impact on the hydrogen industry in Ireland. The development of significant demand for hydrogen in Ireland is therefore contingent on the development of renewables at scale, particularly offshore wind in the medium to long-term. Ireland must deliver affordable electricity, and in turn hydrogen, allowing end-users to reduce emissions while maintaining a sustainable business case. In the short-term, the use of onshore renewables and otherwise curtailed and constrained electricity can be used for hydrogen production for initial projects to minimise costs and therefore the level of subsidy required.

5 – Policy Levers and Key Uncertainties

Given the nascent nature of the renewable hydrogen industry in Ireland, there is much uncertainty around how it is likely to develop in the coming years and decades. This early stage, however, also represents an opportunity to lay the foundations that could allow Ireland to maximise its renewable energy resources and create long-term, sustainable, value for the economy. Hydrogen is to be an integrated part of a much wider energy system and effective policy must reflect this, enabling emissions reductions through the suite of technologies at our disposal. It is also crucial to mitigate significant risks and account for uncertainties, insofar as is possible. For example, the use of hydrogen for energy storage is a potential means of mitigation against the risk of price spikes or supply disruptions to energy imports in the context of energy security. How the hydrogen industry in Ireland develops as per the pathways described and discussed above, will be dependent upon a wide variety of critical factors, including policy. Key policy levers, risks, and uncertainties as they relate to hydrogen are discussed in the following chapter.

Policy Levers

At both a national and EU level, policy is a crucial tool in enabling climate action and the energy transition more broadly. This can be implemented in a variety of ways, such as taxes to discourage certain practices (e.g. carbon taxes), regulation of industries, mandates, targets and subsidies. The success of wind, solar and batteries is a direct result of a wide range of policies adopted by various governments across the world to develop what were once expensive technologies with low technological readiness levels. Even though these solutions are now mature, and in most cases cost-competitive with incumbents, barriers to deployment remain. These range from persistent planning issues, to financing challenges resulting from markets originally designed for traditional energy sources, and a global and concerted effort from fossil fuel companies to disrupt and delay progress on clean energy[24]. This highlights the extent of the challenge faced by technologies such as hydrogen that are required to achieve deep economy-wide emissions reductions, minimising and eventually eliminating reliance on fossil fuels.

This is particularly true given that costs for hydrogen, and other solutions such as biofuels, are unlikely to be competitive without significant policy support to catalyse deployment and realise cost reductions. When produced via electrolysis, electricity accounts for the majority of the cost of hydrogen. As a result, polices which aid in the timely delivery of

[24] Gentille and Gupta, Orchestrating the narrative: The role of fossil fuel companies in delaying the energy transition, Renewable and Sustainable Energy Reviews. 2025

renewables, reducing the cost of electricity, will have a considerable effect on the evolving industry.

Currently, the cost of capital equipment, such as electrolysers, compressors and storage has remained high due in part to a supply-demand imbalance with manufacturing supply chains not yet at full maturity. These high infrastructure costs may need to be offset by public support in the short-term to ensure first mover projects can reach a positive final investment decision, as demonstrated in other geographies. However, given the majority contribution of electricity costs to the cost of hydrogen, operational support may be more effective in helping projects to scale to commerciality. In the long-term, assuming the availability of lower cost renewable power in Ireland, hydrogen may still struggle to reach the traditionally low prices associated with fossil fuels, particularly natural gas.

Although achieving zero emissions in sectors of the economy not easily electrified will require a large transformation of the energy system, it is achievable, and crucially, affordable[25]. With technologies such as solar, BEVs, and heat pumps already cost saving, the additional costs of achieving zero emissions for more challenging sectors, though not insignificant, are affordable in many instances. According to Energy Transitions Commission's *Mission Possible* report, achieving net zero emissions in cement production would add 3% to the cost of a house. For net zero emissions in aviation, the cost to a consumer of a long-haul (6,500km) flight would be 10-20% higher, indicating that although initial costs are high, achieving zero-emissions can be achieved without burdening citizens with huge costs.

Of course, the question remains as to the exact role of policy in facilitating a transition that delivers a cleaner, healthier, and safer world. In relation to hydrogen in Ireland specifically, encouraging hydrogen demand where needed and on a suitable timeline is key. This can be done by incentivising emissions reductions across the industrial sector, and creating a level playing field for all solutions, including hydrogen. The use of hydrogen is likely best prioritised for sectors where electrification is not possible or challenging, and particularly for sectors where hydrogen is used for the creation of a higher value or critical products. This includes applications such as biofuel upgrading, e-fuels, cement, and raw materials. As demonstrated by the findings from *4 - Hydrogen Demand Pathways to 2050*, the use of hydrogen for power is critical to achieve a secure, zero emissions power system. This can be enabled by market design that creates a viable business case for long-duration energy storage technologies (greater than 12 hours) and clean peaking plants.

[25] Energy Transitions Commission, Mission Possible: Reaching Net Zero Carbon Emissions from Harder-to-Abate Sectors by Mid-Century.2018

It is also crucial to facilitate the delivery of a coordinated hydrogen value chain. The foundation of this value chain is low-cost and available clean electricity. The timely delivery of both onshore and offshore renewables at scale is critical to realising domestic supply of hydrogen at scale. In addition, storage and distribution infrastructure is vital to connect supply and demand and provide resilience of supply. The role of government, as demonstrated in other EU countries, is therefore crucial in many ways to sector scale-up: ensuring the correct regulatory and safety frameworks are in place; providing a suitably skilled workforce; and removing some risk associated with investments needed to build critical infrastructure.

Alongside the variety of potential policy mechanisms mentioned at the start of this section, public financial support remains one of the most consistent structures used to increase the growth of hydrogen, and other innovative energy solutions. Capital support in the form of grants or low-interest loans are options that have been explored in most European geographies (e.g. UK - Net Zero Hydrogen Fund, EU - Innovation Fund) to help overcome the high upfront costs for many projects. Another capital funding route of interest are the Clean Hydrogen Partnership's hydrogen valleys which provide funding across the full hydrogen value chain to support cluster development. In addition, operational support is becoming increasingly popular for producers or end-users to offset currently high electricity and hydrogen costs in medium-to-large scale projects. The use of contracts for difference (CfDs) has proven successful in the delivery of onshore wind in Ireland and could be repurposed in some form for hydrogen as in the UK's hydrogen business models, or the EU's Hydrogen Bank auctions. The signpost funds mentioned, alongside reducing financial risk, have also acted as strong strategic signals to the sector to increase stakeholder confidence. The assessment of the suitability, efficacy and cost of potential policy mechanisms is a key area for future work, including identification of effective policy from other jurisdictions and sectors internationally.

Risks and Uncertainties

The estimates set out in the previous chapters have accounted for significant uncertainty, particularly in the longer-term. Potential risks have been considered where most relevant, but of course there are uncertainties and risks that may not yet be clear in this ever-changing economic and geopolitical landscape. A number of key risks and uncertainties have been identified over the course of this work, from market engagement and desktop literature review and demand analysis.

Offshore Wind

As mentioned previously, the development of hydrogen demand at scale is contingent on the availability of an affordable supply of hydrogen. Whilst it is possible that some hydrogen could be imported, via a retrofitted gas interconnector from Great Britain for example, development of domestic supply is preferrable. Whilst initial hydrogen production projects in Ireland are likely to utilise lower cost onshore renewables, the timely delivery of large volumes of offshore wind at reasonable cost is critical to developing a long-term indigenous supply capability. Not only will this deliver immediate emissions reductions in the electricity sector and enable wider electrification, it can create a favourable business case for hydrogen, with electrolysers maximising use of low-price renewable electricity at times of high wind generation and ramping down or off at times of low generation, high demand and high prices. How this can be enabled by progressive policy is a key area for future work.

None of this is guaranteed however, with many stakeholders interviewed as part of the market engagement exercise expressing frustration at the pace of wind deployment to date. Many believe that 2030 targets are already out of reach due to slow planning, long grid connection times, and lack of clarity on timelines for future auctions. In addition, Ireland's ports do not currently have the capacity to construct such offshore wind farms. This shortcoming is well documented[26], and investment is required in port infrastructure to change this. If realised, the opportunity to not only accelerate progress towards offshore wind targets but also to create local content and jobs is considerable. The risk of not delivering on offshore wind will have consequences not only for hydrogen but across the Irish economy. Another aspect is the risk that the offshore wind that is delivered is high cost as the cost of delays is factored in to bid prices. This would be detrimental to potential hydrogen production in Ireland and increases the risk that the import of energy would remain the status quo, thereby significantly damaging the prospect of high-value energy product exports from Ireland in the long-term.

On this note, under the Committed Action pathway it is assumed that floating wind achieves technical maturity and acceptably low-cost for deployment and use as a source of electricity for hydrogen production. However, this is not a given and will only be achieved if a number of key elements align. Unprecedented grid capacity investment will be needed to connect large volumes of floating offshore wind to the Irish grid, in addition to adequately resourced planning authorities to enable the realisation of best-practice projects. Given Ireland is likely to be a latecomer to the technology, with deployments already underway in Portugal and Scotland, learnings from these first-mover projects will be crucial in the delivery of large floating wind projects at scale, on-time, and at a reasonable cost. This will

[26] Wind Energy Ireland. National Port Study. (2022).

help to ensure a secure and affordable supply of electricity not only for hydrogen but also for electricity consumers around the country.

The Gas Network

Ireland's gas network is used to move vast quantities of energy around the country for power generation and heat, with a total gas demand in 2024 of 53.4 TWh[27]. As gas demand falls as renewable penetration and electrification rise, there is an opportunity to repurpose this multi-billion euro asset for the transmission and storage of renewable gases such as hydrogen and biomethane. There are a number of significant challenges and key questions that need to be addressed to achieve this, however. Starting with the long-term end-goal of zero-emissions in mind, the question of what the gas network looks like in this scenario is important. It may be required to carry two different gases in hydrogen and methane (fossil or bio) and could even be used to transport carbon dioxide for storage or use for e-fuels production. How to divide up the network for these different molecules under an ongoing energy transition requires careful consideration and planning. There is also the fact there will be far less demand for energy in the form of gas. Even in the Committed Action scenario, hydrogen demand in 2050 is between 11.6 and 34.4 TWh, which represents a significant reduction in comparison to current gas consumption. As a result, the cost per unit energy of maintaining the network could increase, negatively impacting business cases for hydrogen as additional costs may then be passed on to hydrogen consumers. This is highly uncertain but nonetheless, managing the network transition and costs in the long-term is a key challenge that must be considered.

As part of the transformation to a zero or near-zero energy system, how the use of the gas grid changes over time is another key uncertainty. When and where parts of the gas grid will be either converted or new pipelines developed to transport hydrogen will be influenced by many factors. This must occur in the context of maintaining adequate security of supply. For example, should one interconnector to Great Britain be converted to hydrogen, this would then mean that the remaining interconnector would be the single point of supply for gas into the country and single point of failure in the event of a supply disruption. The deployment of significant gas storage or alternative import routes could therefore, in combination with multitude of other factors, enable an earlier conversion of existing infrastructure to hydrogen. The state-led Strategic Gas Emergency Reserve (SGER) project that plans to facilitate a floating storage and regasification unit (FSRU) on the Shannon Estuary in Co. Clare is particularly relevant in this regard. It is worth noting that such liquified natural gas (LNG) infrastructure has much in common with liquid hydrogen terminals for import and export. In addition, the pace of delivery of renewables will have an outsized impact on gas

[27] Gas Networks Ireland, Ireland's Gas Network – Keeping Ireland's energy moving. 2025

demand, displacing gas usage in power, and through electrification, heat. A significant decrease in natural gas demand could also facilitate the conversion of parts of the network to hydrogen by freeing up capacity. However, this will be influenced by a variety of other factors including peak demand levels, and network resilience requirements. As such the gas network must be actively managed as part of the transition to zero-emissions. This is a key area for future work that is set to be addressed under Action #12 (Network Transition Plan) of the National Hydrogen Strategy Implementation Plan.

The Power System

Another uncertainty is the extent of the role hydrogen will play in a future zero emissions power system. Other options for dispatchable power do exist, including the use of natural gas with CCS (though this is not a zero-emissions solution), and biofuels. These solutions may win out over hydrogen under certain policy conditions. For example, in a scenario where net negative emissions are required from the power system, this would incentivise the deployment of bioenergy with CCS, which, in theory, can be negative emissions. In practice, there are likely limits to the potential use of biomass for power in Ireland due to low feedstock availability. There is also the possibility that the share of other medium to long duration energy storage technologies such as iron-air batteries and thermal rock storage results in a smaller role for hydrogen. It is important to note that such technologies are included in the power system analyses carried out which are used as the basis for the estimates in this work (see Appendix A). The Irish government, via the Department of Climate, Energy, and the Environment's Decarbonised Energy System Study (DESS – being carried out by SEAI), is investigating the future development of Ireland's power system with respect to its net-zero targets. This study is expected to assess in further detail the role of various technologies, including hydrogen, in a net-zero Irish power system. Having said this, energy systems models cannot predict the future, and the projected make-up of an optimised zero emissions power system is likely to change over time.

A key point here is the advantage of hydrogen from a strategic and energy security point of view. Unlike the use of imported biofuels or natural gas for power generation, hydrogen would allow Irish sovereignty over its electricity supply, with the potential to achieve energy security through 100% independence. Using only energy produced on the island of Ireland would protect Irish consumers from high electricity prices caused by spikes in global energy markets.

Northern Ireland and UK Policy

As Ireland is part of an all-island energy system for electricity and gas, this has a profound impact on the developing hydrogen industry on the island which is heavily interlinked with both. This highlights the need for a coordinated approach from governments and industry in both Ireland and Northern Ireland. Continued alignment in policy is crucial particularly when developing shared infrastructure across the island. SEMO, the market operator for the Integrated Single Electricity Market (I-SEM) on the island is a great example of the coordinated approach required. As mentioned above, policy and market design will be crucial to maximising the potential of hydrogen in the electricity sector both on the demand and generation side, with the success of the DS3 programme[28] for the provision of electricity system services a prime example of how Ireland can take a world-leading approach.

There is of course always the risk that politics and policy diverge. This could go both ways. For example, ambitious policy from the UK could drive progress in Northern Ireland, leaving Ireland behind or perhaps influencing Irish policymakers to follow suit. Likewise, a slow down or lack of policy implementation in the UK would have a knock-on effect on the Irish energy system. However, the recently extended Memorandum of Understanding (MoU) between Ireland and the UK regarding co-operation in the energy transition, alongside historical energy collaboration in areas such as natural gas security of supply, minimises the likelihood of this risk.

Clean Fuels and Bioeconomy

Despite the significant role projected for clean fuels production in a zero emissions Irish economy and in the *Committed Action* pathway, the technological maturity of some clean fuel production technologies, particularly for e-fuels at commercial scale, remains low. As a result, the projections included in this work are based on the assumption that such technologies receive significant investment to achieve the necessary cost-reductions and scaling.

There is an opportunity, therefore, for Ireland to leverage its world-leading expertise and strong R&D base in this regard. Ireland is already seen as a potential testbed for e-fuels production, as evidenced by the planned Galetech and H2FUELS pilot projects. Such projects can act as a stepping stone to commercial scale, positioning Ireland as world-leading in the field. This is particularly relevant given the large presence and influence of the aviation industry in Ireland, from aviation leasing to airlines.

There are considerable barriers to initialising SAF production in Ireland, however, namely affordability of renewable energy. This directly impacts on the price of feedstocks including hydrogen and biogenic carbon dioxide when produced via electrolysis and carbon capture. These are intrinsically linked and vital to any company considering Ireland for potential SAF production. Without affordable renewable energy, fuel producers will likely establish operations in other locations. Ultimately the location of supportive policies and market

[28] EirGrid Group, Delivering a Secure, Sustainable Electricity System

economics of fuel suppliers and airlines will drive geographic uptake based on willingness to pay.

In addition to e-fuels, there is the potential for Ireland to build on its R&D expertise in bioeconomy and its large agricultural sector to develop products, not only fuels from bio-feedstocks and clean energy. From novel biofuel production pathways to precision fermentation there are any number of ways that Ireland can increase the value add of clean energy by leveraging existing expertise and research capabilities. One pressing reason for this is the potential to build on Ireland's well-established and world-leading food sector through the production of microbial foods via processes such as precision fermentation. Such technologies offer notable benefits across quality and sustainability areas but further technology advancements are required to increase cost-competitiveness with conventional food products[29]. This could be a key opportunity to not only safeguard, but potentially grow food-based jobs into the future based on an strong domestic supply of both hydrogen and biogenic carbon dioxide.

Hydrogen Road Mobility

To what extent hydrogen will play a role in road mobility is another key uncertainty. With uptake of electric vehicles ever-increasing due to improvements in technology and cost-reductions, the projected role of hydrogen vehicles has been reduced to heavy duty and niche applications. Some foresee no role for hydrogen in road mobility based on the assumption that battery technology will continue to improve and achieve new breakthroughs. Whilst this was echoed by a few stakeholders interviewed as part of this work's market engagement exercise, it was not the view reflected by those in the industry as well as many relevant experts.

The EU's RED III legislation mandates that 1% of energy supplied to road and rail mobility in 2030 should be met by RFNBOs, to strategize and develop the role of hydrogen and hydrogen-derivatives within the sector. Within this legislation, the use of RFNBOs as an intermediate resource for the production of transport fuels or biofuels is also counted towards this target (commonly referred to as the 'refinery route'). As such, renewable hydrogen used for the production of HVO, as well as direct use of hydrogen within mobility powertrains could both provide meaningful pathways to achieve required targets.

There is in fact a possibility that hydrogen plays a larger role than expected in the medium term due to grid constraints and challenges in the deployment of charging infrastructure. Although the exact market share of hydrogen vehicles in the long-term cannot be known, a small role for hydrogen vehicles in transport corresponds to thousands of vehicles on Irish

[29] Roland Berger. The promise of precision fermentation: Can it really change the game? (2025).

roads, along with the associated refuelling infrastructure that must be built, starting with the EU's AFIR requirements.

Industrial Growth

Ireland's renewable energy potential far exceeds its current demand for energy, and for this potential to be realised, industrial expansion will be required to serve as a demand for this energy. This expansion could lead to unprecedented clean economic growth for Ireland. There are, however, a number of different industrial applications that could underpin this growth and which if ultimately developed will be heavily influenced by strategic policy from government. For example, in theory the 114 TWh of excess energy Ireland could produce in 2050 could be used to produce hydrogen for use in heavy industry such as steel and chemicals. Given Ireland's low industrial base and lack of these industries currently, this is perhaps unlikely. Another option is to use the excess electricity to supply data centre power demands with hydrogen used as a clean backup fuel. This could be done by co-locating data centres with renewables and hydrogen and other industry in a cluster or 'energy park' approach. Top-down energy system planning which designates particular regions and sites for such clusters or parks can catalyse investment in renewables and hydrogen, whilst optimising overall system efficiency by locating industry and power demand in parts of the grid where renewables are available and the grid is not constrained. This aligns with the IDA and Enterprise Ireland's strategic objective of balanced regional development. Such an approach can also serve to alleviate stress on other parts of the grid and ensure grid capacity can be used for the electrification of homes and businesses and that power is not a constraint for new housing developments in population centres.

In relation to data centres, there is a risk that the current appetite for electricity demand is not sustained in the long-term. This could occur due to breakthroughs in data centre or artificial intelligence (AI) computational efficiency which could significantly reduce power requirements. There is also the risk that current widespread investment in AI and data centres is a bubble which will eventually burst. So, while there is an opportunity for Ireland to position itself as a clean, green home for data centres in the long-term, it would be advantageous to diversify the portfolio of large energy users that could be facilitated by widespread renewable energy deployment and strategically located energy parks in Ireland.

The opportunity lies in using Ireland's renewable energy to create high value products which either offset costly imports or drive new export markets. From data to clean fuels or microbial food products, hydrogen is a key feedstock which is required to realise this economic growth potential. Ireland is well positioned to take advantage of this lucrative opportunity, but must seed market development now to maximise long-term potential.

6 – Conclusions, Recommendations & Next Steps

The National Hydrogen Strategy sets out that hydrogen will have an important role to play in achieving deep emissions reductions in Ireland. With its abundant renewable energy resource, particularly in offshore wind, Ireland has a distinct opportunity to not only achieve its legally binding target of climate neutrality by 2050, but to also deliver long-term sustainable economic prosperity. Produced from clean energy, hydrogen can be used to reduce emissions from a variety of end-uses and applications, and even to produce high-value products for export. As a result, there has been a significant increase in discussion and debate around hydrogen in Ireland in recent years. However, the precise role hydrogen is likely to play, including in the sectors of the economy where it will be needed for decarbonisation is still somewhat uncertain. Through extensive market engagement, literature review and desktop analysis, this work has set out to address this knowledge gap. After determining that Ireland's existing demand for hydrogen is low in comparison to more heavily industrialised neighbouring countries, the likely role of hydrogen in a zero-emissions Irish economy was assessed. Based on this analysis, three pathways or trajectories for hydrogen demand from the present day to mid-century were set out: Insufficient Progress, Delayed Growth, and Committed Action.

The results of the analysis indicate that key end-use sectors for hydrogen demand include power generation, clean fuels production, high-temperature industrial processes, and heavy-duty road mobility. In power generation, hydrogen acts as a crucial long-term energy storage mechanism, supplying 5-18% of total electricity demand in a zero-emissions power system in 2050. Hydrogen is also required for the production of clean fuels such as biofuels and e-fuels for aviation and shipping, both significant potential markets driven by EU mandates. For other industrial processes and road mobility, hydrogen plays, by comparison, a small but important role facilitating decarbonisation, with both sectors containing some key early projects which can kickstart the industry in Ireland.

The variance in hydrogen demand between the three pathways examined is stark, with the industry failing to scale and deliver emissions reductions or economic opportunities in the Insufficient Progress pathway. In Delayed Growth, the industry is held back by delays to key infrastructure such as offshore wind, with hydrogen demand scaling in the late 2030s to between 1.2 and 2.2 TWh but failing to fully capitalise on the opportunity to produce clean fuels. The step-change that occurs in Committed Action, with multiple small-to medium scale commercial projects operational in the late 2020s and early 2030s means the industry is primed and ready to scale later in the 2030s. This is facilitated by the build out of offshore wind, as well as pipeline and storage infrastructure. In this scenario, 11.6 to 34.4 TWh of hydrogen is used in Ireland across power generation, clean fuels, industry and mobility in 2050, falling just short of zero-emissions.

Key to achieving scale-up of the hydrogen industry in Ireland is to incentivise demand for suitable applications. Whilst support across the value chain is required, demand development remains a common barrier due to a number of factors, particularly cost. A blend of carrot and stick will be required to discourage polluting practices whilst facilitating the adoption of clean solutions for industry, including hydrogen. The cost of electricity, the main feedstock for hydrogen production, remains a barrier to deployment. Therefore, deployment of renewables, for capacity building and to drive down costs, particularly offshore wind, is crucial to facilitating hydrogen demand growth. Top-down, holistic planning for energy and industry in Ireland is also vital, particularly with respect to the build-out timelines associated with renewables and grid. Clear signposting in this area will allow more efficient project development for clean energy solutions, such as hydrogen, which are expected to play a key supporting role to electrification in Ireland's trajectory towards zero emissions. Outputs from DCEE's DESS study are likely to provide some clarity in this area.

A focus on clusters, valleys and energy parks where renewable energy and hydrogen supply, storage, and demand are co-located, can reduce costs and catalyse demand in key regions. Such locations can also act as critical hubs from which to expand hydrogen and related activities. To realise the long-term economic growth opportunities enabled by hydrogen, it is necessary for Ireland to leverage its existing industry, expertise, and research and innovation base, to identify and maximise its value-addition for its clean energy resources, from data and clean fuels to precision fermentation-based products. There is also a further crucial role for government in both ensuring that the country's workforce is adequately skilled to capitalise on the economic opportunity presented by hydrogen and the energy transition, as well as driving public acceptance to further accelerate adoption.

Key areas of future work that have been identified include a review of policy mechanisms from other jurisdictions and sectors to aid in the appropriate design of effective public support for hydrogen and related industrial sectors. This would involve the assessment of both capital and operational supports, given the large proportion of hydrogen cost attributed to the cost of electricity. Analysis as to how policy can enable hydrogen to utilise electricity at times of high renewables output to minimise costs, and help to reduce curtailment and constraint issues is of particular importance. Further examination of and planning for the role of the gas grid and large-scale hydrogen storage in Ireland's future energy system is also a key priority. Further work could analyse Ireland's potential sectoral demand for hydrogen in more detail, identifying key locations, and estimating end-use specific costs to ascertain affordability and compare to other clean solutions. Given Ireland’s shared energy system with Northern Ireland, cross-border collaboration on hydrogen and industrial policy development would be advantageous to maximise impact and ensure alignment.

Without doubt, hydrogen, in conjunction with offshore wind at scale, can be a catalyst for the transformation of the Irish economy, delivering energy security and economic growth. Ireland has the potential to develop world leading industries based on its abundance of clean energy, from provision of power to large energy users, to the production of high-value products such as e-fuels for aviation. Progress of early projects must not be delayed, with flexible government support prioritised for projects which contribute towards Ireland’s long-term vision of a clean, secure, and prosperous economy.

References*

ACER. European hydrogen markets 2025 market monitoring report. 2025.

Aryanpur, V., Rogan, F. Decarbonising road freight transport: The role of zero-emission trucks and intangible costs. *Sci Rep* 14, 2113. 2024

Climate Action And Low Carbon Development (Amendment) Bill. 2021

Department of Transport. Ireland's Sustainable Aviation Fuel Policy Roadmap. 2025.

Draghi, M. The Future of European Competitiveness. 2024.

Ember. Global Electricity Mid-Year Insights 2025. 2025.

EirGrid and SONI. Tomorrow's Energy Scenarios. 2023

EirGrid Group. All-Island Resource Adequacy Assessment 2025-2034. 2025

EirGrid Group. Delivering a Secure, Sustainable Electricity System. 2021

EirGrid Group. System and Renewable Data Reports. 2025

Electricity Association of Ireland. Our Zero Emission Future. 2021

Energy Transitions Commission. Mission Possible: Reaching Net-Zero Carbon Emissions From Harder-To -Abate Sectors By Mid – Century. 2018

European Union. Regulation (EU) 2023/2405 of the European Parliament and of the Council of 18 October 2023 on ensuring a level playing field for sustainable air transport (ReFuelEU Aviation). 2023

ESB. Driven to Make a Difference: Net Zero by 2040 Strategy. 2024

ESB. Net Zero 2040 Pathway Report. 2024

European Commission. Alternative Fuels Infrastructure. 2024

European Commission, The European Green Deal. 2019

European Commission. Renewable Energy Directive. 2023.

European Commission. Renewable Hydrogen. 2023

Eurostat. Solar: main source of EU electricity in June with 22%. 2025

European Union, REPowerEU. 2022

Gas Networks Ireland. Ireland's Gas Network – Keeping Ireland's energy moving. 2025

Gas Networks Ireland. Network Development Plan. 2024

Gentille and Gupta. Orchestrating the narrative: The role of fossil fuel companies in delaying the energy transition, Renewable and Sustainable Energy Reviews. 2025

Government of Ireland. Climate Action Plan. 2025

Government of Ireland. National Hydrogen Strategy. 2023

Government of Ireland. Powering Prosperity – Ireland's Offshore Wind Industrial Strategy. 2024

Hydrogen Mobility Ireland. Collective Ambition of HMI Members. 2024

Hydrogen Mobility Ireland. The Need for and Vision of Hydrogen Mobility in Ireland. 2024

IEA. World Energy Outlook 2020. 2020

Irish Fiscal Advisory Council and Climate Change Advisory Council. A colossal missed opportunity: Ireland's climate action and the potential costs of missing targets. 2025

Mehigan and Deane, Our Zero e-Mission Future. 2020

Moran, C. Challenges and opportunities in future hydrogen supply chain design and operation: A techno-economic analysis. University of Galway. 2024

Our World in Data. Why did the renewables become so cheap so fast? 2020 (Updated in 2025)

Roland Berger. The promise of precision fermentation: Can it really change the game? (2025).

Sustainable Energy Authority of Ireland. Low Carbon Gases for Heat. 2022

Sustainable Energy Authority of Ireland. National Heat Study. 2022

Wind Energy Ireland. Hydrogen and Wind Energy. 2022

Wind Energy Ireland. Ireland's Offshore Wind Potential. 2023Yue, X et al. Least cost energy system pathways towards 100% renewable energy in Ireland by 2050. 2020

Wind Energy Ireland. National Port Study. (2022).

**Many of the sources which informed this study are not publicly available, including unpublished academic work and commercially sensitive data. For more detail see Appendices.*