

Insight paper

Assessing the potential of hydrogen in decarbonising residential heating in Ireland

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About the authors



Devasanthini Devaraj

Modelling Analyst

Cornwall Insight

+44 (0)1603 542176

d.devaraj@cornwall-insight.com

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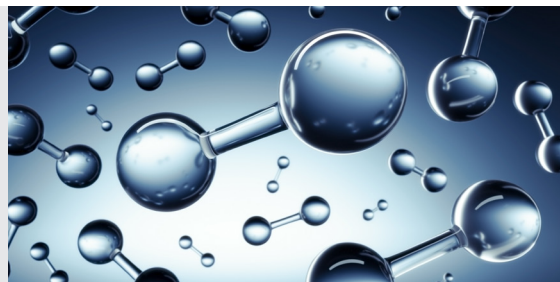
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Assessing the potential of hydrogen in decarbonising residential heating in Ireland



1. Executive Summary

Ireland has an ambitious vision to reach net zero by 2050, and decarbonising residential heating is a significant challenge. This report examines the potential for hydrogen-based heating solutions in decarbonising residential heating in Ireland.

On comparing the various options of using hydrogen for domestic heating in Ireland, hydrogen blending in the gas network is likely the most effective solution. It provides a non-disruptive solution to the consumers and yields substantial CO₂ savings.

Based on our analysis, we estimate ~1 TWh of hydrogen demand annually to supply 20% hydrogen blended gas to the domestic sector. Other hydrogen heating solutions, although technically feasible, are restricted by connectivity to the gas network and the availability of more efficient heating solutions such as heat pumps.

2. Residential heating in Ireland

Ireland has approximately two million households, and 79% of these households use oil, gas or peat for space and water heating. Oil has been the largest source of heating fuel since 2000, followed by natural gas.

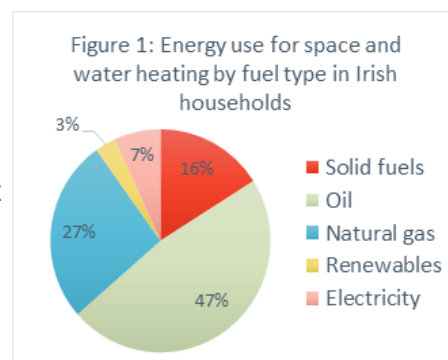
According to Gas Networks Ireland (GNI), 706,000 homes are connected to the natural gas network currently, with GNI aiming to connect an additional 300,000 homes to the gas network in the short to medium-term future.

The annual energy use in an average Irish home is 18.5 MWh (~15 MWh for a UK household), where 61% and 19% of the energy are used for space and water heating respectively.

2.1. Challenges in decarbonising the heat sector

The residential sector accounts for 29% of the country's total CO₂ emissions, which is significantly higher compared to the UK's domestic sector which accounts for 14% of its CO₂ emissions. Meeting on-demand heating needs in a secure and reliable way is challenging, which in turn makes decarbonising the sector extremely difficult. The optimal heating solution for households will vary depending on technology availability, property type, consumer preferences, fuel prices, and government policies. It is unlikely that a single low carbon heating solution will be adopted across the country; a mix of technological solutions including hydrogen-ready boilers and heat pumps can be expected in the net-zero future.

Gas energy sources have the advantage in terms of compression/storage, and hence blending hydrogen with natural gas in the gas network could become a key strategy to eliminate the need for co-deployment of hydrogen supply and demand technologies.



Source: Sustainable Energy Authority of Ireland

2.2. Renewable gas in the gas network

GNI established a dedicated biomethane injection point into the gas network in 2019. The entry point in Cush Co. Kildare, currently supplying 36 GWh of domestically produced biomethane, is capable of supplying renewable gas to 9,000 homes. Approval last year for a second renewable gas injection facility is expected to increase biomethane capacity to supply 75,000 homes. Supplying biomethane through gas networks has been identified as the cheapest decarbonisation pathway for domestic heat. Hence, gas networks in Ireland will have a major role in decarbonising domestic heat in homes that are connected, or will be connected, to the gas network.

GNI targets net zero by 2050, with natural gas being gradually replaced by a mix of biomethane, abated natural gas (natural gas with Carbon Capture and Storage (CCS)) and hydrogen. GNI's short to medium-term vision is to use available and mature energy sources such as natural gas and biomethane. Plans include injecting 11 TWh of renewable gas into the gas networks by 2030 and adopting technologies such as CCS and hydrogen in the long term (post-2035). Initial hydrogen injection is expected to enter the gas network in the mid-2030s, and by 2050 hydrogen would constitute 13% (11 TWh) of total gas in the network.

2.3. Opportunities for hydrogen

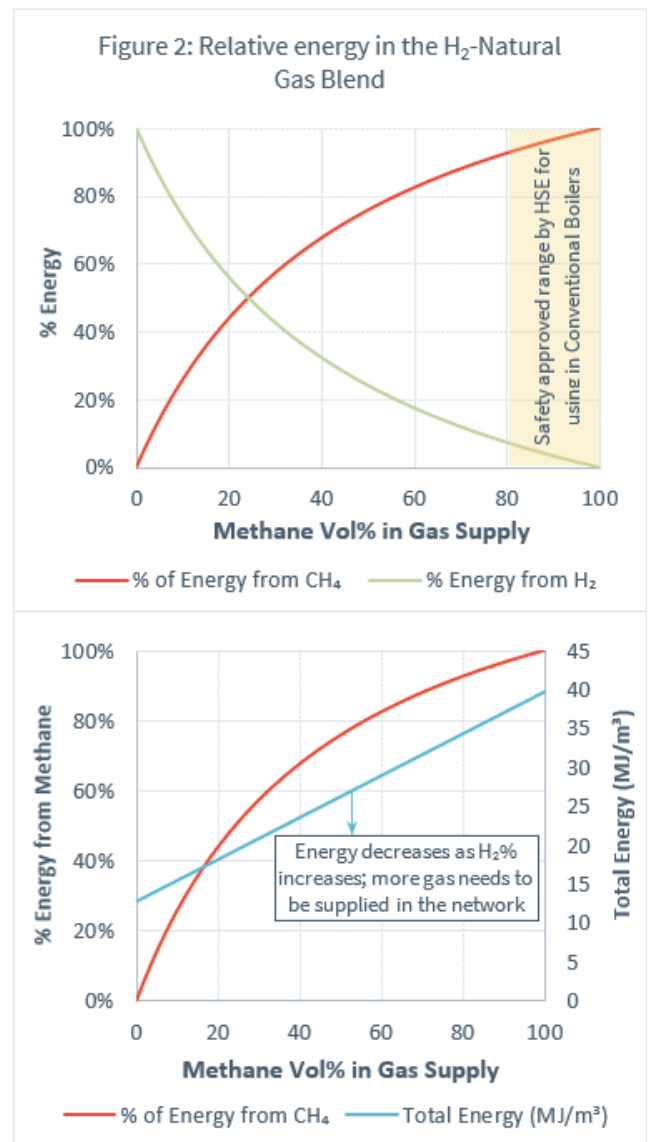
The Irish Government is working on releasing a national hydrogen strategy by the end of Q2 22. Hydrogen consumption targets are likely to be set for industry, heavy road transport, aviation, shipping, and power generation. However, hydrogen for heating in buildings is not likely to be prioritised. In comparison, UK's hydrogen strategy perceives domestic decarbonisation using hydrogen heating solutions along with heat pumps.

3. Technological feasibility of using hydrogen for heating in homes

There are three potential hydrogen heating solutions: hydrogen blending in natural gas network, hydrogen-ready boilers, and H₂ hybrid heating (heat pump + hydrogen boiler). Table 1 compares the potential installation and operating costs of these hydrogen-based heating solutions.

3.1. Hydrogen blending in gas network

Up to 20% hydrogen will be blended with natural gas in the gas network, and the conventional boilers will burn the blended gas. This is widely regarded as a short-term decarbonisation solution and will be rolled out as early as 2023 in countries like the UK.



Source: Cornwall Insight

3.2. Hydrogen-ready boilers

A hydrogen boiler works similarly to a natural gas boiler but burns hydrogen instead of natural gas. As the properties of hydrogen are different to natural gas, some parts of the boiler such as the flame detector and burner operate differently compared to a natural gas boiler. Boilers for 100% hydrogen are not commercially available yet, although several boiler manufacturers including Worcester Bosch and Viessmann have been developing a hydrogen-ready boiler.

A hydrogen-ready boiler is designed to run on a combination of gases including hydrogen. Therefore, they will initially burn natural gas or a 20% hydrogen – natural gas blend. It can be easily modified to run on 100% hydrogen if and when the gas network is transitioned to 100% hydrogen. The manufacturers are aiming to make them available for deployment as early as 2025 (in the UK). Their cost and installation time are similar to a conventional gas boiler and are a less disruptive alternative to consumers compared to heat pumps.

3.3. H₂ hybrid heating

Hybrid heating solutions are an established and available technology. Households using H₂ hybrid heating will have a heat pump and a hydrogen boiler operating alongside each other. The cost and duration (an average of 2.5 days) of installation are similar to heat pump only systems. However, the size of the heat pumps is smaller for a similar household due to the nature of the system.

Table 1: Comparison of hydrogen-based heating solutions for an average Irish home

Category	100% H ₂ Boiler	20% H ₂ Boiler	H ₂ Hybrid Heating	HP
Upfront Installation Cost € ^{1,8}	3250	2900	13300	18000
Recommended Home Upgrade Cost € ^{2,8}	7000	7000	7000	-
Annual Fuel Requirement MWh ³	16.4 (H ₂) ⁴	15.19 (NG) + 1.21 (H ₂) ^{4,5}	4.02 (Electricity) + 3.06 (H ₂) ^{4,6}	4.90 (Electricity)
Annual Fuel Cost € ⁷	2381	1239	1404	1233

Source: Cornwall Insight, Energy and Utilities Alliance, Sustainable Energy Authority of Ireland

¹ It includes installation cost and maintenance for the first year.

² It includes cost of window glazing, loft and wall insulation. Cost of home upgrade varies with house type and an average value is used here. Recommended upgrades are considered 'required' for heat pump installations and its cost is included in the upfront cost.

³ Annual energy use in an average Irish home is used as a reference to calculate annual fuel requirement.

⁴ Efficiency of H₂ boiler and Hydrogen-ready Boiler is 90%.

⁵ Fig 2: In 20% H₂ blend, 7.39% of the energy is supplied from H₂.

⁶ In H₂ hybrid heating, 81.4% of the daily heating demand is supplied from H₂ (based on Hourly dispatch profile for Hybrid Heat Pump and H₂ Boiler from Future Energy Scenarios UK 2020).

⁷ According to Sustainable Energy Authority of Ireland, the domestic consumers paid €70/MWh and €250/MWh for natural gas and electricity in 2020. H₂ is priced at €7.2/kg, which is the cost of SMRCCS in the Netherlands.

⁸ Currency conversion from GBP to Euro applied.



Having discussed the different options of using hydrogen for domestic heating in Ireland, hydrogen blending in the gas network will be the most likely solution

4. Implementation potential for hydrogen-based heating solutions

Hydrogen has a lower density compared to natural gas and will be transported at a higher pressure in the gas network. Hence, an additional internal piping upgrade which costs around €95 (per household) will be needed while installing a hydrogen-ready boiler or H₂ Hybrid heating solution in households. The wide adoption of hydrogen-ready boilers needs repurposing natural gas infrastructure to include Hydrogen Grid Entry Unit (GEUs), mixers and analysers, and facilities to transport or store hydrogen-natural gas blends.

Large industrial clusters that are direct off-takers of hydrogen (refineries, ammonia, and steel production) exist in countries such as the UK and Germany. They are set to facilitate the development of a dedicated regional hydrogen network, supplying hydrogen for domestic heating and favour the transition to 100% hydrogen boilers. However, the Irish industrial landscape (pharmaceuticals, food and beverages) is different and does not provide an optimal landscape for hydrogen network development. This greatly limits the transition to 100% hydrogen boilers in households.

Adopting H₂ hybrid heating is constrained by three major elements:

- Widespread uptake of heat pumps,
- Deep retrofitting of houses to improve energy efficiency, and
- Gas grid connectivity to ensure hydrogen supply.

Therefore, H₂ hybrid heating is an unlikely decarbonisation solution for Ireland.

Currently, only a third of the households in Ireland are connected to the gas grid. The cost incurred by the consumers for gas connection is outlined in Table 2, which shows obtaining a one-off connection is less expensive. However, the process can be expensive and challenging for a non-gas estate connection. For example, a mains extension costing €75,000 to connect 50 households would cost €1,150 per household, and the standard domestic connection charges will apply. The low gas network connectivity limits the adaptation of hydrogen-based solutions further.

Table 2: Cost estimate to connect household to gas network in Ireland

Scenario	Connection Charges by GNI
A one-off connection where a house exists in the gas area.	€250 for pipe lengths <15 m Additional €51 per metre for pipe lengths >15m
Non-gas estate connection which requires an extension of the mains pipeline. At least 20% of the properties in the estate need to be interested to obtain a non-gas estate connection.	Standard domestic connection charge applies (as above). Supplemental charge to cover the cost of mains extension (excess of cost over expected network tariff revenue needs to be paid by the consumers).

Source: Connections Policy Document (Gas Networks Ireland)

Having discussed the different options of using hydrogen for domestic heating in Ireland, hydrogen blending in the gas network will be the most likely solution. Blending hydrogen in the gas network provides non-disruptive carbon savings while using the existing infrastructure. A tonne of CO₂ emissions can be avoided annually by supplying a 20% hydrogen blended gas to just 7 Irish households. We estimate 0.9 - 1.2 TWh of hydrogen will be required to supply 20% hydrogen-blend gas to all the households connected to the gas grid, which in turn needs ~2 GW of dedicated renewable capacity to generate the estimated hydrogen demand.

5. Next steps and recommendations

Several hurdles need to be overcome to create confidence in progressing hydrogen in the domestic sector in Ireland. Some of the key steps that need to occur are:

5.1. Investigate Irish housing stock

To further determine the feasibility of uptake of hydrogen boilers or H₂ hybrid heating, various features of Irish housing stock such as income, energy efficiency improvements, property type, tenure, and grid connectivity needs to be investigated in detail.

5.2. Demonstrate feasibility and value of hydrogen blending in the gas network

Across Europe, the permitted levels of hydrogen in the gas network vary between 0.1% and 12%. Successful demonstration of feasibility and safety of varying levels of hydrogen blend in the gas network is required to roll out the solution nationwide. In addition, robust evidence to demonstrate consumer experience in using hydrogen-natural gas blends needs to be established.

In November 2021, GNI's hydrogen innovation facility in Dublin launched a pilot study to investigate the operation and performance of household appliances with varying levels of hydrogen blends in natural gas. Other examples of success have been in the UK where HyDeploy demonstrated the viability of hydrogen injection (20%) into the gas network, although mixed views were obtained for adopting 100% hydrogen as it required significant disruption.

5.3. Establishing government targets

Installing new oil and gas boilers in new builds is expected to be banned from 2022 and 2025 respectively, but more binding targets for low carbon heating solutions are needed. For example, targets for hydrogen injection into the gas grid set by the government can enable the wider adoption of hydrogen heating solutions in Ireland. In addition, the current exclusion of renewable gas as renewable technology by the building regulations do not favour renewable gas-based heating. Therefore, state support is required to cover the price gap between wholesale natural gas and the cost of producing renewable gas.

5.4. Progress in low-carbon hydrogen production

There is little progress in hydrogen supply development so far. Currently, Ireland has one commercial electrolyser in Dublin producing 200 kg/day (~2.9 GWh annually) hydrogen for aerospace, pharmaceuticals, and biomedical industries. We identified eight project proposals for low-carbon hydrogen production in Ireland, yet they are all at the concept phase with limited planning or undergoing feasibility studies.

If you would like to find out more about our hydrogen services, please contact Robert Buckley on 01603 604400, or email r.buckley@cornwall-insight.com.

See also our Insight paper [*Industrial decarbonisation key for UK low carbon hydrogen, October 2021*](#)

CORNWALL INSIGHT

CREATING CLARITY

The Academy, 42 Pearse St
Dublin, D02 YX88

T +353 (0) 657 3420

E enquiries@cornwall-insight.ie

W cornwall-insight.ie