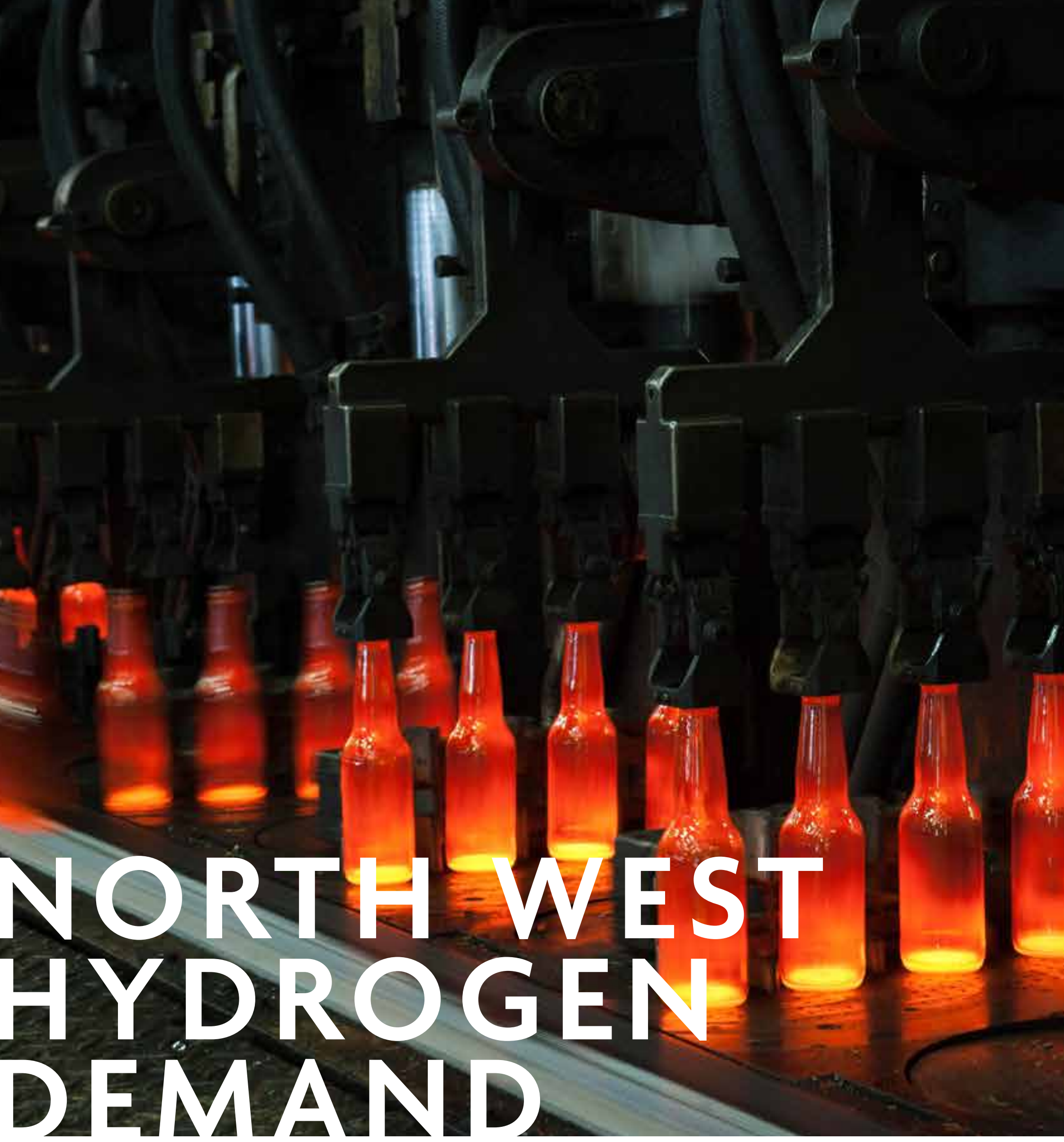

NORTH WEST HYDROGEN DEMAND

SIDE STUDY 2024

www.nwhydrogenalliance.co.uk

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CONTENTS

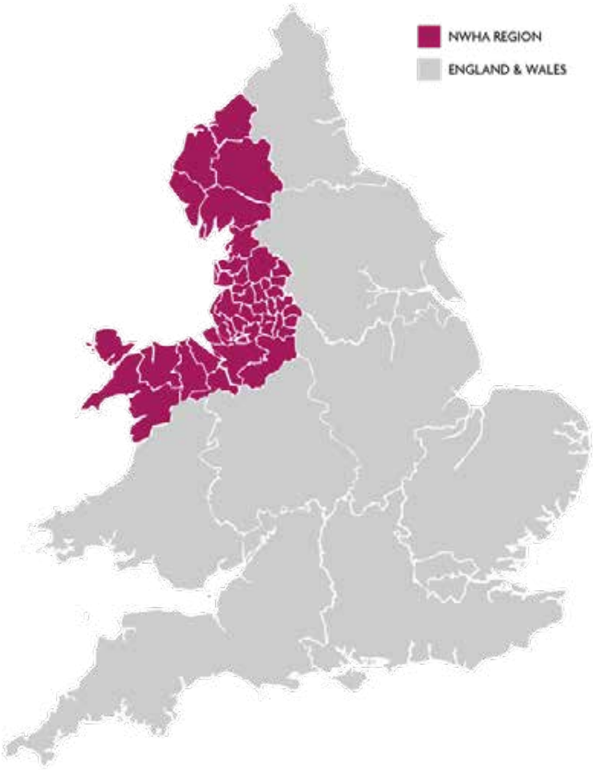
OVERVIEW

LOCAL SITES
suitable for CO_2 and hydrogen storage

LARGE INDUSTRIAL
energy demand in the region

BETWEEN 32 & 48 TWh
of low carbon hydrogen demand

This study will use existing demand studies, conducting a combination of top-down and bottom-up analysis to deliver a projection of future hydrogen supply and demand (defined in TWh) in the North West region, up to 2050.



SCOPE OF THIS PROJECT:

REGION

North West of England (including Cumbria) and North Wales.

SCENARIOS

Include three scenarios with levels of hydrogen use (low, central and high).

SECTORS INCLUDE:

Sectors: Include the following sectoral breakdown:

- Power
- Industry
- Transport
- Heat

EXECUTIVE SUMMARY

- The North West of England & North Wales region has lots of factors that lend itself to early adoption of hydrogen, including a large industrial energy demand, local sites suitable for CO_2 storage and salt layers which are suitable for salt cavern hydrogen storage. This has led to the region having some of the most developed early projects.
- This study estimates that by 2050 there could be between 32 and 48 TWh of low carbon hydrogen demand in the region. This level of demand could be supported by 5.0 – 7.5 GW of low carbon hydrogen production capacity.
- Industry and power generation are expected to be the first movers for significant volumes of hydrogen demand. These sectors could be responsible for up to 11 TWh of hydrogen demand by 2030 in the region.
- By 2030, hydrogen demand could vary between 4.5 and 12.5 TWh. These levels of demand would have an associated production capacity between 0.7 and 2.0 GW.

THE HYDROGEN PRODUCTION BUSINESS MODEL

The Hydrogen Production Business Model (HPBM) is the UK government's policy for incentivising production and demand for low carbon hydrogen. It is a two-way variable premium model, similar to offshore wind Contract for Differences (CfDs), however the HPBM has multiple reference prices and other features that make it more complex such as a price discovery incentive.

The level of subsidy for a producer may change over time depending on the achieved sales price and the natural gas price.

Aims of business model:

- Provide a level of revenue certainty for hydrogen producers
- Create a market for low carbon hydrogen by making hydrogen available for end users at cost as low as natural gas
- Ensure value for money for government by making producers pay back if hydrogen price rises above strike price

This policy is the main lever to incentivise switching to low carbon hydrogen by making hydrogen available to end users at the price potentially as low as natural gas[1]. There are other supporting policies such as UK Emissions Trading Scheme (ETS) that impose costs on fossil fuel use and create additional incentives for decarbonisation.

HYDROGEN DEMAND: INDUSTRY

INDUSTRY

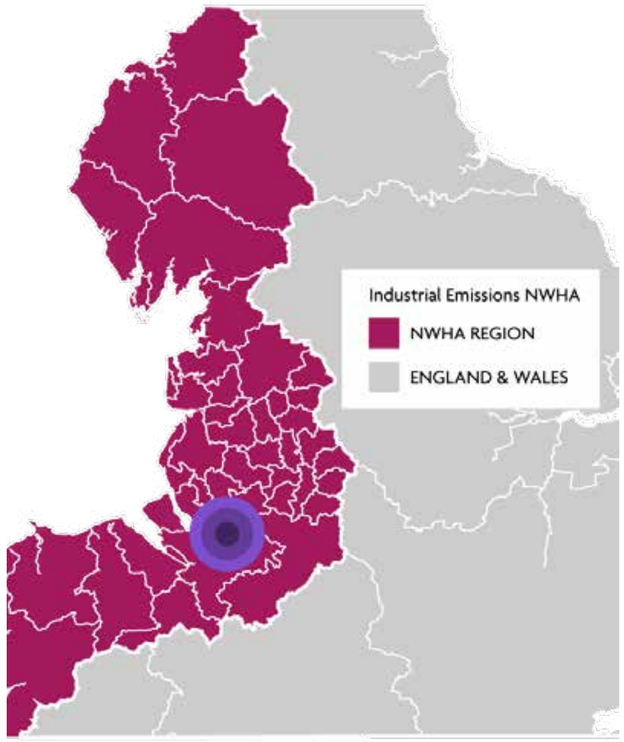
INDUSTRIAL EMISSIONS & HYDROGEN'S ROLE

- Current industrial emissions in NWHA – 8.0 Mt CO_{22}
- Industrial emissions in North West Industrial Cluster – 5.0 Mt CO_{23}
- The adjacent heat map shows how concentrated the industrial emissions in the region are around the Merseyside area.
- Competitor energy sources and key markets:

  - Electrification: Low temperature processes

  - Gas w/Carbon Capture Storage (CCS): Large high temperature sites

  - Biomass/biofuels: Range of processes but availability concerns



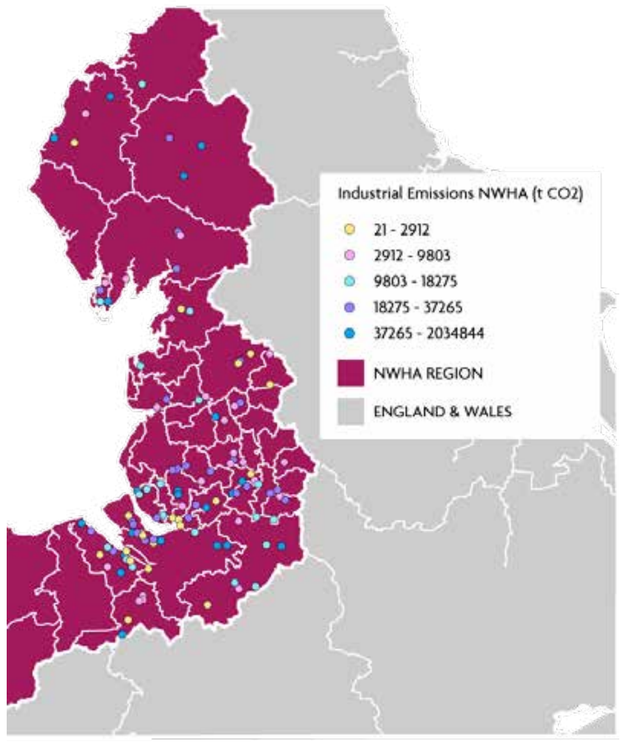
INDUSTRIAL EMISSIONS & POLICY DRIVERS

1. Current policy

- Hydrogen Production Business Model: Provides hydrogen to end users for a price as low as natural gas[1].
- UK Emissions Trading Scheme (ETS): Places a carbon price on industrial emissions (although majority of industrial allowances are currently provided for free)[4].

2. Potential future policies

- Carbon Border Adjustment Mechanism (CBAM): WOULD place a carbon price on imports allowing the removal of free allowances from UK ETS[5].
- Carbon CfD: Would create greater certainty of carbon price.
- Product Standards: Would phase out the use of high carbon products in certain sectors[5].
- Public Procurement: Would create demand for low carbon products[5].

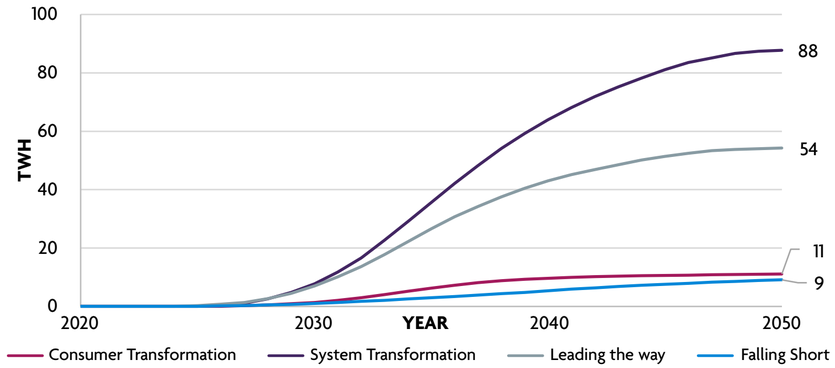


HYDROGEN DEMAND: INDUSTRY METHODOLOGY

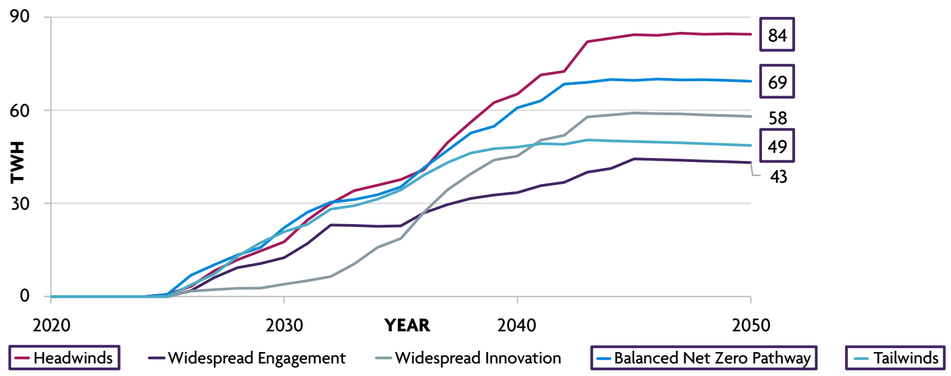
Two sources were used for an initial investigation of industry demand for hydrogen on a nationwide scale:

- Future Energy Scenarios 2023(FES)- National Grid (GB)[6]
- Sixth Carbon Budget (6CB) - Carbon Change Committee (UK)[7]

INDUSTRY DEMAND FOR HYDROGEN IN GB (FES)



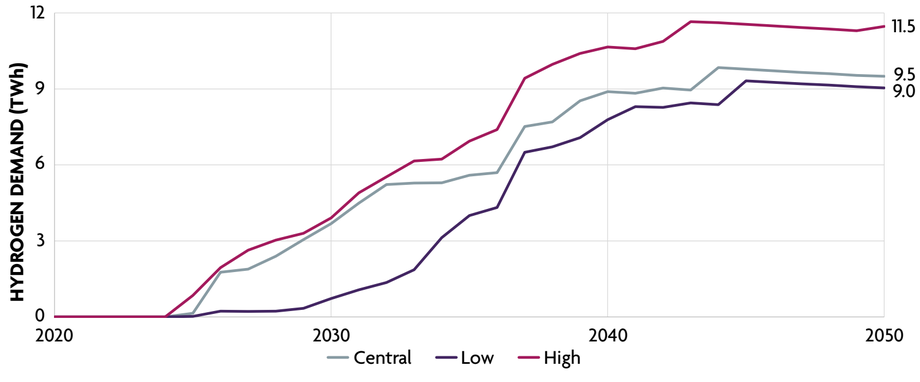
INDUSTRY DEMAND FOR HYDROGEN IN GB (FES)



N-ZIP model was run for each of the three highlighted scenarios in the NWHA region[8]

HYDROGEN DEMAND: INDUSTRY RESULTS

HYDROGEN DEMAND FOR INDUSTRY IN NORTH WEST ENGLAND & NORTH WALES



HYDROGEN DEMAND: TRANSPORT

TRANSPORT

HYDROGEN DEMAND: TRANSPORT POLICY DRIVERS

- Hydrogen Production Business Model: Provides hydrogen to end users for a price as low as natural gas.

- Renewable Transport Fuel Obligation: Places an obligation for fuel suppliers to provide an increasing proportion of low carbon fuels.

SURFACE TRANSPORT

- Fossil fuel phase out date: Provides a backstop for the sale of new fossil fuel vehicles.

MARITIME

- UK ETS: Maritime's inclusion in ETS is expected to begin in 2026 with the government consulting on details. Once included this will increase the cost of high emission fuels and increase incentives to switch to lower carbon alternatives.

AVIATION

- UK ETS: Aviation will have its free allocation under UK ETS phased out by 2026. This will apply a carbon price to emissions from aviation and increase incentives for low carbon fuels.

- SAF Mandate: The SAF (sustainable aviation fuel) mandate will place on obligation on aviation fuel suppliers to provide an increasing proportion of low carbon fuels. This will be introduced in 2025 and government have committed to 10% of jet fuel being from sustainable sources by 2030.

- SAF Revenue Certainty: Government have committed to introduce a revenue certainty scheme for SAF. This could be based on a CfD model, but details are yet to be consulted on.

HYDROGEN DEMAND: TRANSPORT METHODOLOGY

1. Using the Future Energy Scenarios (National Grid, 2023), nationwide hydrogen demand data for each transport type was collated, processed, and plotted.

2. The government's Statistics Data Tables for the North West England and North Wales were then used to determine the proportion of transport in these regions compared to Great Britain.

3. This proportion was directly applied to the nationwide hydrogen demand to estimate the hydrogen demand in North West England and North Wales.

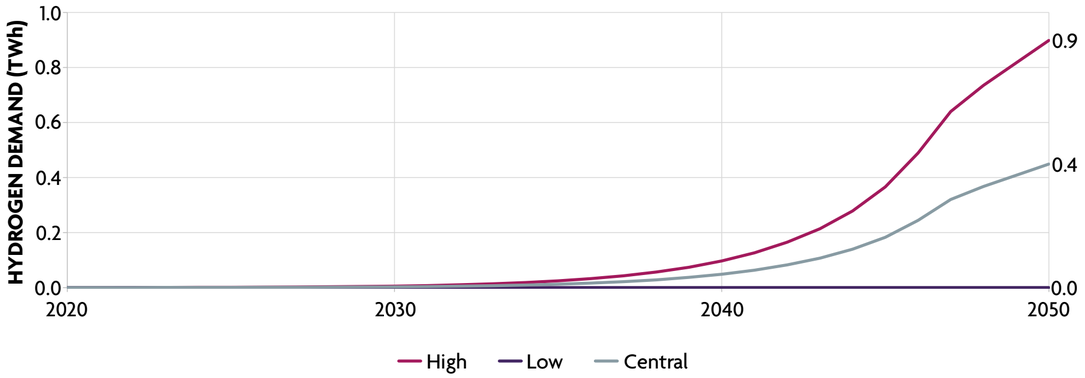
SURFACE TRANSPORT

HYDROGEN DEMAND: CARS

Sources: Future Energy Scenarios (National Grid, 2023)[6] & DfT's Licensing Statistics Data Tables[13]

Proportion of LGVs in North West England and North Wales: 11.61%

HYDROGEN DEMAND FROM CARS IN NORTH WEST ENGLAND & NORTH WALES

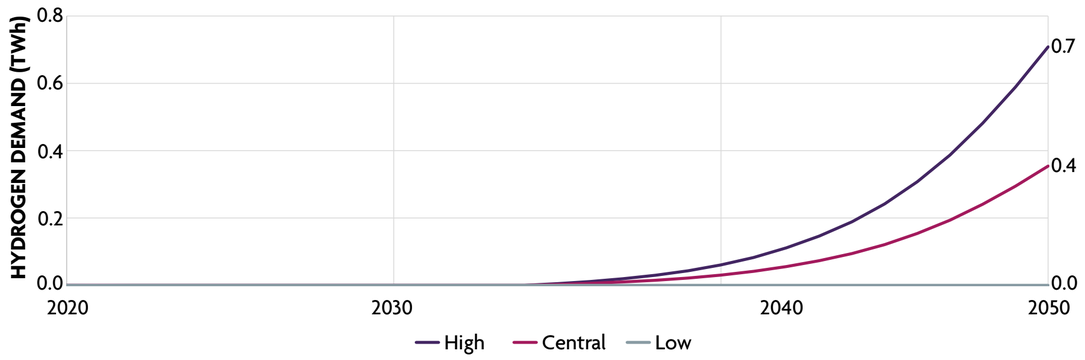


HYDROGEN DEMAND: LGVS

Sources: Future Energy Scenarios (National Grid, 2023)[6] & DfT's Licensing Statistics Data Tables[13]

Proportion of LGVs in North West England and North Wales: 11.61%

HYDROGEN DEMAND FOR LGVS IN NORTH WEST ENGLAND & NORTH WALES

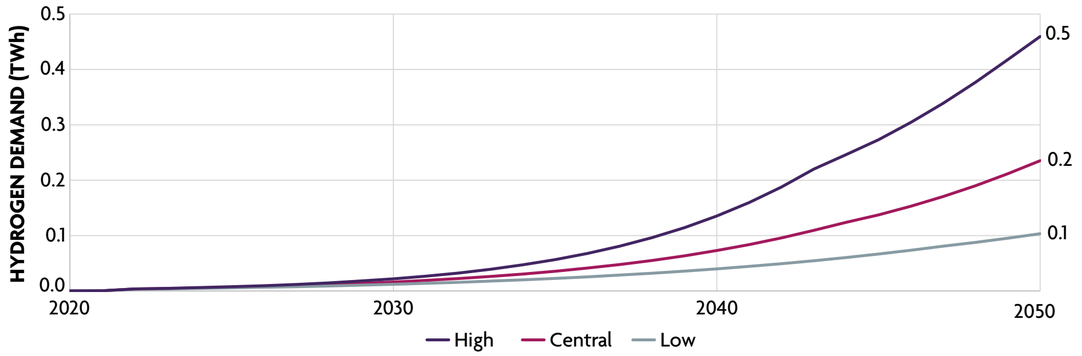


HYDROGEN DEMAND: BUSES

Sources: Future Energy Scenarios (National Grid, 2023)[6] & DfT's Licensing Statistics Data Tables[13]

Proportion of buses in North West England and North Wales: 11.44%

HYDROGEN DEMAND OF BUSES IN NORTH WEST ENGLAND & NORTH WALES

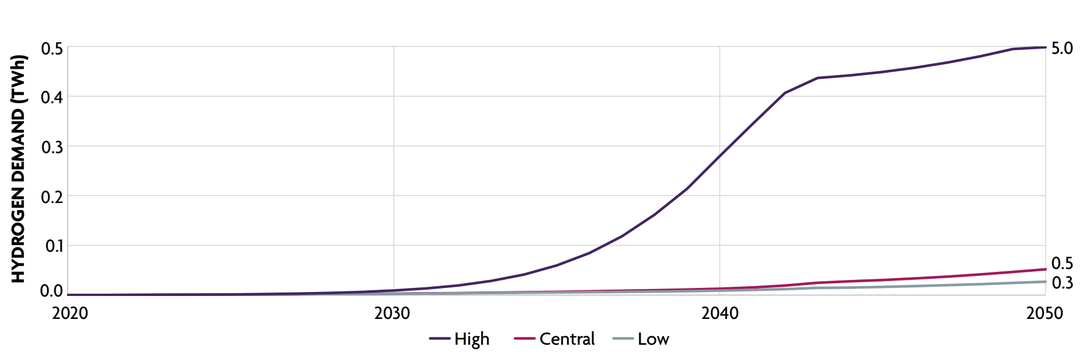


HYDROGEN DEMAND: HGVS

Sources: Future Energy Scenarios (National Grid, 2023)[6] & DfT's Licensing Statistics Data Tables[13]

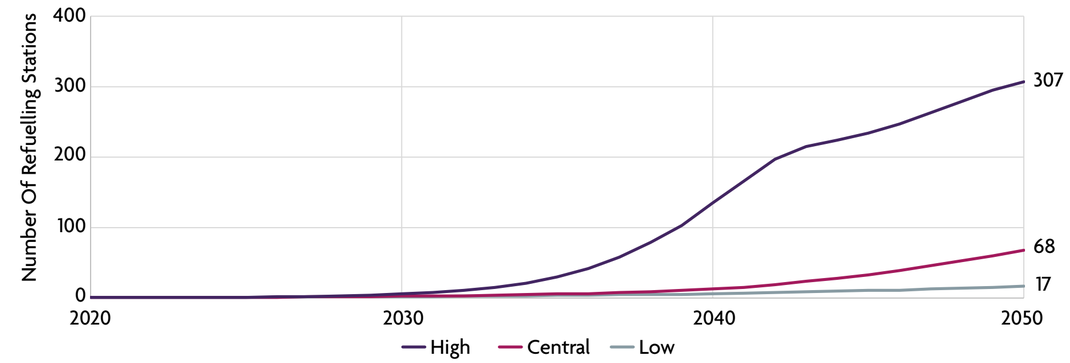
Proportion of HGVs in North West England and North Wales: 12.88%

HYDROGEN DEMAND OF HGVS IN NORTH WEST ENGLAND & NORTH WALES



HYDROGEN REFUELLING STATIONS

NUMBER OF 2T/DAY HYDROGEN REFUELLING STATIONS AT 80% UTILISATION

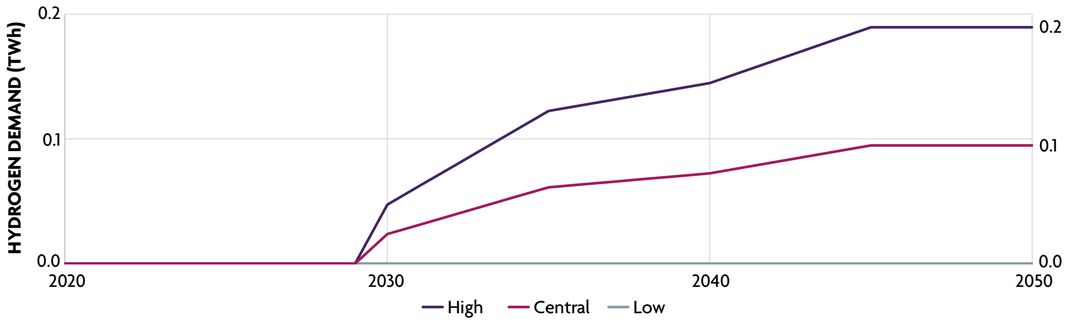


HYDROGEN DEMAND: RAIL

Sources: Future Energy Scenarios (National Grid, 2023)[6] & Office of Rail and Road's Entries and Exit data[14]

Proportion of Rail activity in North West England and North Wales: 9.09%

HYDROGEN DEMAND FOR RAIL IN NORTH WEST & NORTH WALES



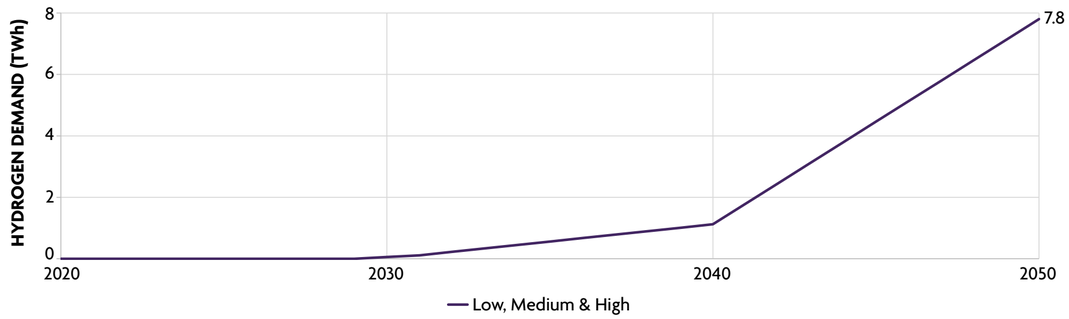
AVIATION

HYDROGEN DEMAND: AVIATION

Sources: Future Energy Scenarios (National Grid, 2023)[6] & Governments Statistics on Terminal Passengers[15]

Proportion of Aviation in North West England and North Wales: 11.21%

HYDROGEN DEMAND FOR AVIATION IN NORTH WEST ENGLAND & NORTH WALES



AVIATION COMPARISON TO LITERATURE

AIRPORT SIZE	SMALL		MEDIUM		SOURCE
Year	**2035**	**2050**	**2035**	**2050**	
Million Passengers Per Annum (MPPA)	7.5	10	35	50	ATI: Hydrogen Infrastructure and Operations
Average Daily LH_2 Demand (million litres)	0.1	0.7	0.6	6.5	
Average Daily LH_2 Demand (kg)	7,100	49,700	42,600	461,500	Calc
Annual LH_2 Demand (t)	2,592	18,141	15,549	168,448	
Annual LH_2 Demand ($GWh_{(HHV)}$)	102	715	613	6,637	Calc
Annual LH_2 Demand ($TWh_{(HHV)}$)	0.10	0.71	0.61	6.64	
NWHA IMPLIED DEMAND			**AIRPORT SIZE**		
Manchester airport annual passengers (MMPA)	30		Medium airport		DfT (AVI0102e)
Liverpool airport annual passengers (MMPA)	5		Small airport		
Implied hydrogen demand for region in 2035 ($TWh_{(HHV)}$)	0.71				
Implied hydrogen demand for region in 2050 ($TWh_{(HHV)}$)	7.35				

Aviation demand by scaling NG data:
- 0.56 $TWh_{(HHV)}$ in 2035
- 7.80 $TWh_{(HHV)}$ in 2050

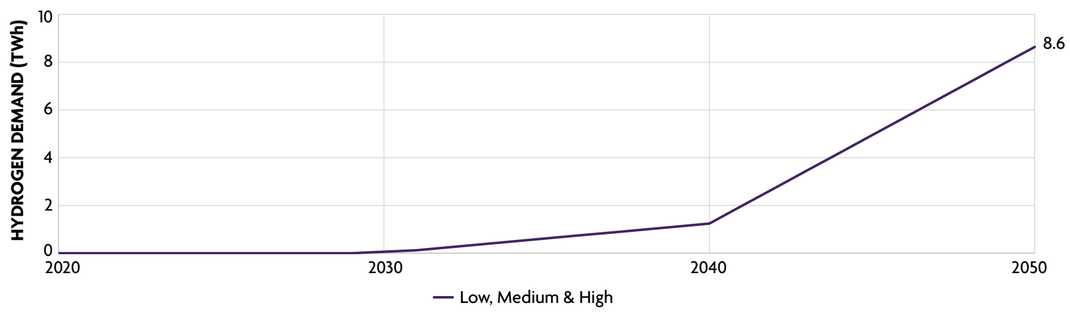
SHIPPING

HYDROGEN DEMAND: SHIPPING

Sources: Future Energy Scenarios (National Grid, 2023)[6] & Government's Maritime Statistics: Volume (millions) by cargo[16]

Proportion of Aviation in North West England and North Wales: 12.42%

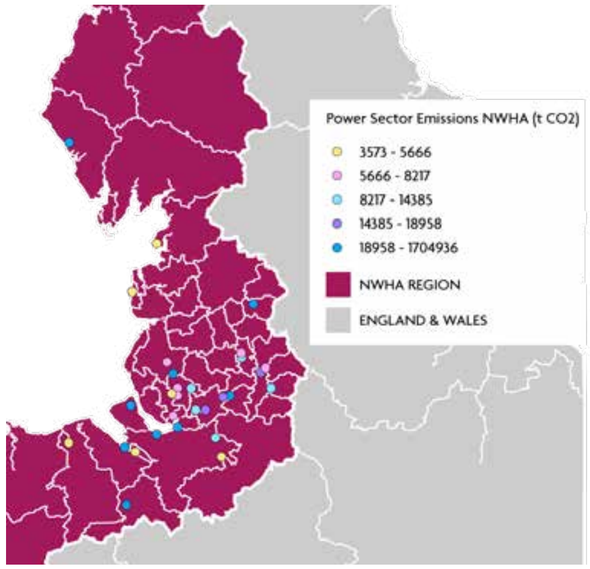
HYDROGEN DEMAND FOR SHIPPING IN NORTH WEST ENGLAND & NORTH WALES



HYDROGEN DEMAND: POWER

POWER SECTOR EMISSIONS & DECARBONISATION OPTIONS

- Current power sector emissions in region – 4.2 Mt CO_2[2]
- Government target to decarbonise the electricity grid by 2035[17]
- There are two key large-scale dispatchable technology solutions:
  - Hydrogen: expected to be cheapest technology for low load factor operation (below 20-30%)[18]
  - Gas with CCS: expected to be cheapest technology for higher load factor operation[18]
- Biofuels may also be used although feedstock availability may pose challenges.



POWER SECTOR POLICY

CURRENT POLICY

- UK ETS: The emissions trading scheme (ETS) places a carbon price on emissions (primarily from the power and industrial sectors). This increases the cost of high carbon power generation and encourages decarbonisation[4].
- Carbon Price Support (CPS): The carbon price support is a top up to the ETS for power generators. The current rate for the CPS is £18/tCO_2[19].
- Net Zero Electricity System by 2035: The government has a target for a Net Zero electricity system by 203517. Labour have announced plans to bring this target forward to 2030[20].

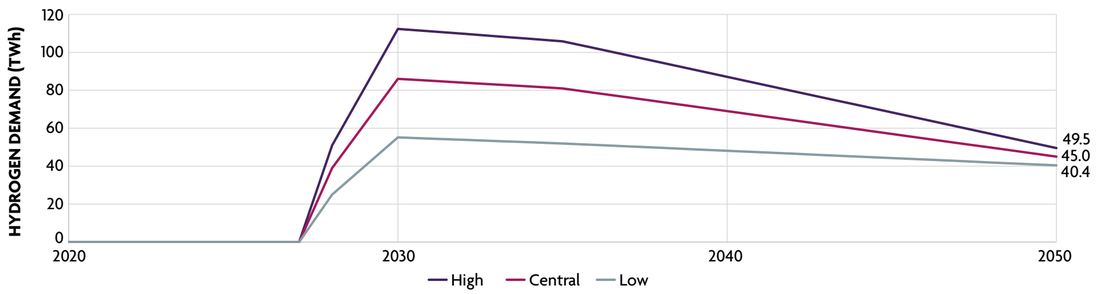
FUTURE POLICY

- Hydrogen to power business model: Government exploring the need for a hydrogen to power business model[21].

HYDROGEN DEMAND: POWER METHODOLOGY

Power demand estimates for the region are based on the CCC report, Delivering a reliable decarbonised power system (2023).

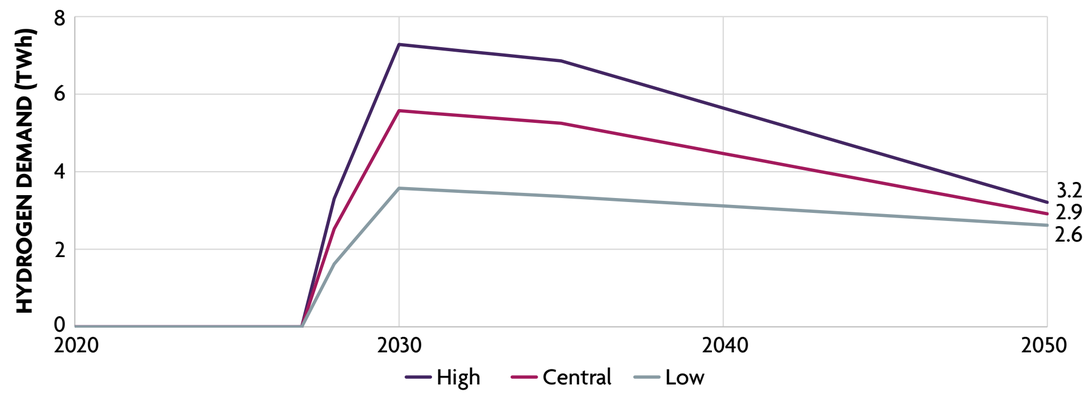
HYDROGEN DEMAND FOR POWER IN GREAT BRITAIN



Using the DUKES report on power stations in the GB to find the proportion of installed capacity of power stations in the North West England & North Wales compared to that of the rest of the GB – **6.44%**[23].

HYDROGEN DEMAND: POWER RESULTS

HYDROGEN DEMAND FOR POWER IN NORTH WEST ENGLAND & NORTH WALES



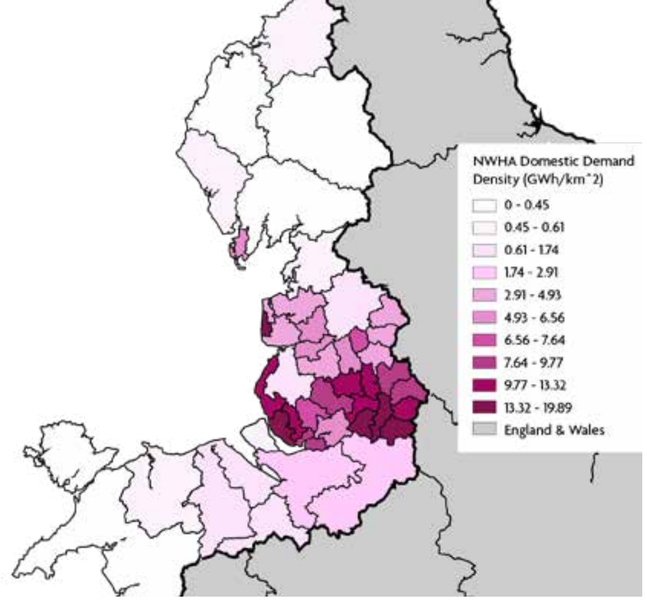
HYDROGEN DEMAND: HEAT

DOMESTIC NATURAL GAS CONSUMPTION & POLICY

Domestic natural gas consumption in the region is 43.4 TWh (2021)[24].

The map shows domestic natural gas demand density in GWh/km^2 in 2021, shown in deciles.

Key policy for hydrogen heat is the **2026 strategic decision on hydrogen heating** that the government is planning to take[25].

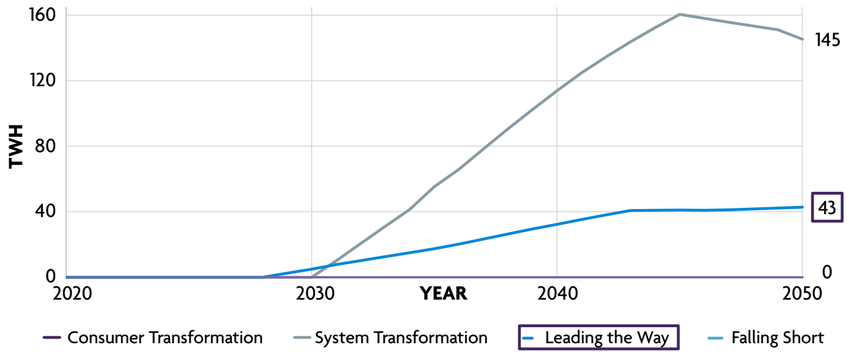


HYDROGEN DEMAND: RESIDENTIAL HEATING METHODOLOGY

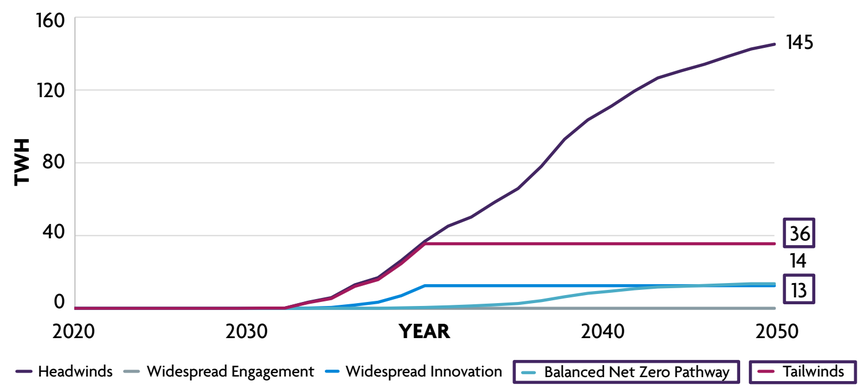
Two sources were used for an initial investigation of residential heating demand for hydrogen on a nationwide scale:

- **Future Energy Scenarios 2023(FES)** - National Grid (GB)[6]
- **Sixth Carbon Budget (6CB)** - Carbon Change Committee (UK)[7]

HYDROGEN DEMAND - RESIDENTIAL HEATING – GB (FES)



HYDROGEN DEMAND - RESIDENTIAL HEATING – UK (6CB)

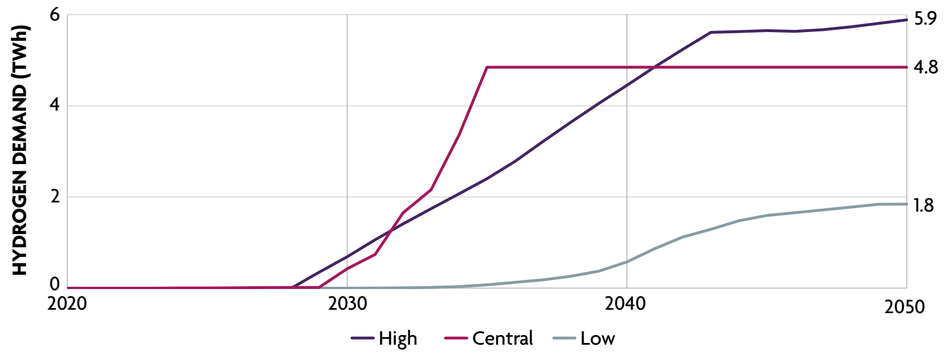


Used gas demand by local authority data to calculate the relative gas consumption in North West England and North Wales.

- **13.75%** of Residential heating in Great Britain
- **13.62%** of Residential heating in UK

HYDROGEN DEMAND: RESIDENTIAL HEATING METHODOLOGY

HYDROGEN DEMAND FOR RESIDENTIAL HEATING IN NORTH WEST ENGLAND & NORTH WALES



HYDROGEN DEMAND: RESIDENTIAL HEATING CONTEXT

- Assumed energy efficiency measures reduce heat demand based on Climate Change Committee (CCC) Scenarios[7]:
  - High - 11%
  - Central – 16%
  - Low – 12% (to keep consistency with Balanced Pathway used for demand)
- Heat demand per EPC band has been developed using current government data[26] and applying these assumed energy efficiency savings to each band.
- For the high and central demand scenarios, it is assumed that all homes that convert to hydrogen switch to hydrogen boilers. For the low scenario, it is assumed that the homes that use hydrogen use hybrid heat pumps with the hydrogen boiler supplying a quarter of demand.

HYDROGEN DEMAND: RESIDENTIAL HEATING CONTEXT

The table below shows the indicative proportions of each EPC band that could switch to hydrogen in the region, worse EPC ratings are more likely to switch to hydrogen due to less suitability for heat pumps.

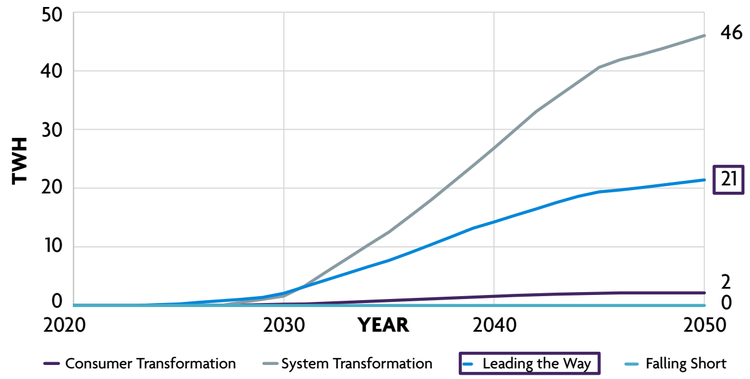
HIGH SCENARIO - 2050								
	EPC A	EPC B	EPC C	EPC D	EPC E	EPC F	EPC G	TOTAL
Proportion H2	0%	0%	10%	18%	30%	40%	50%	
Number of homes	18,067	479,262	1,530,345	1,234,084	298,461	71,240	28,440	3,659,900
Number of H2 homes	-	-	153,035	222,135	89,538	28,496	14,220	507,424
H2 demand (TWh)	-	-	1.44	2.61	1.23	0.42	0.17	5.88
CENTRAL SCENARIO - 2050								
	EPC A	EPC B	EPC C	EPC D	EPC E	EPC F	EPC G	TOTAL
Proportion H2	0%	0%	10%	15%	20%	40%	50%	
Number of homes	18,067	479,262	1,530,345	1,234,084	298,461	71,240	28,440	3,659,900
Number of H2 homes	-	-	155,330	190,049	60,886	28,496	14,220	448,981
H2 demand (TWh)	-	-	1.38	2.11	0.79	0.40	0.16	4.84
LOW (HYBRID) SCENARIO - 2050								
	EPC A	EPC B	EPC C	EPC D	EPC E	EPC F	EPC G	TOTAL
Proportion H2	0%	0%	0%	35%	40%	50%	60%	
Number of homes	18,067	479,262	1,530,345	1,234,084	298,461	71,240	28,440	3,659,900
Number of H2 homes	-	-	-	431,930	119,385	35,620	17,064	603,998
H2 demand (TWh)	-	-	-	1.25	0.40	0.13	0.05	1.84

HYDROGEN DEMAND: NON-RESIDENTIAL HEATING METHODOLOGY

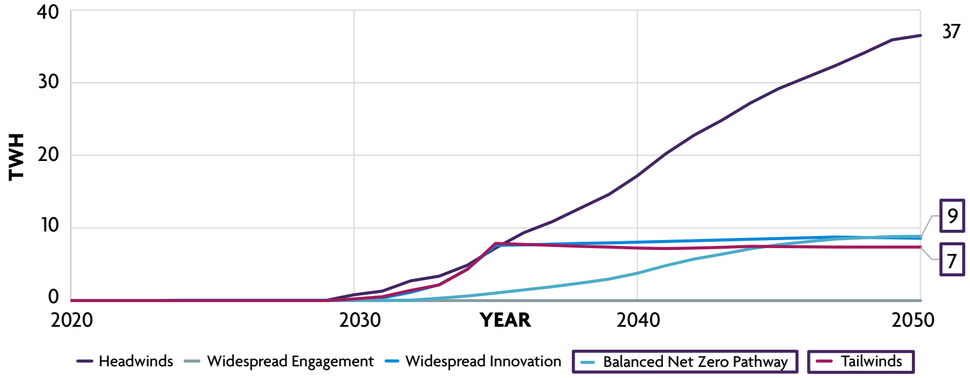
Two sources were used for an initial investigation of residential heating demand for hydrogen on a nationwide scale:

- **Future Energy Scenarios 2023(FES)** - National Grid (GB)[6]
- **Sixth Carbon Budget (6CB)** - Climate Change Committee (UK)[7]

HYDROGEN DEMAND – NON-RESIDENTIAL HEATING – GB (FES)



HYDROGEN DEMAND - NON-RESIDENTIAL HEATING – UK (6CB)

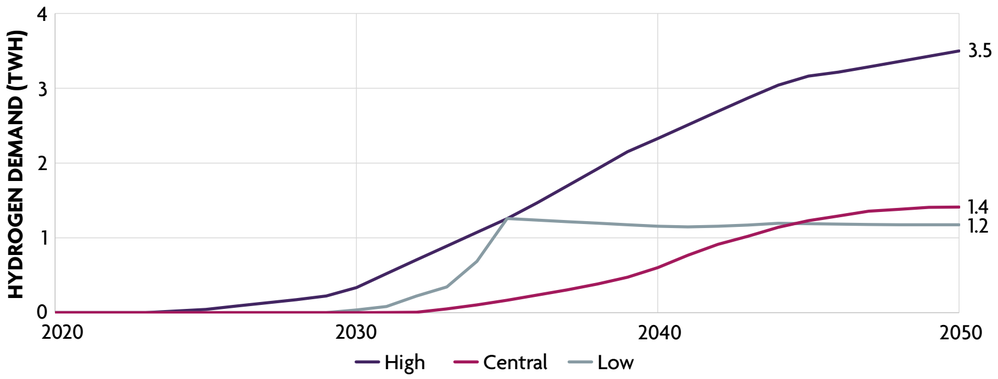


Used gas demand by local authority data to calculate the relative gas consumption in North West England and North Wales.

- **16.34%** of Residential heating in Great Britain
- **15.98%** of Residential heating in UK

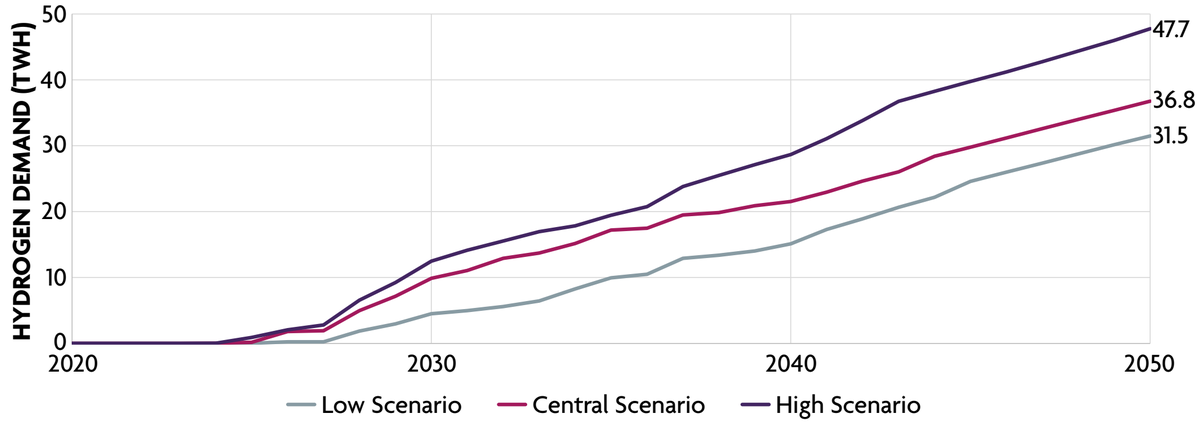
HYDROGEN DEMAND: NON-RESIDENTIAL HEATING METHODOLOGY

HYDROGEN DEMAND FOR NON-RESIDENTIAL HEATING IN NORTH WEST ENGLAND & NORTH WALES



TOTAL HYDROGEN DEMAND

TOTAL HYDROGEN DEMAND IN NORTH WEST ENGLAND AND NORTH WALES

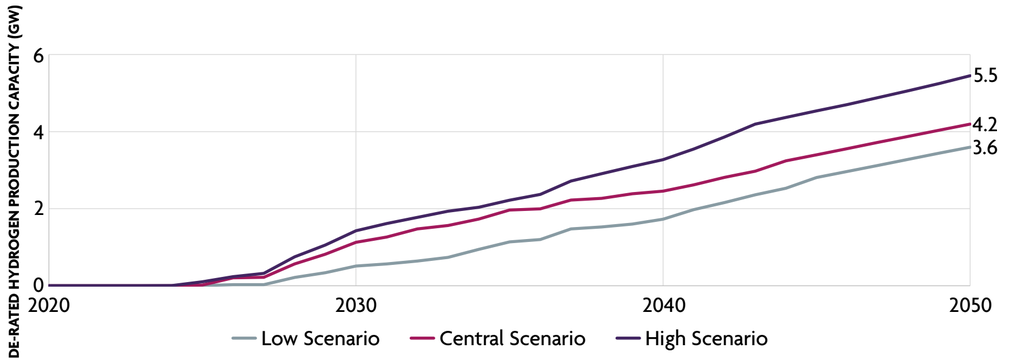


HYDROGEN SUPPLY

TOTAL HYDROGEN SUPPLY: DE-RATED

De-rated hydrogen supply in this case assumes 100% load factor, actual capacities would be larger if using real life load factors. These are expected to be up to 95% for CCUS-enabled production and between 25% and 63% for electrolytic production[27].

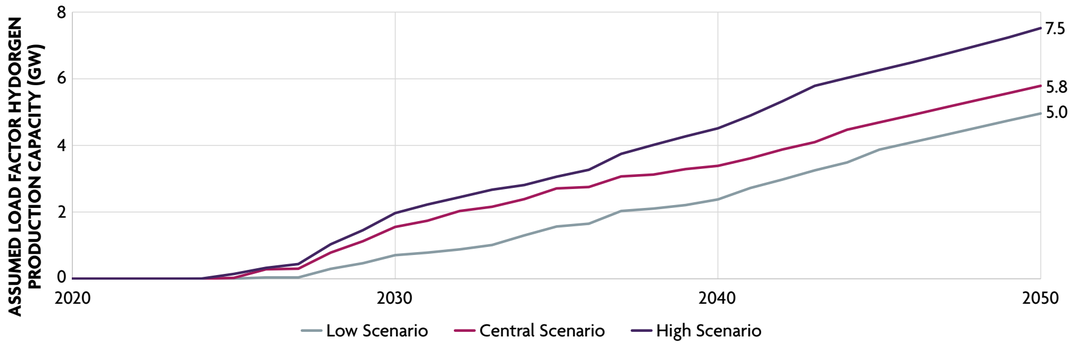
DE-RATED HYDROGEN SUPPLY TO SUPPORT DEMAND IN NORTH WEST ENGLAND AND NORTH WALES



TOTAL HYDROGEN SUPPLY: ASSUMED LOAD FACTORS

The following graph shows hydrogen production capacity based on assumed load factors. An even split between electrolytic and CCUS-enabled hydrogen capacities is assumed with load factors of 50% and 95% respectively[27].

HYDROGEN SUPPLY TO SUPPORT DEMAND IN NORTH WEST ENGLAND AND NORTH WALES



OTHER INFRASTRUCTURE

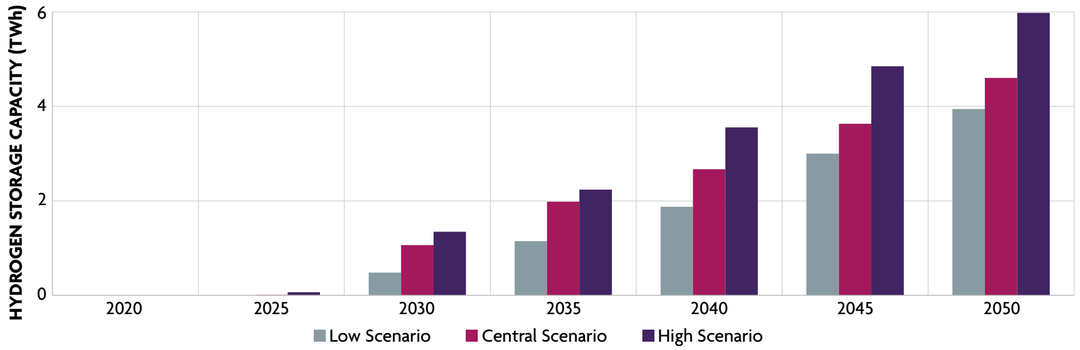
OTHER INFRASTRUCTURE: BLENDING

- Hydrogen blending could provide demand side flexibility for producers who have excess hydrogen supply, for example if an offtaker goes offline.
- This will be critical in the early phases of the hydrogen economy before widespread hydrogen transport and storage infrastructure becomes available.
- The government has undertaken a consultation on the potential for blending into the distribution network[28].
- The current government position is that blending may be allowed as an offtake of last resort i.e. not as a primary offtake for production projects. Another potential option for blending is to enable electrolytic hydrogen to provide strategic benefits to the energy system e.g. producing hydrogen from curtailed electricity and blending.
- Blending could theoretically allow hydrogen up to 20% on a volumetric basis. Due to government's position and the requirement for flexible production or large scale storage, actual blending volumes are likely to be much lower than this.

OTHER INFRASTRUCTURE: HYDROGEN STORAGE

Hydrogen storage estimates are based on the proportion of storage to hydrogen demand in FES 2023[6].

HYDROGEN STORAGE TO SUPPORT DEMAND IN NORTH WEST ENGLAND AND NORTH WALES



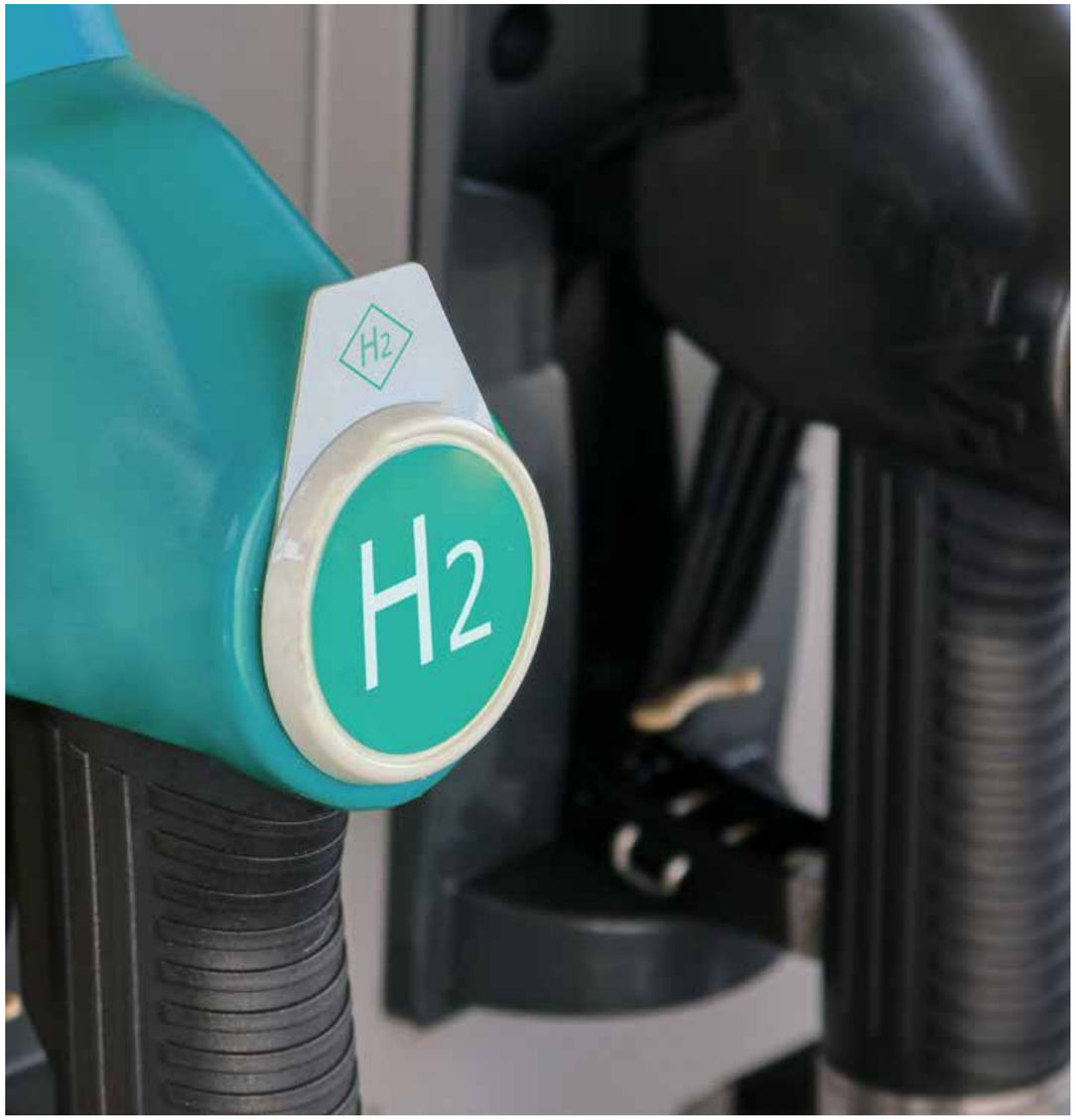
2030 SUMMARY

2030 SUMMARY TABLE

2030 DATA SUMMARY	LOW	CENTRAL	HIGH
Demand (TWh)	4.5	9.9	12.5
De-rated Hydrogen Supply to Support Demand (GW)*	0.5	1.1	1.4
Assumed Load Factor Hydrogen Supply to Support Demand (GW)**	0.7	1.6	2.0
Hydrogen Storage to Support Demand (TWh	0.5	1.1	1.3

* De-rated supply here assumes 100% load factor due to uncertainty in load factors and production technologies.

** Assumed even split between electrolytic and CCUS-enabled hydrogen with load factors of 50% and 95% respectively.



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STUDIES

EQUANS (2022) NET ZERO NORTH WEST: ELECTROLYTIC HYDROGEN RECOMMENDATIONS REPORT

	BULL		BEAR	
ANNUAL HYDROGEN CONSUMPTION (TWh/a)	2030	2040	2030	2040
Residential	0.46	5.96	0.18	-
Commercial	0.71	8.97	0.27	-
Industrial	22.68	29.55	12.37	18.49
Transport	0.61	1.43	0.24	0.61
Power	0.83	3.35	0.99	4.10
Total	25.29	49.26	14.05	23.2

Table 1 The annual requirement for hydrogen for the bull and bear demand scenarios.

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North West Hydrogen Alliance