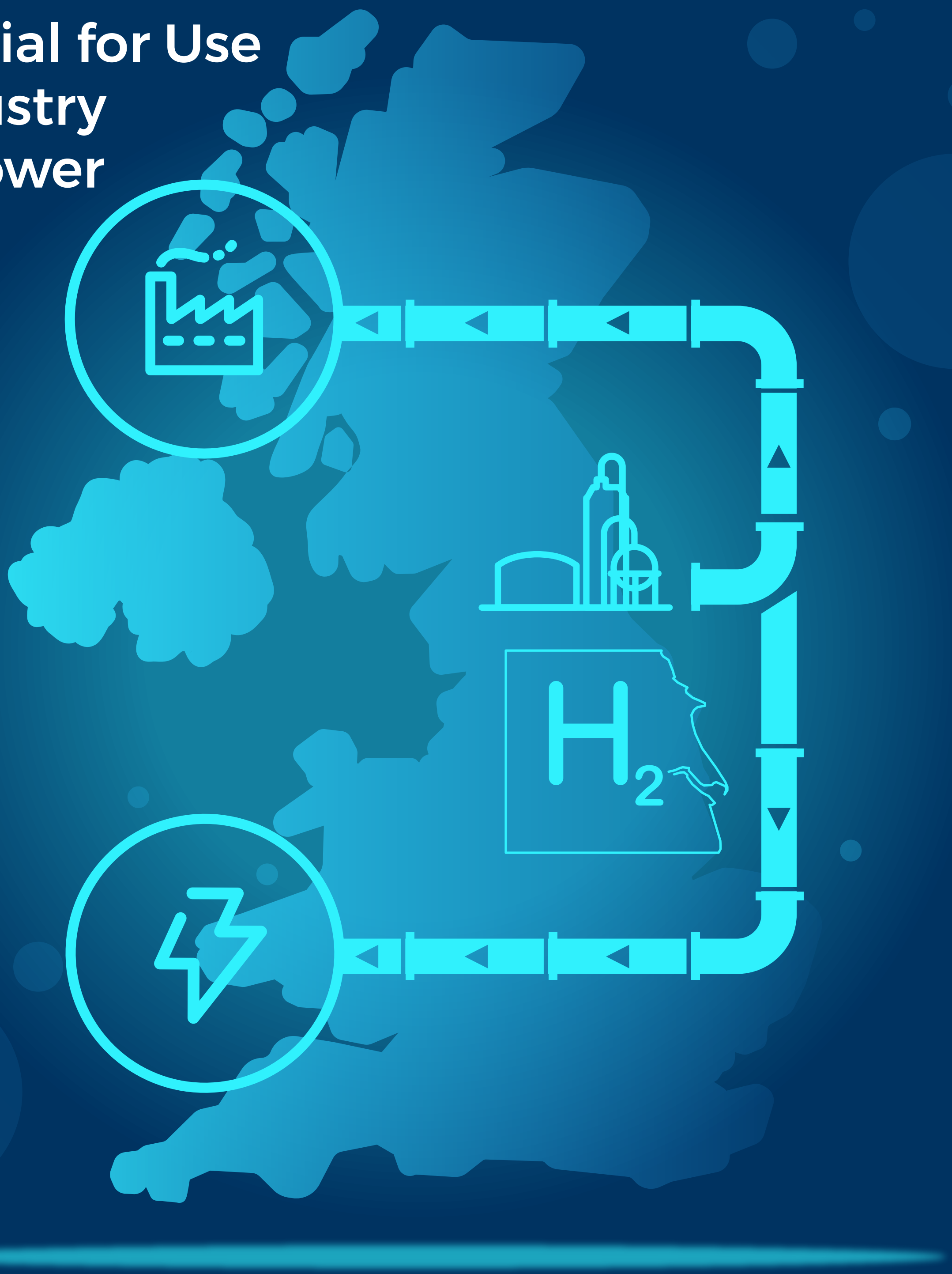
Hy-Impact Series

Study 4: Hydrogen in Yorkshire & the Humber

Potential for Use in Industry and Power



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A report for

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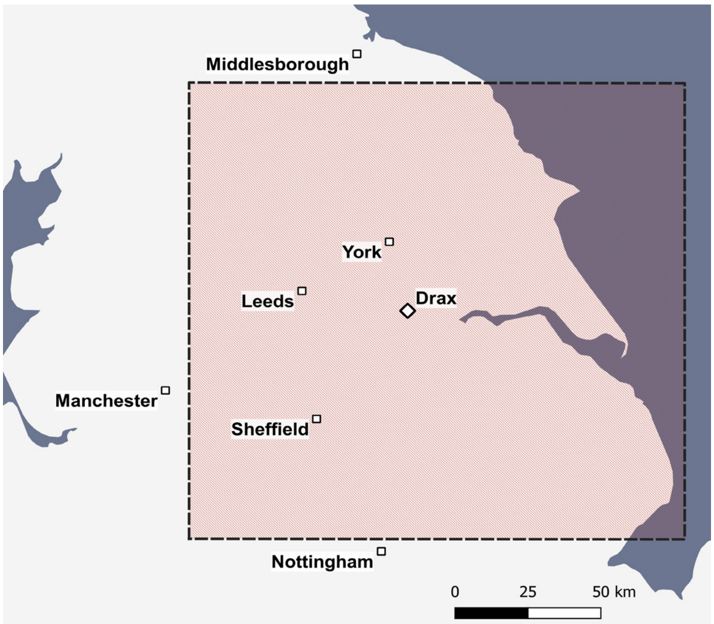
Note: The main body of this report includes confidential data and it is not publicly available. The findings presented in this executive summary are shown at an aggregated and anonymised level.

Final report date: **November 2019**

Executive Summary

Overview

The UK has recently committed to net-zero greenhouse gas emissions by 2050, the first major nation to propose this target. Hydrogen has been identified as a key energy vector due to its potential role in decarbonising heat, industry, and power. 'Blue' hydrogen, involving reformation of natural gas combined with carbon capture and storage (CCS), offers a low carbon fuel with potential for net-zero emissions when biomethane is blended into the natural gas feedstock. The delivery of hydrogen to energy intensive end users could represent a credible early pathway for large scale hydrogen deployment. This would provide considerable scope for emissions reduction; in 2018 the business, industry and power sectors accounted for ~39% of total UK greenhouse gas emissions.



This study aims to identify potential users of large hydrogen volumes in Yorkshire and the Humber region (see Figure 1). To enable a cost-effective transition to hydrogen, initial projects must focus on supplying a small number of large users, ideally concentrated in clusters. The network can then be extended to establish a future UK hydrogen network, encompassing all sectors. This study focusses primarily on the analysis of sites with a large potential hydrogen demand in energy intensive industries and the power sector.

Figure 1: map showing the study area, centered on the potential Drax hydrogen production site and extending beyond Leeds, Sheffield and York.

The Yorkshire and Humber industrial cluster

The Yorkshire and Humber industrial cluster, located near the coast around the borders of Yorkshire and Lincolnshire, is the largest of the 6 major UK industrial clusters by both greenhouse gas emissions and energy usage. The development of offshore wind in the North Sea has led to the Humber being marketed as the UK's 'Energy Estuary', and this is expanding to encompass other low carbon energy opportunities. The industrial area around the Humber estuary is ideal as the first industrial cluster to develop a blue hydrogen and CCS capability, allowing this key industrial heartland to become a net-zero cluster in line with CCC recommendations and timescales. Furthermore, the early introduction of blue hydrogen in the Yorkshire and Humber industrial cluster will pave the way to reduce costs associated with any later introduction of green hydrogen produced locally from offshore wind in the North Sea.

There is strong support for decarbonisation initiatives from local organisations. The Humber Local Enterprise Partnership (LEP) aims to drive the growth of the Humber economy, and is actively looking at decarbonisation initiatives with its members. The LEP is currently working with government towards an industrial strategy for the area, and energy and clean growth were identified as the key areas for development. AURA is a University of Hull initiative to support innovation in and commercialisation of low carbon technologies and is opening a new Innovation Centre later this year.

The Yorkshire and Humber industrial cluster must further develop a coherent voice and integrated strategy. The Yorkshire and Humber cluster has industry spread over a larger area than other smaller clusters like Teesside or Merseyside, and so the 'cluster' is less concentrated. Most of the 'Humber' local initiatives focus on the area close to the Humber estuary, so further collaboration is required to develop the wider region's decarbonisation vision, expanding the geographical area through Yorkshire and beyond. The recently announced partnership between Drax Group, Equinor and National Grid Ventures could be the ideal consortium to support this, as it has ambitions to develop a hydrogen production facility and CCS network in the region, paving the way for the creation of the first UK net-zero industrial cluster.[1]

Opportunities for hydrogen use across different sectors

There are opportunities for hydrogen use across many different industrial sectors in the Yorkshire and Humber industrial cluster, providing compelling opportunities for the development of a local hydrogen economy. The key application of hydrogen in industry is likely to be replacement of natural gas fuel with hydrogen in heating equipment.

- **Glass manufacturing** sites are large energy consumers within the region and have a very consistent pattern of large energy usage. However, significant technical uncertainties around firing glass furnaces with hydrogen remain.
- **Gas terminals** have boilers and compressors which might be suitable to convert to hydrogen and have a steady pattern of demand.
- **Refineries** make their own hydrogen and could be involved with hydrogen production. The small amount of natural gas blended with internally generated fuels may also be replaced with hydrogen, technical challenges permitting.
- **Chemicals** sites have experience with the relevant regulations around the use of hydrogen, and mostly use indirect heating appliances which are simpler to convert to hydrogen than direct fired appliances.
- **The steel industry** has significant opportunities for hydrogen use in secondary steel sites, though regulations on steel quality means the impact of hydrogen as a fuel needs to be carefully investigated. The main concerns revolve around heat transfer from hydrogen combustion and embrittlement of steel due to hydrogen diffusion that may occur during the finishing process.

1 Drax 2019, Leading energy companies announce new zero-carbon UK partnership

- **The cement sector** currently uses a mix of fuels, mainly solid fuels. Conversion to hydrogen could involve moderate investment to replace or retrofit the large burners. The high proportion of process emissions (~66%) places hydrogen in competition with CCS technologies in any effort to decarbonise the sector.

- **The lime sector** could use hydrogen to replace natural gas, though product purity requirements might cause technical difficulties across most of the sector due to the increased water content of flue gases compared to natural gas. Additionally, process emissions are very high in the sector (50%) and may open discussion for the use of industrial CCS for decarbonisation.

- **Other industrial sectors** also have opportunities for hydrogen use, though these are generally smaller potential users. Boilers in sectors such as food and drink could be converted to hydrogen, however indirect heating in ceramics kilns or food ovens will require significant equipment development.

In addition to the feasibility and costs of a retrofit to hydrogen technologies, the operational cost of hydrogen fuel use will also be relevant in the decision-making process around hydrogen fuel-switching. **A framework to incentivise a hydrogen economy will need to be developed** as unsubsidised blue hydrogen is currently more expensive than most other fuels used in industry.

Factors influencing early conversion to hydrogen

To assess the potential of sites to be early movers in hydrogen use, our analysis considered the likely hydrogen demand in 2030, the distance from the hydrogen production facility and a range of factors influencing the 'likelihood of conversion'. The likelihood factors include technology availability in 2025, technical barriers, cost of conversion, economic implications of shutdown time, decarbonisation strategies, the future outlook of operations and regional or national policies and regulations. These were combined to give an overall ranking for the potential of industrial sites as early hydrogen users.

The proposed hydrogen production facility considered in this study is located within the Drax site, as outlined in the memorandum of understanding of the new Zero Carbon Humber partnership composed of Drax Group, Equinor and National Grid Ventures.[2]

Results

The identification of large potential hydrogen users in the Humber region and analysis of factors influencing their early conversion to hydrogen was followed by stakeholder engagement to refine the site-specific estimates. Finally, a map was created, showing the location of each site, together with the relative conversion likelihood and potential demand. This assisted in the identification of local clusters and in the recommendation of potential corridors for the construction of the future hydrogen transmission system, analogous to the current natural gas national transmission system (NTS) (see Figure 2).

2 Drax 2019, Leading energy companies announce new zero-carbon UK partnership

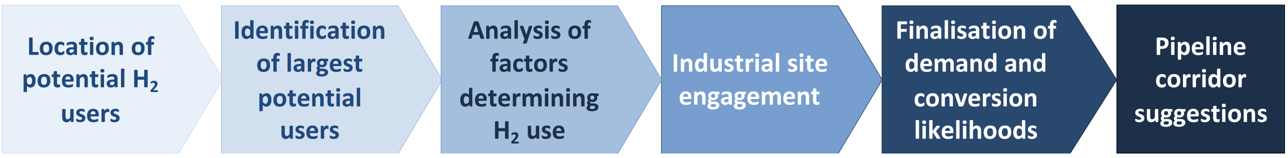


Figure 2: Overview flowchart of the project approach

Our findings are summarised in Table 1, Figure 3 and Figure 4. This study encompassed a large region when assessing the potential hydrogen users in the Yorkshire and Humber industrial cluster, as shown in Figure 1. The sites considered are shown in Figure 4, although not all of these sites were interviewed in the study. One additional site near Scarborough was omitted from Figure 4 and from our analysis as it is geographically isolated from the rest of the industrial sites.

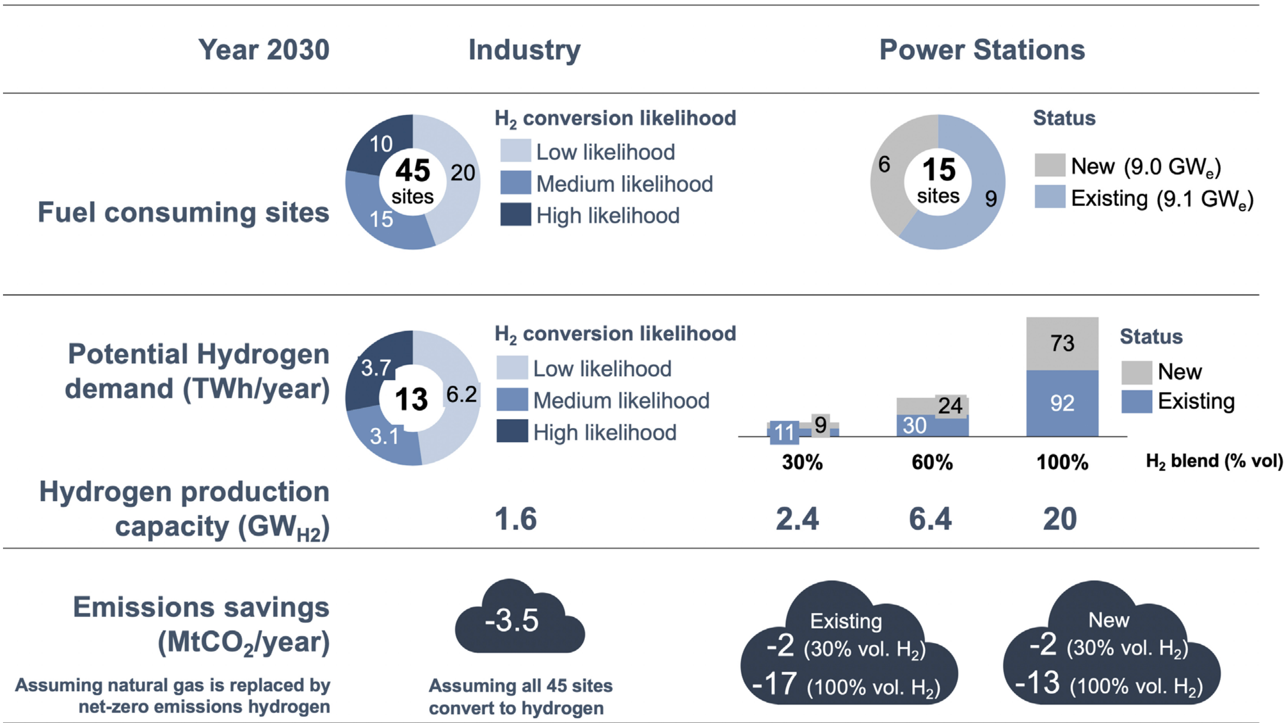


Figure 3: Overview of key results for the potential demand for hydrogen in the Yorkshire and Humber region

Industrial sites, excluding power stations, were assessed for both their potential hydrogen demand in 2030 and their likelihood of conversion. Table 1 summarises the results, categorising each of the 45 industrial sites into low, medium or high hydrogen demand and independently low, medium or high conversion likelihood. The final row and column provide the total number of sites and hydrogen demand in each category.

Table 1: Hydrogen demand and conversion likelihood of industrial sites in 2030

		Potential site hydrogen demand in 2030			
		Low **100-200 GWh/year**	**Medium** **200-400 GWh/year**	**High** **>400 GWh/year**	**Total**
Conversion likelihood	**Low**	6 sites 1.0 TWh/year	9 sites 2.5 TWh/year	5 sites 2.8 TWh/year	**20 sites** **6.2 TWh/year**
	Medium	12 sites 1.7 TWh/year	1 site 0.2 TWh/year	2 sites 1.2 TWh/year	**15 sites** **3.1 TWh/year**
	High	4 sites 0.7 TWh/year	3 sites 1.0 TWh/year	3 sites 2.0 TWh/year	**10 sites** **3.7 TWh/year**
Total		**22 sites** **3.4 TWh/year**	**13 sites** **3.7 TWh/year**	**10 sites** **5.9 TWh/year**	**45 sites** **13.0 TWh/year**

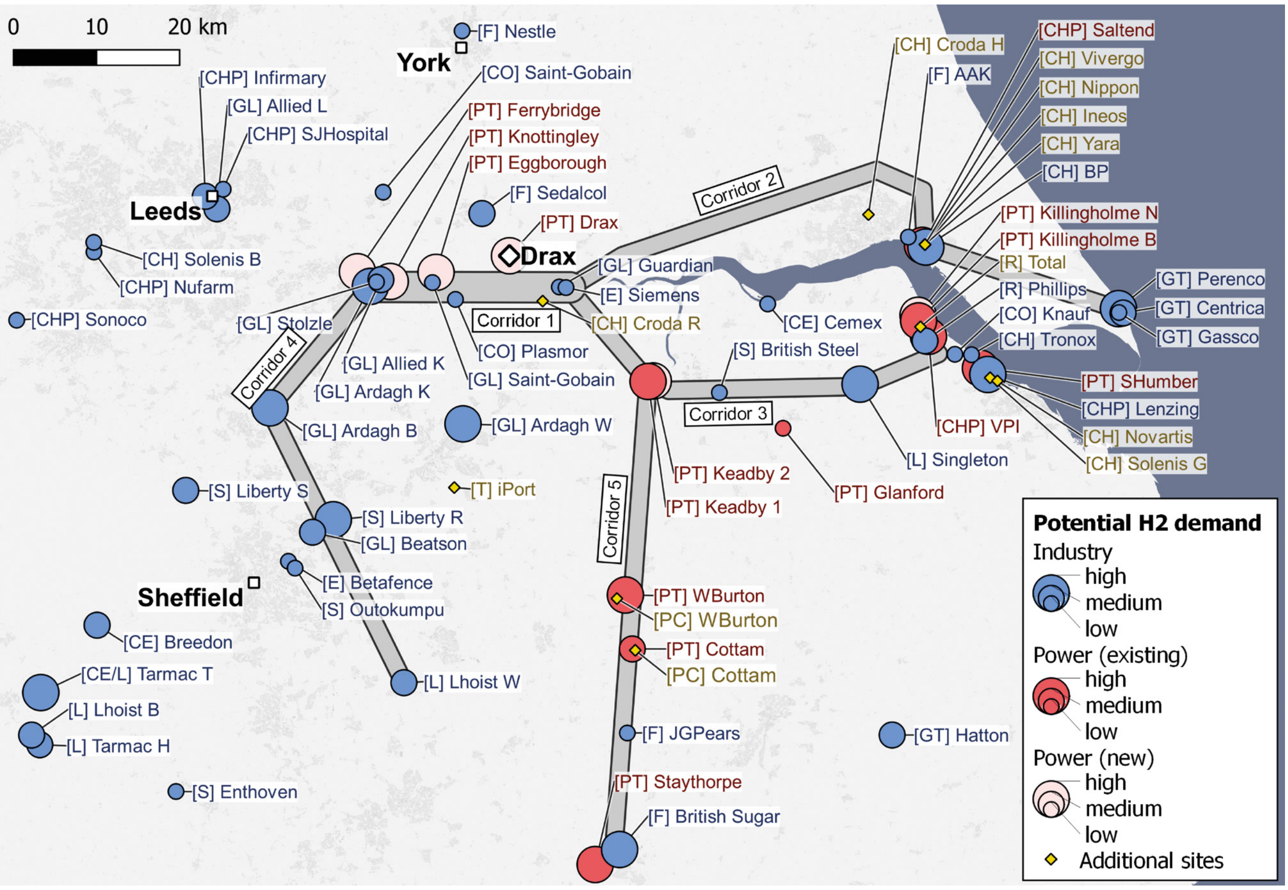


Figure 4: Mapping of the large industrial and power emitters in the region

Legend

[CE] = Cement
[CH] = Chemicals
[CHP] = CHP
[CO] = Constr. materials
[E] = Engineering
[F] = Food and Drink
[GL] = Glass
[GT]= Gas Terminals
[L] = Lime
[PC] = Coal power station
[PT]= CCGT/OCGT power
[R] = Refineries
[S] = Iron and Steel
[T] =Transport

Conclusions and Recommendations

The total potential scale of industrial hydrogen consumption in 2030 was found to be up to ~13 TWh/year. Hydrogen demand from current power stations could potentially amount to ~11 TWh/year when blending natural gas with 30% hydrogen by volume, and up to 92 TWh/year for 100% hydrogen. There is significant potential in the Yorkshire and Humber Industrial cluster for hydrogen use in both industry and power, providing an ideal area for an early hydrogen cluster conversion. Around 45 current industrial sites were estimated to have a potential hydrogen demand >100 GWh/year each in 2030. The study area also includes 8 currently operating Combined Cycle Gas Turbines (CCGT) and one Open Cycle Gas Turbine (OCGT) power station that could convert to blending hydrogen with natural gas, as well as a further 6 new CCGTs potentially being built in the region.

Emission savings resulting from hydrogen conversion by 2040 of the 45 industrial sites considered would amount to ~3.5 $MtCO_2$/year. Emission savings from the 9 existing power stations would be between 2 $MtCO_2$/year and 17 $MtCO_2$/year, depending on the percentage of hydrogen in the fuel blend (see Figure 3). These figures assume the use of blue hydrogen produced from a mix of natural gas and biomethane in combination with CCS, such that the net carbon footprint of the fuel is zero.[3]

Those sites taking part in our interviews were generally interested but mostly uninformed about the potential of hydrogen to decarbonise their site. The remaining technical challenges and uncertainties mean sites will require guarantees of equipment operation, financial support, and a secure hydrogen supply before conversion can occur. One of the key advantages of the delivery of hydrogen to large users through new pipework is the opportunity for sites to have a dual supply of both natural gas and hydrogen, enabling time for tests and reducing risks to industry.

There are a number of actions required to progress this project and decarbonisation of the Yorkshire and Humber industrial cluster:

- **Further engagement with the key potential sites** highlighted in this study to develop detailed understanding of the cost, challenges and timeframes for hydrogen conversion.
- **Research on potential barriers for hydrogen pipework** in the corridors proposed, such as regulatory challenges or significant infrastructure barriers.
- **Technical:** potential links with the sectoral organisations (e.g. Industry associations such as British Glass) and projects (e.g. BEIS fuel switching demonstrations) to ensure technical barriers are understood and overcome in line with expectations.
- **Investment:** detailed assessment of the total investment required for a hydrogen industrial conversion project in the region.

Recommendations more broadly relating to regional decarbonisation, which are relevant to this work:

- **Development of a wider Yorkshire and Humber industrial cluster decarbonisation vision, including a coherent voice for the cluster.** This may involve a working group or alliance with a broad range of public and private stakeholders and good contacts across the region. This group could also facilitate information sharing and coordinate funding applications.
- **Detailed technical analysis on the cluster** should be carried out to understand what technology mix would be technically and economically most appropriate and where synergies lie between sites/ technologies.
- **Analysis on funding and business model(s)** for the cluster to deliver this vision (e.g. low-carbon by 2030 and net-zero by 2040). This would include the level of funding required, as well as the financial mechanism through which that should be distributed.

3 Net-zero hydrogen: Hydrogen production with CCS and bioenergy, Element Energy for Equinor, 2019

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