elementenergy

ZERO CARBON HUMBER

THE IMPACTS OF DECARBONISING YORKSHIRE AND THE HUMBER

A Report for the Zero Carbon Humber Consortium

drax equinor nationalgrid ventures

Element Energy

November 2019

Element Energy Limited, Suite 1, Bishop Bateman Court, Thompson's Lane, Cambridge, CB5 8AQ, Tel: +44 (0)1223 852499

Authors

This report has been prepared by Element Energy.

Element Energy is a strategic energy consultancy, specialising in the intelligent analysis of low carbon energy. Since its inception in 2003, Element Energy provides consultancy services across a wide range of sectors, including carbon capture and storage and industrial decarbonisation, smart electricity and gas networks, energy storage, renewable energy systems, buildings and low carbon transport. With a team of over 60 specialists, Element Energy provides consultancy on both technical and strategic issues, believing that the technical and engineering understanding of the real-world challenges support the strategic work and vice versa.

This executive summary is part of a wider modelling work conducted by Element Energy for the Zero Carbon Humber Consortium. For comments or queries please contact:

Emrah Durusut	Associate Director	emrah.durusut@element-energy.co.uk
Silvian Baltac	Senior Consultant	silvian.baltac@element-energy.co.uk
Richard Simon	Consultant	richard.simon@element-energy.co.uk

Note on terminology

Throughout the report, **blue hydrogen** refers to hydrogen produced from a feedstock of natural gas by autothermal reforming (ATR) coupled with carbon capture, utilisation, and storage (CCUS) of the resulting carbon dioxide emissions.

Disclaimer

This study was commissioned by the Zero Carbon Humber Consortium (Drax, Equinor, and National Grid Ventures). The conclusions and recommendations do not necessarily represent the view of the Consortium. Whilst every effort has been made to ensure the accuracy of this report, neither the Consortium nor Element Energy warrant its accuracy or will, regardless of its or their negligence, assume liability for any foreseeable or unforeseeable use made of this report which liability is hereby excluded.

All costs shown in this report are estimated based on the best available data and were established following literature review and consultation with key stakeholders, however they do not represent cost projections planned by any of the consortium members and may change upon a closer assessment of the infrastructure deployment requirements of each project phase.

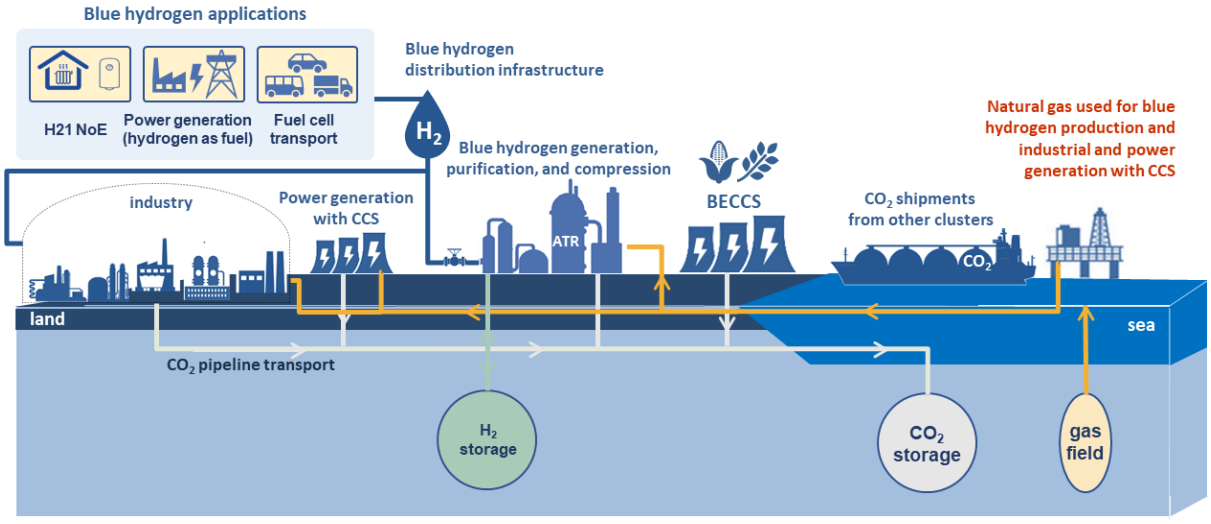
Executive Summary

The UK has recently become the first major economy to pass legislation to achieve net zero emissions change by 2050. This follows the recommendations of the Committee on Climate Change's (CCC) recently published "Net Zero" report, which showed that eliminating emissions by 2050 is feasible. This level of ambition will require deep decarbonisation of all sectors of the UK economy, including industry, and will involve large-scale deployment of innovative technologies. Whilst a variety of technologies and approaches are available for decarbonising different sectors of the economy, the CCC recommended investment be prioritised in two complementary technologies, Hydrogen and Carbon Capture, Utilisation and Storage (CCUS), due to their pivotal roles in enabling long-term deep decarbonisation.

Without deep decarbonisation options and with increasing carbon tariffs, UK industry is at risk of decline, putting millions of UK jobs in danger. Industrial clusters are seen as a key area for decarbonisation due to their important contribution to the UK economy and their pivotal role in consolidating the hydrogen and CCUS infrastructure likely necessary to decarbonise other sectors.

The UK is already moving forward in the integration of CCUS and hydrogen generation in key clusters. In 2019, Drax Group, Equinor and National Grid Ventures announced a Memorandum of Understanding to explore how a large-scale CCUS network and a hydrogen production facility could be constructed in the Humber industrial cluster in the mid-2020s[1] - the Zero Carbon Humber partnership.

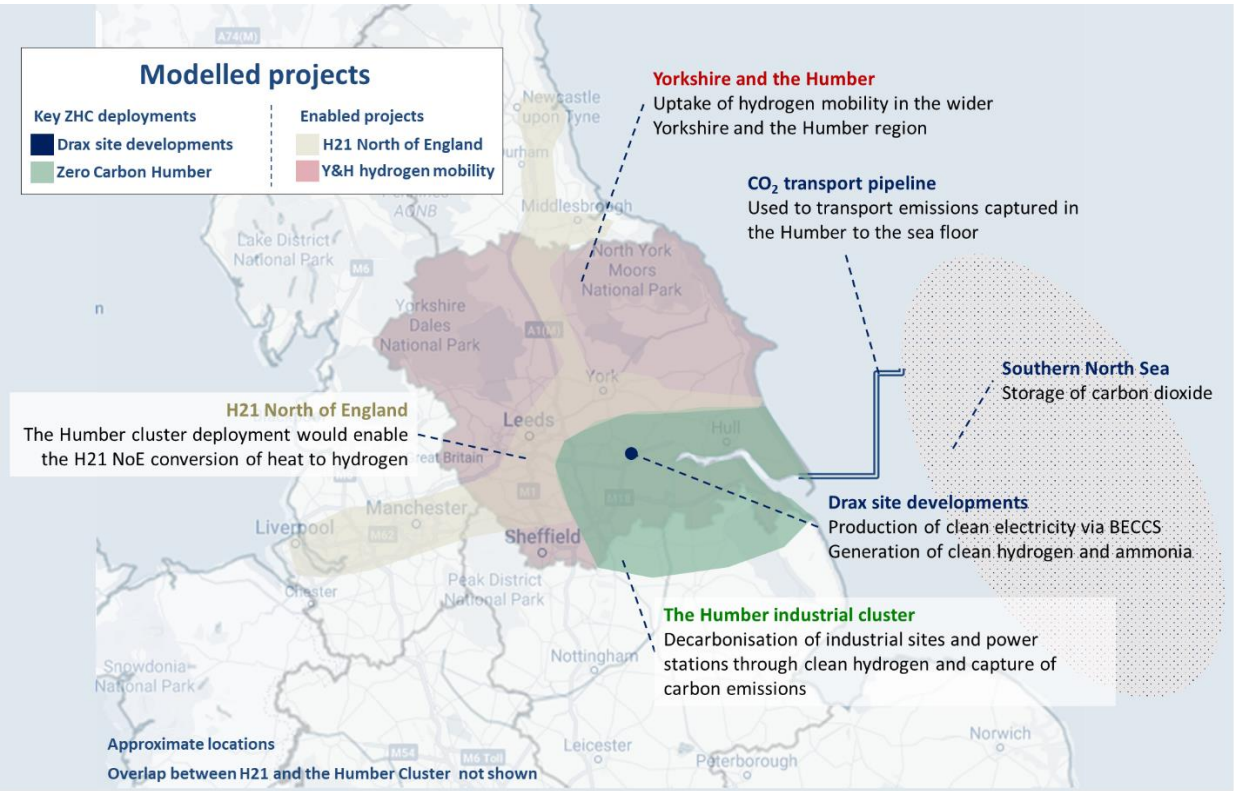
The Humber cluster is the UK's largest cluster by industrial emissions, and its prompt decarbonisation is critical to the UK economy. This decarbonisation will be underpinned by the deployment of CCUS to enable decarbonisation of power and industry, with the cluster's proximity to the Southern North Sea, an ideal area for CO_2 storage, a key regional advantage. The Drax Power Station has already converted to biomass, and connection to CCUS infrastructure would enable negative emissions through the world's first BECCS (bio-energy with carbon capture and storage) plant. The presence of the CCUS network would also allow production of low carbon "blue" hydrogen from natural gas, with the CO_2 emissions captured. Industrial sites or power stations in the cluster will therefore be able to decarbonise by either connecting to the CCUS network or by using blue hydrogen as a replacement for fossil fuels.



The Zero Carbon Humber partnership could help enable decarbonisation across a wider geographic area, stretching beyond the boundaries of the cluster itself. The region contains several power stations which could use hydrogen (either as a pure gas or blended with natural gas) or CCUS to generate cleaner electricity. Other sectors and projects could also be supplied with low carbon hydrogen, such as H21 North of England (H21 NoE). This initiative aims to convert the gas grid in the North of England

[1] Leading energy companies announce new zero-carbon UK partnership, Drax press release, 27th May 2019

to hydrogen, allowing the decarbonisation of heat in domestic and commercial buildings and providing the fuel supply to allow the uptake of hydrogen mobility.



The Zero Carbon Humber project is expected to pave the way towards wide-scale UK decarbonisation, with all industrial clusters expected to deploy hydrogen and CCUS to achieve net zero by 2050. It is therefore paramount to understand the financial implications of this deployment, and the opportunities and benefits it provides for industry, the Yorkshire and the Humber area, and the UK as a whole.

This study investigated and modelled the deployment of decarbonisation technologies and the resulting regional and national economic benefits. This focused on two types of deployment:

- Key developments related to the Zero Humber Cluster projects, including developments on the Drax Power Station site, and the decarbonisation of the Humber cluster. These projects would take place in the industrial area around Humber estuary.
- Projects which would be enabled by the Zero Carbon Humber developments, including H21 North of England (NoE), which aims to decarbonise domestic heating in Yorkshire and the Humber region and further beyond. In addition, the hydrogen deployment in the Humber cluster would enable the uptake of hydrogen mobility in the wide Yorkshire and the Humber region.

Whilst some investment will fall outside the region, a large majority will fall within the Yorkshire and Humber region. Additionally, whilst some of the materials and services needed for these developments could be sourced from outside the region, significant economic and employment benefits could be unlocked by the region.

Zero Carbon Humber has 2 phases: Anchor Projects, then Consolidation

In the first phase (up to 2027), critical infrastructure would be installed, and the effectiveness of the deployed technologies would be demonstrated, involving:

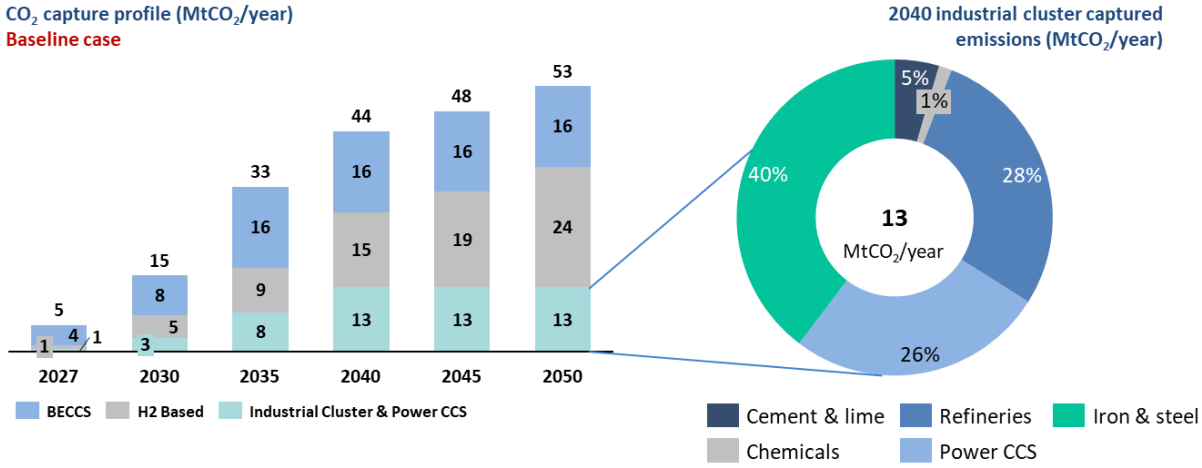
- Installation of carbon capture on one of the four Drax biomass units to enable BECCS by 2027.
- Installation of an autothermal reformer (ATR) for hydrogen production in the Humber by 2025.
- Development of CO_2 transport and storage infrastructure for storing emissions captured from hydrogen production and Drax's BECCS.
- Use of the hydrogen produced near the hydrogen production plant in a 'low carbon' ammonia production plant, and to test various domestic and industrial appliances.

The second phase would focus on consolidating and expanding the hydrogen production capacity and implementing CCUS or hydrogen fuel switching for end users in the wider Yorkshire and Humber region. This would involve:

- Installation of CCUS at the three remaining biomass units at Drax maximising to enable a BECCS capacity of 16 $MtCO_2$/year.
- Increasing the hydrogen production capacity in the Humber region to ~13.7 GW by 2050.
- Expansion of the CO_2 Transport and Storage infrastructure to enable ~53 $MtCO_2$/year of CO_2 storage, with ~13 $MtCO_2$/year captured from industry and power stations throughout the region.
- Fuel switching of industry to hydrogen, with ~7.7 TWh of hydrogen used on ~40 large industrial sites in the region in 2050, across 10 industries including chemicals, food, glass, and metals.
- Conversion of five power stations in the Humber to blend hydrogen in current assets, with up to two power stations using pure hydrogen in new turbines.
- Decarbonising domestic commercial and industrial heat through the H21 North of England programme. This converts the gas distribution network from natural gas to hydrogen and upgrades end user's appliances to use hydrogen, including ~3.8 million homes. By 2036, this would use ~22 TWh of hydrogen from the hydrogen production facility in the Humber, and would deploy an additional 8.5 GW of ATR capacity. After 2036, additional hydrogen will be supplied to the national H21 conversion programme.
- Deploying hydrogen mobility in the region through over one million hydrogen fuel cell vehicles, and at least 15 hydrogen refuelling stations.

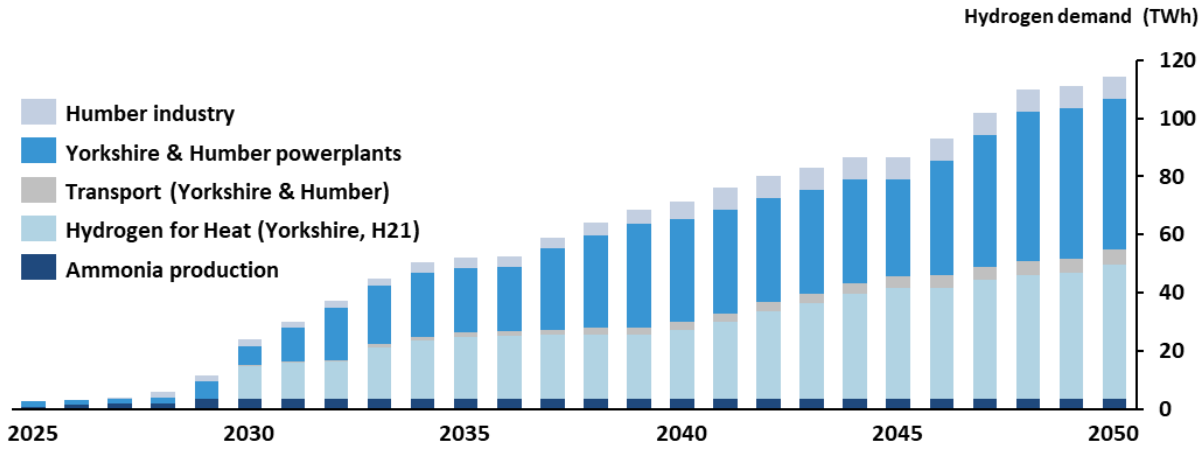
Capture Profile

The first CO_2 pipeline will become operational by 2027, setting the foundation of the Humber industrial decarbonisation. This will collect emissions from the Drax biomass units, the hydrogen production ATRs, and the industrial cluster, and will enable BECCS and blue hydrogen production. As the cluster decarbonises and hydrogen production increases, the carbon dioxide transport and storage infrastructure will be expanded. To ensure decarbonisation of the entire Humber cluster, the transport and storage pipeline will be designed to run in close proximity to power stations and key industrial sites which require CCUS to decarbonise, including cement and lime production, refineries and chemicals, and iron and steel manufacturing. We estimate that by 2040, the capture rate will reach 44 $MtCO_2$/year, and, as the hydrogen production capacity expands, the capture rate will exceed 53 $MtCO_2$/year in 2050.



Hydrogen Demand and Usage in the Region

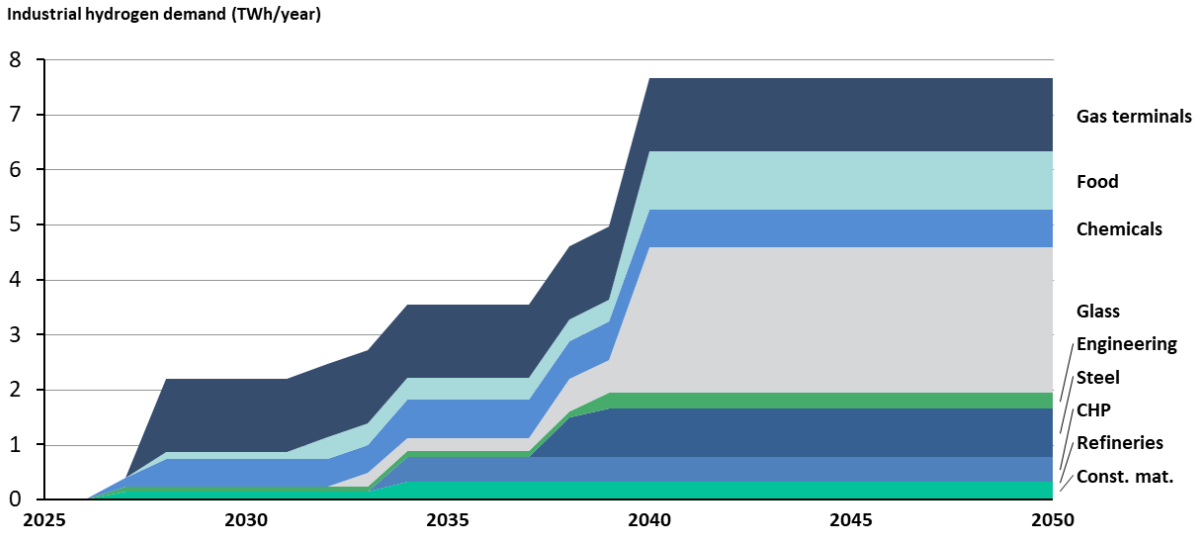
We estimate that by 2050, ~114 TWh/year hydrogen could be produced, used, and exported to the Humber industrial cluster, to the wider Yorkshire and the Humber area, and beyond:



The hydrogen produced in the Humber could provide opportunities to decarbonise:

- Production of clean ammonia placing the Humber as a leader in the manufacturing of a new generation of 'low carbon' commodities

- 40 large industrial sites ranging from chemicals to glass manufacturing and steel making could decarbonise by using ~7.7 TWh/year hydrogen in 2050.



- Conversion of five power stations in the Humber to blend hydrogen in current assets, with up to two power stations using pure hydrogen in new turbines. This would use 52 TWh/year of hydrogen in 2050.
- Uptake of hydrogen fuel cell electric vehicles in the Yorkshire and the Humber area, modelled to use 4.5 TWh/year of hydrogen in 2050.
- Decarbonisation of domestic and commercial heating both in the Yorkshire and the Humber area and further, as part of the H21 Programme.

Tens of thousands of medium-term jobs could be generated in the UK, many of these in the Yorkshire and Humber region

To ensure swift decarbonisation, work would start in the early 2020s, with the first installations operational by 2027. A rapid infrastructure roll-out and consolidation would follow, continuing until 2050, with capital investment peaking in the mid-2030s.

The mid-term peak in CAPEX, driven by the planning, construction, installation, and deployment of infrastructure, could lead to the generation of tens of thousands of direct jobs in the UK and the additional of billions of pounds of gross value added to the UK economy in 2035. These jobs would not be limited to deploying the relevant infrastructure in the field (e.g. laying down pipelines and installing machinery), but would also create substantial additional demand for the processed metal goods and specialised machinery and appliances that are generally produced by factories in industrial areas such as the Humber.

A variety of industries could benefit from the creation of these jobs, with the three main industrial activities being construction, fabricated metal products, and machinery and equipment. It must be noted that although these jobs would be created at a UK level, many positions could and very likely would be sourced locally.

The local construction industry is expected to capture a significant proportion of the jobs, given the supply-chain and logistics advantages. Similarly, architectural and engineering services could also take advantage of their local knowledge of the topography and local industrial infrastructure (e.g. electricity and gas grid) to capture local opportunities. Whilst the Yorkshire and Humber region does lead in certain industrial sectors, and the majority of the CAPEX jobs could be staffed locally, local business must be aware of potential competition, ensure adequate training for current and new staff, and prepare to provide the appropriate services.

Thousands of direct jobs could be generated operating/maintaining the infrastructure

Once the infrastructure has reached scale and maturity, thousands of long-term jobs will be created covering activities such as manning, technical support, and regular or extraordinary maintenance. The largest number of jobs would be generated in the repair and support activity, to maintain and operate infrastructure. Other employment activities benefiting from the deployment would be transport via pipeline, support for the oil and gas industries (required for the subsea CO_2 storage in aquifers and depleted hydrocarbon fields), and manufacture of industrial gases (hydrogen and ammonia). Given the nature of OPEX jobs, the large majority of these jobs are likely to be based locally, providing long-term opportunities for local communities and leading to local regeneration.

Additional Benefits include Export of Skills and Services, Air Quality Improvements, and Regional Regeneration

Further benefits, beyond creating thousands of direct jobs and billion pounds in GVA, are expected from the Zero Carbon Humber deployment. The project will drive a large amount of investment in the region, which will be accompanied by indirect employment opportunities and investment in local infrastructure, education, and skills. These could lead to long-term regeneration of the local region, which includes some of the most deprived areas of the UK.

Once the local deployment is complete, opportunities for the region's industries would continue. As likely one of the first UK clusters to decarbonise, local businesses would have acquired valuable skills and expertise. This early exposure and these new skills would allow businesses to offer new services and reposition themselves on the market, potentially capturing work in other UK regions looking to decarbonise, or even other industrial clusters abroad.

The Zero Carbon Humber project could also reposition the Yorkshire and Humber region as a leader in the increasingly important global market of low-carbon products and commodities. The region would have the capability to export many low-carbon industrial products, including steel, chemicals, ammonia, and cement.

The Yorkshire and Humber region, as one of the first UK clusters to deploy large scale CCUS, would have the opportunity to help support those CCUS clusters across the UK and Europe where CO_2 storage infrastructure is not available. The Humber could provide CO_2 storage services to these clusters, such as South Wales and contribute towards the UK's wider decarbonisation. Significant domestic and international demand for CO_2 shipping within UK waters is projected, and some of this could be captured by the Yorkshire and Humber region.

Uptake of hydrogen mobility, with over one million hydrogen vehicles deployed by 2050, could lead to a significant reduction in hazardous air pollution emissions, including nitrogen oxides (NO_x) and particular matter (PM). These pollutants are linked with several long-term medical conditions and many premature deaths, and the improved air quality in the Yorkshire and Humber is estimated to lead to ~£14 m in avoided social damage costs in 2050.

The Zero Carbon Humber project will increase the uptake of hydrogen in the area, and this will help the proliferation of green hydrogen, generated using large-scale water electrolysis and local renewable electricity (e.g. offshore wind). Increased use of hydrogen in the region would encourage the deployment of these two technologies locally, enabling new opportunities for the construction and machinery industries and creating additional jobs from the "green" hydrogen infrastructure.

Unlocking the region's potential requires swift, concerted action

A strong policy push and a large capital investment will be required for the successful deployment of hydrogen and CCUS in the Humber area. This deployment will deploy and demonstrate a wide range of technologies, including the generation of "blue" hydrogen, power generation using BECCS, industrial carbon capture, hydrogen power stations, and the use of hydrogen in industry, domestic dwellings, and mobility.

Lack of investment or delayed investment in the Yorkshire and Humber region could have significant consequences for the region and the UK as a whole. As well as removing the jobs created by the deployment, lack of action could prevent the UK from achieving its 2050 climate goals and put the future of the region's energy intensive industries, employing over 50,000 people, at risk. If unable to decarbonise in a coherent and economic manner, increasing carbon prices could cause a decline in local industry, with economic and environmental consequences. Without support to decarbonise, industries competing in international markets will be unable to remain competitive and pass additional costs on to their consumers, resulting in a significant risk of carbon leakage - industries could simply relocate to regions with less stringent environmental regulations to reduce costs, thereby simply moving CO_2 emissions abroad, rather than eliminating them. It is therefore crucial that public-private industrial decarbonisation starts immediately, focussing on the following areas:

To ensure the benefits of blue hydrogen and CCUS are fully exploited, investment must start immediately. This project will be essential to enable the decarbonisation of the Yorkshire and Humber region, deploying and validating large-scale deployment of low-carbon technologies at a multisector level, ranging from BECCS to hydrogen in industry and power. Delays in investment and deployment may have serious long-term consequences and could affect the feasibility of the UK achieving its 2050 net-zero targets.

Engagement with local stakeholders is essential to ensure effective and timely deployment. The benefits described in this report are based on concerted collaboration between the cluster, including industry, power stations, and local authorities. This will be necessary to deploy key infrastructure in a timely manner and suit the decarbonisation needs of all stakeholders in the region.

Close relationships with local businesses and educational bodies will be necessary to provide a skilled workforce for deploying and operating the infrastructure and ensure that jobs are created within the area. This would require rethinking the services provided by local businesses and an update of educational courses in order to provide appropriate training for the future generations.