

IDRIC

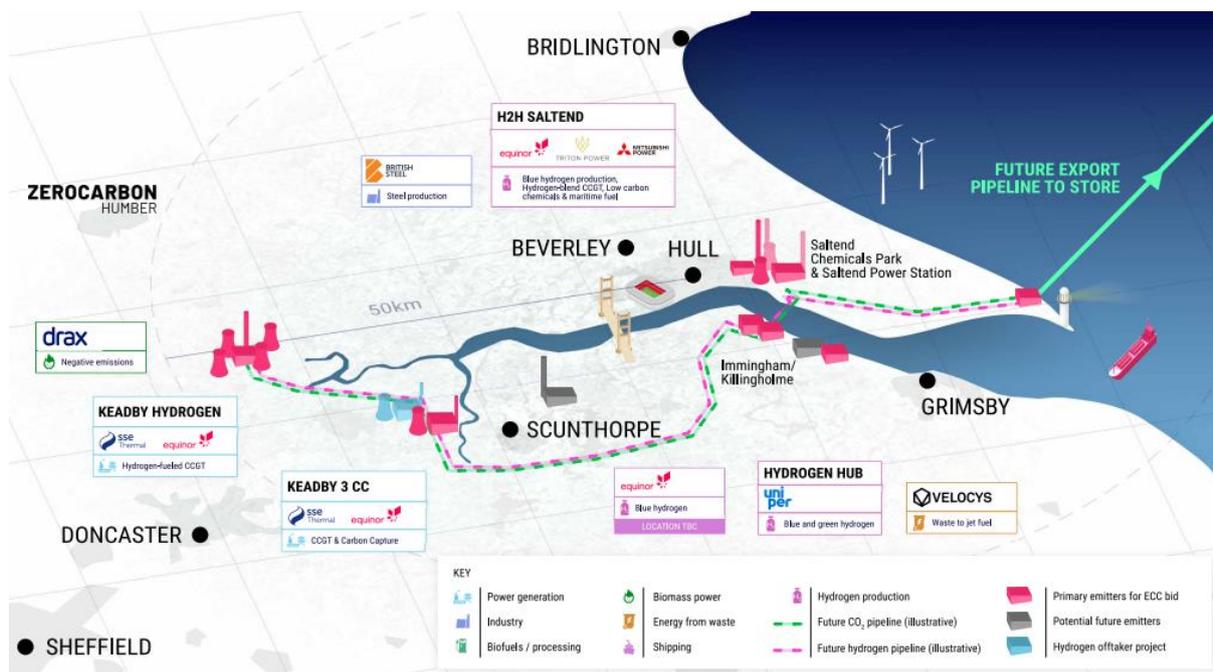
Cluster Mapping Report: The Humber industrial cluster

March 2022

Diarmaid Clery and Clair Gough

Tyndall Centre for Climate Change Research

University of Manchester



Source: East Coast Cluster, <https://eastcoastcluster.co.uk/>

Citation:

If you are using this document in your own writing, our preferred citation is:

Clery, D. and Gough, C. (2022) Cluster Mapping Report: The Humber industrial cluster. UK Industrial Decarbonisation Research and Innovation Centre (IDRIC) project report. Available from: <https://idric.org/>

Introduction

This report provides a brief summary of the Humber Industrial Cluster, accounting for the unique configurations of industries, geographies, historical and environmental factors. The purpose of this report is to set out the broader context for building a social licence to operate (SLO) for the region's industrial decarbonisation, as a resource for stakeholders across academic, industrial, NGO and policy communities. It should be seen as a 'living document' which will be reviewed and updated over the course of the project, informed by a series of deliberative workshops with stakeholders and citizens from across the region. A summary of the first of these workshops can be found in the Appendix to this document.

To accelerate industrial decarbonisation at scale, low carbon technologies (including carbon capture usage and storage (CCUS) and Hydrogen production) require a strong social licence to operate (SLO). SLO refers to the level of support for projects and technologies assembled to deliver industrial decarbonisation in the region. A very low level of social licence may be enough for a development to proceed and be tolerated but fragile support may signal risks to developers and societal stakeholders alike. Better outcomes will be achieved with higher levels of social licence, whereby projects are identified as credible and legitimate approaches to delivering decarbonisation, and dependent on establishing trust between societal actors and those responsible for developing, delivering and regulating projects. It is thus important to understand specific contexts and past events which will influence the evolving social licence.

The IDRIC project 'protective spaces and social licence to operate industrial decarbonisation in the clusters' aims to develop a blueprint setting out the cluster-specific conditions and challenges associated with developing a social licence in the HyNet NW and Humber clusters respectively. This report marks the first phase in this process and presents the backdrop to plans for a zero-carbon cluster.

The UK Industrial Decarbonisation Challenge

The UK Industrial Decarbonisation Research and Innovation Centre (IDRIC) is the national focal point and international gateway for UK industrial decarbonisation research and innovation. The project 'protective spaces and social licence to operate industrial decarbonisation' is part of IDRIC's extensive multidisciplinary integrated research programme. As part of the '10 point plan for a green industrial revolution'¹ (2020) within the Net Zero Strategy (2021), the UK Government has committed to establish two low carbon industrial clusters by mid-2020s and four by 2030, with a national target of 20-30 MtCO₂ captured per year by 2030².

Since 2019, the UK Research and Innovation (UKRI) Industrial Decarbonisation Challenge Fund (IDCF) is investing £170m, across a two-stage process, with a further £261m matched by projects' industrial partners. Six industrial clusters across the UK have received funding for cluster plans and roadmaps (Phase 1) and nine deployment projects (Phase 2). The BEIS Cluster Sequencing Process has awarded 'Track 1' status to two of these clusters: the East Coast Cluster (comprising the Humber and Teesside) and the HyNet cluster in the Northwest (NW), to proceed with developing 'Front End Engineering and Designs (FEED)' studies for carbon dioxide and hydrogen transport and storage infrastructure and bid into the CCS Infrastructure Fund³. During 2022, Phase 2 of the UK cluster sequencing programme will identify emitters (power, industry or hydrogen) that may connect to the Track 1 clusters.

In 2020, The Humber Cluster secured Stage 1 funding for a short feasibility study to begin developing the cluster plan for the transition to net zero for industry in the Humber, including the **Humber Industrial Decarbonisation Roadmap** and the **Humber Industrial Decarbonisation Deployment Project (Humber-DP)**, followed by funding for the **Humber Industrial Cluster Plan**⁴ which aims to set out the technologies, infrastructure and investment needed to transition the Humber Cluster to become net zero by 2040.

In 2021, Stage 2 of the ISCF provided funding for cluster plan and deployment projects. In the Humber, the **Zero Carbon Humber** project, will connect new onshore CO₂ and hydrogen pipelines to H2H Saltend hydrogen production, Keadby 3 gas power station and biomass-fired Drax power station, with potential for 8 MtCO₂/yr by 2030⁵ using shared offshore CO₂ transport and storage infrastructure created through the **Northern**

Endurance Partnership (with the Teesside cluster). A third project, **Humber Zero**, will support decarbonisation of the combined heat and power and refinery facilities at Immingham, with potential for another 8 MtCO₂/yr by 2030⁶.

Humber Cluster Overview

The Humber cluster is the **largest emitter of CO₂** of all the UK industrial clusters, with sites located north and south of the Humber Estuary, connected by the Humber Bridge. In 1996, the former county of Humberside was split into four unitary authorities: North Lincolnshire, North East Lincolnshire, Kingston upon Hull and East Riding of Yorkshire, within the wider region of Yorkshire and the Humber region. Unlike West and South Yorkshire respectively, the four authorities neighbouring the Humber estuary are not yet represented by a combined authority or elected Mayor. The Humber's Local Enterprise Partnerships (LEPs), which bring together local authorities and businesses, were reconfigured in 2021 when Humber LEP was replaced by Hull and East Yorkshire (HEY LEP) and north and north east Lincolnshire joined Greater Lincolnshire LEP. The Humber Industrial Cluster Plan is led by HEYLEP, working with CATCH (a membership organisation for the energy, process, engineering and renewables industry in Yorkshire and the Humber) and eight industrial partners to develop a strategic roadmap for decarbonising the region's industries, aiming for **net zero by 2040**.

The Humber cluster plan focuses on **decarbonising the steel and chemical industries**, its 2030 vision set out on the Humber Industrial Decarbonisation Map⁷. Two of the UK's six oil refineries and one of two integrated steelworks are located in the region, alongside energy from waste, biofuel, cement, lime and glass manufacturers. Drax power station is the UK's largest power station; entirely fired by biomass since 2021, it has the potential to become the world's first biomass energy with carbon capture storage (BECCS) power plant to provide **greenhouse gas removal**. Hydrogen production can enable nearby industrial processes to decarbonise by switching fuels and as part of a wider Hydrogen economy. Planned **new CO₂ and hydrogen pipelines** will link CCS-enabled hydrogen production, BECCS power, combined cycle gas turbines and steel production to offshore **CO₂ storage** sites below the North Sea in a saline aquifer (Endurance), via Easington, and depleted gas fields (Viking) via Theddlethorpe. Salt caverns which extend through the region provide potential for **onshore hydrogen storage**, with plans to convert the Rough gas storage reservoir to provide **offshore hydrogen storage**.

The region has a long-held strategic importance for energy supply and industrial processing and the cluster hosts significant **heavy industry** and **power generation facilities**. The **Humber Enterprise Zone** is the largest in the UK. Energy intensive industries account for around one in ten jobs in the Humber region⁸; recent analysis by Vivid Economics suggests that deploying CCS and hydrogen technologies could create up to 49,700 new jobs in the Humber region, including a potential 25,200 high quality direct jobs in the sector⁹.

Promoted as the UK's **Energy Estuary**, the region also hosts the Humber **offshore wind cluster**, with the world's largest offshore wind farm under construction off Hornsea, its operations and maintenance managed through the East coast Hub at Grimsby, and a new marine energy park to manufacture turbine components approved. The Gigastack project will couple large-scale offshore wind from Hornsea 2 with green hydrogen production supplying the Phillips 66 Humber Refinery. However, access to the seabed for the offshore wind cluster in parallel with the industrial decarbonisation cluster will require coordination to avoid any conflicts of access¹⁰.

The four major ports of Hull, Goole, Immingham and Grimsby have Government funding to operate as a collective *freeport*, making it **the UK's busiest port complex**, with the potential to receive CO₂ by ship destined for the region's offshore storage sites. HEYLEP's 2021 Humber Estuary plan¹¹ identified three key challenges: transitioning to net zero whilst maintaining the region's industries, EU trade arrangements, and managing flood risks. Hull has been identified as the UK's second most vulnerable city after London for flood risk, suffering major flooding in 2007 and 2013¹², with recent upgrades to flood defences along the River Hull.

Partnerships and stakeholder networks

The Humber has built a strong regional identity across its industry and business communities, with a variety of consortia focused on supporting different priorities. These include:

- The **Humber Industrial Cluster Plan (HICP)**, established in 2021, brings together membership organisation, CATCH, with the HEYLEP and 8 industry partners to collaborate on developing a roadmap to decarbonise industry across the Humber region by 2040.
- The **Zero Carbon Humber (ZCH)** partnership secured funding from the ISCF to develop parallel CO₂ and H₂ pipelines between the major emitters in the Humber region, enabling fuel-switching and CCS.
- **Humber Zero** secured funding from the ISCF to retrofit carbon capture on two gas turbines and auxiliary boilers at a Combined Heat and Power (CHP) plant, and a major process unit (Fluid Catalytic Cracker) at Phillips 66's Humber Refinery, in Immingham.
- The **Northern Endurance** partnership, established in 2020 to develop shared offshore infrastructure for transport and storage of CO₂ in the Endurance saline aquifer, serving the Humber and Teesside.
- The **East Coast Cluster** combines Zero Carbon Humber, Net Zero Teesside and the Northern Endurance Partnership, one of two UK clusters selected in the UK government's 2021 cluster sequencing process.
- **East Coast Hydrogen** is a collaboration between National Grid, Northern Gas Networks and Cadent, to a new hydrogen network of repurposed and existing pipelines across North East England.
- The **V Net Zero Humber Cluster** is a separate cluster bid by the **Humber Zero** and **V Net Zero** projects to provide the offshore transport and storage infrastructure at the depleted Viking gas field below the North Sea, not part of the BEIS Track 1 cluster sequencing funding¹³.
- The **Hull and East Yorkshire Local Enterprise Partnership (HEYLEP)**, launched in 2021, taking over the leadership of the Humber Industrial Cluster Plan from the former Humber LEP. HEYLEP represent the region's economic activities north of the Humber estuary.
- **Marketing Humber** works to attract investment and support in businesses within the region, they have been involved with 'the waterline summit 2021' and a 'Humber Industrial Decarbonisation' map.
- The **Industrial Decarbonisation Research and Innovation Centre (IDRIC)** is leading a large research programme associated with the UK clusters. The Humber cluster also has a knowledge exchange partnership with the **University of Hull** and collaborates with many other UK universities.
- The **North East and Yorkshire Energy Hub** is a collaboration of 6 Local Enterprise Partnerships, including the HEY LEP, looking to accelerate the transition to 'Net Zero' through local energy delivery.
- The **Humber Energy Board** launched in January 2022, led by the private sector with public sector support to represent the region's energy interests
- The **Yorkshire and Humber Climate Commission** is an advisory body aiming to bring actors from the public, private and third sectors together to support and guide climate action in the region.

Public engagement with energy or industrial infrastructure

Past campaigns

The social licence for industrial decarbonisation projects will be influenced by earlier industrial and energy developments in the region. Previous interactions between actors involved with advocating, governance and regulation, and campaigning may shape trust and attitudes between all parties for many years, even in relation to plans associated with different technologies and rationales. Gas storage in salt caverns at Aldbrough began in 2012 and was subject to the longest public inquiry in the region's history and associated with protests from shellfishers concerned with the pumping of salt water into the sea¹⁴. A Community Liaison Group was established after the site was commissioned and brings together local communities with the operator, supported by a project Liaison Manager. Other energy developments in the region have attracted opposition from local groups, for example local objections to an onshore windfarm at Fraisthorpe (consented in 2015) concerned with impacts to the local landscape and including a letter of objection from the artist David Hockney. Tension between regional stakeholders related to a compulsory purchase of land from Associated British Ports

(ABP) by Able UK in 2015, to build the Marine Energy Park near Immingham¹⁵, after long-running battle over an area of land at the site. There are long memories of the closure of coal mines across Yorkshire since the 1980s with a resulting restructure of the region’s employment as part of the post-coal energy future.

Other large projects have been the subject of campaigns from national activists including a ‘reclaim the power’ climate protest¹⁶ during the construction of the gas-fired power station at Keadby 2 in August 2019. Later in 2019, workers at Keadby 2 protested over the use of overseas contractors for the building of a new gas-fired plant¹⁷. Drax power station has also been the subject of several actions over the years from being the site of the UK’s first climate camp in 2006, anti-coal protests at its London offices in 2015, and an ‘Axe Drax’¹⁸ campaign in 2019 during plans to convert remaining coal units to gas¹⁹. The conversion to biomass has been a long-running focus of the Biofuelwatch campaigns over wood pellet imports from the US.

Public engagement with the cluster plans and projects

BEIS and UKRI recently commissioned a public dialogue²⁰ to explore opinions relating to carbon capture usage and storage (CCUS) across four of the industrial clusters. The Humber cluster was not included as part of this engagement process, however participants from across the study expressed conditional support for a role for CCUS in achieving net zero emissions. A set of ten criteria were developed during the BEIS dialogue process to guide the future deployment of CCUS technologies:

The entire CCUS process must be safe.	Guaranteed contribution to net zero
Independent oversight and regulation.	Cost effective and timely.
Clear benefits for local communities.	One of several measures to reaching net zero
Meaningful local engagement.	Limit damage to wildlife and the natural environment.
Minimise disrupt to local residents.	Transparency in funding and awarding contracts

Cluster plan projects have conducted formal consultations as part of the planning application process. As a nationally significant infrastructure project, the ‘**Humber Low Carbon Pipelines**’ (delivered by National Grid within the Zero Carbon Humber Project) will require a Development Consent Order (DCO) from the planning inspectorate. The first stage of public consultation was completed in 2021²¹ and explored different route corridor options, with further consultations planned during 2022. Drax has also started the DCO process²² and launched a public consultation in November 2021 to advance its plans to deliver bioenergy with carbon capture and storage (BECCS). The first stage of public consultation for the H2H Saltend was launched in 2021²³, with further consultations proceeding through 2022. In addition to the formal consultation processes, many of the region’s industrial facilities have their own ongoing community engagement programmes.

Conclusion

This report aims to summarise the context for industrial decarbonisation in the Humber region in a way that is useful to a variety of stakeholders in the region. The unique configuration of industry, geography, historical, cultural and environmental factors in the industrial cluster is critical to the deployment of technology-based initiatives which must be seen as credible and legitimate climate change solutions, as part of a social licence to operate (SLO). With several industrial decarbonisation consortia, understanding the configuration of the Humber cluster is complex and, with its recent history of boundary changes and administrative restructuring, lacks a strong unifying voice to champion the region that benefit other clusters. However, the Humber energy estuary is home to nationally significant and energy assets, with the largest emissions of the UK clusters and access to significant CO₂ storage resources, supported by strong partnerships, the Humber cluster provides an opportunity for substantial industrial decarbonisation

The aim of this project is to assess the status of the SLO in the Humber and Hynet NW clusters, including an examination of key issues relating to low carbon technology deployment in the cluster from the perspectives

of both stakeholders and lay publics. This report should be seen as a 'living document' which will be reviewed and updated over the course of the project, informed by a series of workshops with stakeholders and citizens in the region.

Summary

- This report provides a brief summary of the Humber Industrial Cluster and the broader context for building a social licence to operate (SLO) for the region's industrial decarbonisation
- The Humber cluster is the largest of the UK industrial clusters in CO₂ emissions, with sites located north and south of the Humber Estuary, connected by the Humber Bridge
- The region's **strategic importance** in national energy supply and industrial processing, includes two of the UK's six oil refineries and one of two integrated steelworks, alongside energy from waste, biofuel, cement, lime and glass manufacturers
- Significant renewable power generating capacity in the region includes the Humber offshore wind cluster and UK's largest power station at Drax, which, now entirely fired by biomass, has the potential to provide **greenhouse gas removal** biomass energy with carbon capture storage (BECCS)
- Promoted as the UK's **Energy Estuary**, the region also hosts the UK's busiest port complex, with the potential to receive CO₂ by ship destined for the region's offshore storage sites
- With **Track 1** status, as part of the East Coast Cluster, the Humber cluster aims to secure funding from the CCS Infrastructure Fund to become operational by 2026
- The cluster plan includes new CO₂ and hydrogen pipelines to link CO₂ captured from hydrogen production, BECCS power, combined cycle gas turbines and steel production to offshore CO₂ storage sites in a saline aquifer and depleted gas fields below the North Sea
- Potential for **hydrogen storage** in the region in onshore salt caverns and offshore in the Rough gas storage reservoir
- There are several consortia developing projects for decarbonising industry in the Humber cluster:
 - **Humber Industrial Cluster Plan** (HICP) developing a roadmap to decarbonise industry across the Humber region by 2040
 - **Zero Carbon Humber** (ZCH) to develop parallel CO₂ and H₂ pipelines
 - **Humber Zero** to retrofit carbon capture at a Combined Heat and Power (CHP) plant, the Humber Refinery, at Immingham
 - **Northern Endurance Partnership** to develop shared offshore infrastructure taking CO₂ to the Endurance saline aquifer, serving the Humber and Teesside
 - The **East Coast Cluster** comprising Zero Carbon Humber, Net Zero Teesside and the Northern Endurance Partnership, awarded Track 1 status in UK government's 2021 cluster sequencing process enabling it to *pursue funding from the CCS Infrastructure Fund* to become operational by the mid-2020's
 - The **V Net Zero** Humber Cluster is a separate cluster bid by the Humber Zero and V Net Zero projects to provide the offshore transport and storage infrastructure at the depleted Viking gas field below the North Sea
- Cluster plan projects are conducting formal consultations as part of the planning application process including 'Humber Low Carbon Pipelines' (National Grid within the ZCH Project), the BECCS project at Drax and the H2H Saltend project
- In the context of the complex configuration of cluster consortia and the region's recent history of administrative restructuring, the Humber has lacked a clear voice to champion the cluster. However, it is home to nationally significant and energy assets, with access to significant CO₂ storage resources, providing an opportunity for substantial industrial decarbonisation

References

- ¹ HM Government (2020) The Ten Point Plan for a Green Industrial Revolution. Available from: <https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution>
- ² HM Government (2021) Net Zero Strategy: Build Back Greener. Available from: <https://www.gov.uk/government/publications/net-zero-strategy>
- ³ BEIS (2021) October 2021 update: Track-1 clusters confirmed. Available from: <https://www.gov.uk/government/publications/cluster-sequencing-for-carbon-capture-usage-and-storage-ccus-deployment-phase-1-expressions-of-interest/october-2021-update-track-1-clusters-confirmed>
- ⁴ Humber Industrial Cluster Plan (2022) A comprehensive and dynamic plan for the Humber Cluster to achieve NetZero by 2040. Available from: <https://humberindustrialclusterplan.org/>
- ⁵ Element Energy (2019) The Impacts of Decarbonising the Yorkshire and Humber. Available from: http://www.element-energy.co.uk/wordpress/wp-content/uploads/2019/11/20191104_Element-Energy_Zero-Carbon-Humber-Study_Summary-for-Publication.pdf
- ⁶ Humber Zero (2022) What is Humber Zero? Available from: <https://www.humberzero.co.uk/what-is-humber-zero/>
- ⁷ Humber Industrial Cluster Plan (2022) 2030 ambitions for Industrial Decarbonisation in the Humber Region visualised for the first time. Available from: <https://www.humberindustrialclusterplan.org/2030-ambitions-for-industrial-decarbonisation-in-the-humber-region-visualised-for-the-first-time.html>
- ⁸ Humber LEP (2019) Humber Clean Growth Local White Paper. Available from: <https://www.humberlep.org/strategies-and-deals/industrial-strategy/humber-clean-growth-local-white-paper/>
- ⁹ Vivid Economics (2020) Capturing Carbon at Drax: Delivering Jobs, Clean growth and Levelling up the Humber. Available from: <https://www.vivideconomics.com/wp-content/uploads/2020/11/Capturing-Carbon-at-Drax-Delivering-Jobs-Clean-Growth-and-Levelling-Up-the-Humber.pdf>
- ¹⁰ The Guardian (2021) Crown gives go ahead to rival 'net zero carbon' North Sea schemes. Available from: <https://www.theguardian.com/business/2021/oct/23/crown-gives-go-ahead-to-rival-net-zero-carbon-north-sea-schemes>
- ¹¹ HEYLEP (2021) Humber Estuary Plan. Available from: <https://heylep.com/wp-content/uploads/2021/05/Humber-Estuary-Plan-final-draft-Jan-2021.pdf>
- ¹² BBC (2021) COP26: Flooding lessons from Hull, a city below sea level. Available from: <https://www.bbc.co.uk/news/uk-england-humber-59208096>
- ¹³ Business Live (2021) East Coast Cluster uniting Humber and Tees named as government forerunner in carbon capture deployment. Available from: <https://www.business-live.co.uk/economic-development/east-coast-cluster-uniting-humber-21899142>
- ¹⁴ Yorkshire Post (2011) Sea defences to protect work on creating giant gas store. Available from: <https://www.yorkshirepost.co.uk/news/sea-defences-protect-work-creating-giant-gas-store-1937678>
- ¹⁵ BBC (2015) Able Marine Energy Park: ABP drops legal challenge. Available from: <https://www.bbc.co.uk/news/uk-england-humber-31359423>
- ¹⁶ BBC (2019) Climate protesters target Lincolnshire gas power station. Available from: <https://www.bbc.co.uk/news/uk-england-humber-49152523>
- ¹⁷ BBC (2019) Protest over Keadby 2 power station 'overseas' workforce. Available from: <https://www.bbc.co.uk/news/uk-england-humber-50521003>
- ¹⁸ York Press (2020) Axe Drax, say XR campaigners in York. Available from: <https://www.yorkpress.co.uk/news/18469661.axe-drax-say-xr-campaigners-york/>
- ¹⁹ The Guardian (2020) UK approval for biggest gas power station in Europe ruled legal. Available from: <https://www.theguardian.com/environment/2020/may/22/uk-approval-for-biggest-gas-power-station-europe-ruled-legal-high-court-climate-planning>
- ²⁰ Traverse (2021) Carbon Capture Usage and Storage: Public Dialogue. Available from: <https://sciencewise.org.uk/wp-content/uploads/2021/07/ccus-public-perceptions-traverse-report.pdf>
- ²¹ National Grid (2021) Humber Low Carbon Pipelines. Available from: <https://www.nationalgrid.com/our-businesses/national-grid-ventures/humber-low-carbon-pipelines>
- ²² Drax (2021) Our Consultation. Available from: <https://beccs-drax.com/>
- ²³ Equinor (2021) Public Consultation 2021. Available from: <https://engage.erm.com/equinor-h2h-saltend>

Appendix: Stakeholder workshop summary

A participatory workshop was held on 9th February 2022, attended online by stakeholders from the Humber region. 11 participants attended representing industry, cluster consortia (e.g. LEPs), local government, and academia. Working in two separate breakout groups, participants provided feedback on the first draft of this report and contributed to facilitated discussions, summarised below. The outputs from this workshop will be analysed as part of the IDRIC project on Social Licence to Operate.

Session 1: industrial decarbonisation in the Humber.

This session identified the key attributes needed to support industrial decarbonisation of the cluster, identifying particular strengths and challenges for the region. The Humber region was considered to benefit from a strong industrial heritage, with existing physical infrastructure (such as pipelines, ports, storage sites etc) which is supported by strong and diverse partnerships. Policy uncertainty was identified as a key challenge area, including business models and regulatory frameworks, recognising the need for industry to adapt supply chains in line with net zero. The challenge of presenting information in a more honest and understandable manner was also identified as necessary to build support from public and NGOs. Other factors flagged as important but identified as either strengths and challenges by different participants respectively, included: industry and government investment, the potential to exchange knowledge with other clusters or sectors and the availability of structures for involving stakeholders to generate a shared vision of the future.

Session 2 phrases and narratives

Session 2 explored some of the phrases and narratives relating to industrial decarbonisation in the region. Both groups discussed the use of terms '*Superplaces*' and '*levelling up*', then each group discussed other themes based on their inputs at the start of the session. The term *Superplaces* was first used in the Government's '10 point plan' to describe locations with significant renewable energy and infrastructure for industrial decarbonisation but is not widely used outside of government. The place-based aspect was seen as important for community engagement but needs to be connected to the '*levelling up*' agenda. However, the '*levelling-up*' narrative was also met with scepticism, seen as another Government 'buzzword', and associated with a tension between regional pride, the need to share wealth across the UK and a view of the north as being left behind. Typically connected with transport, '*levelling up*' was seen as needing to be better linked to industrial decarbonisation, associated with long-term investment bringing skilled, well-paid jobs and good local infrastructure. The terms *hub/cluster* were seen as useful to frame industry as part of the solution, with *hub and spoke* as way to include emissions outside the cluster. The *Energy Estuary* relates to the area's identity and the iconic Humber bridge and its shipping heritage, although it was noted that the estuary also represents a barrier, dividing the region in two, connected by the bridge. Other narratives around *Clean growth*, used by specialists and industry, and *green recovery* from COVID for industry and employment, were cited, recognising that the decarbonisation narrative should go beyond technology to include the social aspects of decarbonisation.

Session 3 Key topics

Session 3 identified key topics relating to specific elements of hydrogen and CCUS supply chains and applications, alongside more general issues relating to industrial decarbonisation, summarised in Table A1. For *hydrogen*, topics covered production, industry use, transport, storage; for CCS these included CCS for power, CCS for industry, CO₂ transport, CO₂ storage.

Hydrogen	CCUS	Industrial decarbonisation:
<ul style="list-style-type: none"> • Making the case for hydrogen. • Safety (including explosivity, emergency response, leakage from storage sites and regulatory and licencing frameworks) • Costs • Environmental implications of blue vs green hydrogen • Supply chain capabilities including jobs, timing (when available) 	<ul style="list-style-type: none"> • Fossil Fuel Lock In • Cost – and potential for CCS to be the cheapest or only option to decarbonise some applications • Carbon footprint • Understanding BECCS • Constructing new high-pressure pipelines • Safety (leakage, marine impacts) • Repurposing existing assets 	<ul style="list-style-type: none"> • Impact on global competitiveness, export potential and a need for policy to price carbon appropriately • Carbon intensity of imported energy • The cost of net zero • Will government force companies to comply? • Communicating the benefits and drawbacks of decarbonising the clusters • Importance to stakeholders and communities of keeping steel in the UK, it must decarbonise to remain economically viable and is needed for the decarbonisation of multiple sectors • Compatibility of industrial processes with hydrogen/electrification • Conservation / natural capital • Degrowth? • Nuclear

Table A1. Summary of key topics

Session 4 Trust and Confidence

In Session 4 participants considered factors affecting trust between, and confidence in, different sectors in the region, summarised below:

Local/regional government are seen as being responsible for delivering and driving decarbonisation forward, and need to work together to develop long term goals for the wider benefit of the region. However, this depends on them being adequately resourced; how central government deliver on levelling up will impact Local Authority trust.

Central government lost trust over the cancellation of previous CCS competitions, long term goals are needed to promote investor confidence, and enshrining net zero in law has helped, however, this needs to be supported by action from government, based on informed positions; ongoing trust in government remains contingent on events.

Trust between *public* and *industry* is supported by a track record of doing things safely in the past (e.g. experience of managing pipelines) but also depends on trust in the regulator. How dialogues with publics and NGOs are managed, and that industry are transparent and open in their communication, is important to build trust and reduce cynicism from publics, *NGOs* and *media*, while industry need confidence that the public can judge technical issues and interpret risks. The media plays a role in how citizens may be informed about projects but it can be hard for them to identify trustworthy sources; influential figures may help to build trust and support but are difficult to identify. The role of *academics* in developing research that informs industry was also identified.