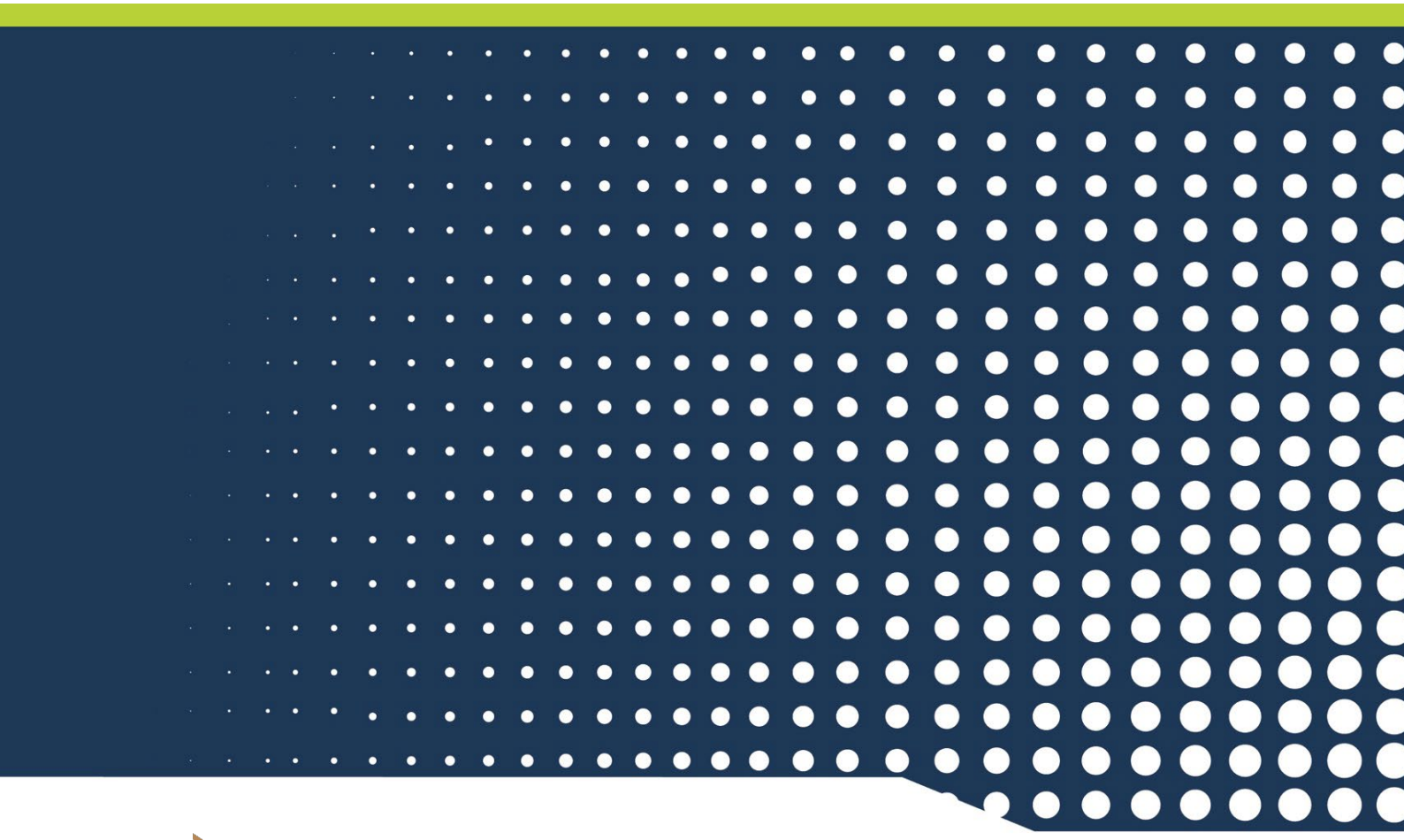
CLUSTER
DECARBONISATION
IN INDUSTRIES

Industrial Decarbonisation Market Great Britain

Scoping Report



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As the operator of the CDI Coordination Office, the Competence Centre on Climate Change Mitigation in Energy-Intensive Industries (KEI) organises the cooperative work between the partners as well as coordinating network events. The KEI is a division of the Zukunft – Umwelt – Gesellschaft (ZUG) gGmbH working on behalf of German Federal Ministry for Economic Affairs and Climate Action (BMWK). Registered office of the ZUG: Robert-Schuman-Platz 3, 53175 Bonn.

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The Humber Industrial Cluster has been at the forefront of the UK's offshore wind technology and talent development for many years. More recently, considerable progress has also been made on the development of numerous hydrogen and CCUS projects, making the Humber Industrial Cluster (HIC or 'the Cluster') an internationally significant testbed for decarbonisation technologies. The Cluster is also ideally placed for carbon infrastructure and storage development projects given the concentration of heavy industry / decarbonisation incentives and its proximity to storage capacity.

"There are few places around the world more crucial to the road to net zero and industrial decarbonisation than the Humber – it is a location from which so much can be achieved and learned".

Jörgen Sandström, Head of Energy, Materials,
Infrastructure Program – Industrial Transformation,
World Economic Forum

Heavy industries in the UK have shown strong economic performance in recent years, with revenues rebounding to pre-pandemic levels. There has also been an upward trend in FDI into the UK in recent years, driven by renewable energy and metals. This strong economic performance should provide a foundation for investment in decarbonisation technology development in future.

There have been substantial levels of public investment in decarbonisation within the Cluster in recent years, across at least 20 significant decarbonisation projects[1]. Strategically significant global businesses, including Phillips 66, Shell, Uniper, RWE and Orsted, have pledged to invest c. £15 billion into Humber-based energy transition activities[2]. However, despite major investment from the UK government and strategically significant global businesses, the level of private investment in smaller clean technology supply chain businesses has been more modest, suggesting that the Cluster may offer unrealised investment opportunities.

The Humber Industrial Cluster is also a key location for research and development activity in renewable energy and decarbonisation. The Humber Industrial Cluster was formed following a 2019 industrial clusters funding competition run by UKRI. Since 2018, the total number of research and innovation funding awards within the cluster has more than trebled, and the number of awards focussing specifically on decarbonisation and the environment has seen an almost five-fold increase. A notable proportion of this funding has focussed on building the knowledge and skills required to leverage social and economic benefits from renewable

[1] https://investhumber.com/industrial-decarbonisation
[2] Humber Energy Board, 'Humber 2030 Vision', Invest Humber

energy and decarbonisation. For example, since 2019 the University of Hull has hosted the UK's main Centre for Doctoral Training in Offshore Wind Energy and the Environment – representing a £6 million investment by two UK research councils.

With the exception of the new UK ETS, the level of divergence between UK and EU decarbonisation policy and legislation in recent years has been limited, and should therefore not present a major barrier to international co-operation on decarbonisation activities. More recent UK policies and legislative developments focus on accelerating the planning process for major infrastructure projects, which should further benefit decarbonisation activity within the Humber region.

In recent years UK decarbonisation policy has favoured hydrogen and CCUS for industrial decarbonisation. Both of these technology areas have received substantial investment in recent years. At the time of writing, the Department for Energy Security and Net Zero (DESNZ) is reviewing all decarbonisation pathways, and the Climate Change Committee will soon publish updated progress and risk assessments as well as new carbon budgets. This may result in greater emphasis on electrification and could present some risk to early-stage hydrogen and CCUS activity. However, regardless of nuances in the specific technology focus, the Humber Industrial Cluster will continue to be a major focal point for industrial decarbonisation in future.

1 Introduction

In March 2024 Zukunft Umwelt Gesellschaft (ZUG) commissioned Perspective Economics Limited to provide information regarding the potential market for industrial decarbonisation in the UK. The market analysis is intended to inform German industry and policy representatives in advance of a visit to the UK's 'Humber Industrial Cluster'. This short report presents key findings from the UK market analysis research in relation to the areas listed below.

Areas of Research

1. Framework conditions for industrial decarbonisation
2. The market for industrial decarbonisation
3. Key stakeholders in decarbonisation

The market analysis has been prepared based on extensive desk-based research, analysis of secondary data and consultation with five UK industrial decarbonisation stakeholders.

1.1 Methodology and Approach

The study involved seven stages as summarised in the sub-sections that follow.

1.1.1 Conception & Project Initiation

An initial project initiation meeting (PIM) was held with ZUG representatives on 15 April 2024. The project initiation meeting established the goals for the study, agreed ways of working, and confirmed the methodology and study approach. This meeting also confirmed key milestones of the study, project and risk management processes, and timescales of all study outputs.

1.1.2 Rapid Evidence Assessment & Co-Design

Following the PIM the study team undertook an initial review (Rapid Evidence Assessment or REA) of publicly available data and documentation including more than 24 official policy documents (2015 – 2024), 10 data sets from a variety of sources (such as the IEA, ONS and EDGAR) and a review of several other sources, from grey literature such as decarbonisation strategies written by industry groups or evaluations of UK government funded support programmes. Key findings from the REA were summarised in a PowerPoint presentation and used to inform a co-design meeting involving wider ZUG stakeholders. The co-design meeting was held on 3rd May 2024 and confirmed that the study should focus in particular on the status of green and blue hydrogen projects operating within the Humber region, and on the regulation of CCUS projects and technologies in the UK compared to Europe.

1.1.3 Competition Analysis

Having confirmed the detailed scope of the market analysis, the study team undertook desk-based research to identify industrial decarbonisation stakeholders in business and science, including UK government departments, departmental agencies, arms-length funding bodies,

regional stakeholders and research institutes. The study team also gathered secondary data from a range of sources to provide deeper analysis of the competitive business environment including investment raising, revenues, employment, research funding and research and development expenditure. Data sources used to inform the competition analysis are presented in the Appendices.

1.1.4 Market Potential

Data collected in Stages 02 and 03 (Market Description and Competition Analysis) were analysed to provide an indication of the potential for industrial decarbonisation in the UK. The market potential analysis included but was not limited to data on emissions, business growth, foreign investment, public research and innovation funding and private investment. At this stage the study team also engaged up to five relevant stakeholders in a semi-structured interview regarding opportunities and challenges facing the market for CCUS and hydrogen in the UK.

1.1.5 Reporting & Presentation

Research findings have been synthesised and incorporated into this short market analysis report. An accompanying presentation provides a further, easily accessible distillation of key findings.

1.1.6 Framework Conditions

The study team conducted desk research to identify and summarise relevant decarbonisation strategies and policies at national and regional geographic levels, as well as relevant regulation, standards, legislation, taxation, and trade policies influencing in-scope technologies. Particular focus was placed on understanding how policies, regulatory and funding conditions relate to international firms entering the market.

1.2 Report Structure

The remainder of the market analysis report is structured as follows:

Section 2: Framework Conditions – a summary of key strategies, policies, market incentives and regulatory factors affecting the market for CCUS and hydrogen production in the UK.

Section 3: Market Description & Competition Analysis – findings regarding the current competitive landscape for CCUS and hydrogen in the UK, including trade and investment trends and key stakeholders.

Section 4: Stakeholder Mapping & Consultation – summary of key UK stakeholders involved in CDI technologies of interest and findings from stakeholder consultation.

Section 5: Conclusions – a brief summary of salient points identified throughout the research.

2 Framework Conditions

This section provides a summary of national and local framework conditions that are shaping industrial decarbonisation across the UK and locally within the Humber region. Framework conditions include key policies and strategies, regulatory and legislative developments and funding programmes.

2.1 National Framework

The sub-sections that follow outline key elements of the framework for decarbonisation across the UK, including common themes contained within national strategies and policies, post-Brexit regulatory developments, and key interventions in the UK decarbonisation market.

2.1.1 Key Strategies & Legislative Developments

Decarbonisation and net zero have been key pillars of policy development in the UK in recent years, and are likely to continue to be policy priorities under any new government. The national framework for decarbonisation in the UK comprises three key strategies, all of which govern a different aspect of the of the overall strategy.

Key Strategies and Policies

- Net Zero Strategy: Build Back Greener (national policy)
- Powering Up Britain: The Net Zero Growth Plan (energy policy)
- Industrial Decarbonisation Strategy (industrial policy).

The UK government's 'Net Zero Strategy' sets out the UK's overarching strategic decarbonisation goal, while 'Powering Up Britain' details how the UK energy sector is going to be decarbonised to reach its decarbonisation objectives, and the 'Industrial Decarbonisation Strategy' details how these national strategies apply to UK industry.

The UK is taking a cluster, or place-based approach to deploying decarbonisation technologies, seeking to take advantage of economies of scale where multiple related industries have co-located (clustered) their operations. Clusters are a good test bed for hydrogen and CCUS as the density of related industries allows for shared infrastructure and by extension shared costs, driving down the risks associated with adopting these technologies for the individual businesses (HM Government, 2021a p. 119).

A summary of objectives and commitments set out in each strategy is provided in the Appendices. Commitments regarding CCUS, Hydrogen, Industrial Energy Transformation and Industrial Decarbonisation Clusters feature across all three strategies (Figure 2.1).

Topic	CCUS	Hydrogen	IETF	Clusters
Strategy				
Industrial Decarbonisation Strategy (IDS, Mar 2021)	~3 MtCO2 industrial capacity (2030) ~6 MtCO2 industrial capacity (2035) 20-30 MtCO2 wider capacity (2030) CCS Infra Fund (£ 1bn)	£240m NZ Hydrogen Fund	£315m (energy efficiency)	4 clusters connected (2030) 1 fully NZ cluster (2040)
Net Zero Strategy (NZ, Oct 2021)	6 MtCO2 capacity (2030) 9 MtCO2 capacity (2035)	5 GW low carbon production (2030)	£315m (energy efficiency)	Hynet (NW) & East Coast (mid-2020s)
Powering Up Britain (PUB, Mar 2023)	20-30 MtCO2 capacity (annually)	10 GW low carbon production (2030)	15 % reduction in final energy demand from buildings (2030)	4 clusters (2030)

Figure 2.1: Consistent UK Decarbonisation Policy Commitments

The UK government has passed a number of important pieces of legislation in recent years, with the past year (2023) seeing two notable changes. The most relevant legislation alongside key updates is detailed in the list below.

Legislation Relevant to Industrial Decarbonisation

- The 2013 update to the *Energy Act* gave the secretary of state the powers needed to engage in Contracts for Difference (CfD) with renewable energy providers leading to the first round opening in 2014. The CfD support energy companies who switch over to renewables by offering them fixed prices for a 15 year period to providing them with protection against potentially volatile market prices, allowing them to recuperate some of the high upfront involved with switching (DESNZ, 2014; DESNZ, 2023a). The CfD scheme is to this day one of the primary ways in which the government supports the development of green energy, in particular the deployment of offshore and onshore wind as well as solar farms, with a budget of £205 million being set aside for the 2023 allocation round (DESNZ, 2023a);

- In 2023 the *Energy Act* was amended again, this time: increasing the government's ability to engage in revenue support contracts beyond the CfD structure with a focus on better supporting the CCUS and hydrogen sector; introducing new procedures for mitigating the environmental impact of offshore wind; establishing a licensing scheme for the transport and storage of carbon and hydrogen; introducing procedures for the safe decommissioning of carbon capture facilities; as well as introducing additional ways of supporting the hydrogen sector through levy's.

- The *Levelling-up and Regeneration Act* (2023) sets out new guidelines that allow for Nationally Significant Infrastructure Projects (NSIPs), including some major renewable energy projects, to go through a 'fast-track' planning process. As part of a related action plan, 10 projects secured funding to assist with the cost of supporting the NSIP process. Selby District Council and North Yorkshire County Council secured funding to deliver the Helios Renewable Energy Project, Drax Bioenergy with CCS and Humber Low Carbon Pipelines.

The Labour Party's 'Energy Mission' paper earmarks £1 billion for industrial decarbonisation and £1.8 billion for upgrading ports across the UK from a 'National Wealth Fund', including investment in renewable energy, CCUS and hydrogen. Specific targets set out in the Energy Mission include 5 GW of floating offshore wind capacity, doubling of onshore wind capacity to 35 GW, tripling solar power to 50 GW and quadrupling offshore wind to 55 GW, all by 2030. The Labour Energy Mission also commits to 10 GW of green hydrogen production for use in flexible power generation, storage and green steel. Labour's Energy Mission does not, however, make any explicit commitments regarding CCUS.

Assuming a new Labour government in Autumn 2024, delegates can remain confident in the UK's commitment to decarbonisation, including hydrogen, but the absence of any specific CCUS commitments may signal a softening of the focus on that particular technology.

2.1.2 Post-Brexit Regulatory Developments

The UK government maintains a log of progress regarding Retained EU Law (REUL). Of the 47 legislative items that refer to carbon and fall under the UK Department for Energy Security

and Net Zero (DESNZ), four have been amended, three have been repealed, two have expired and the remainder are unchanged. The amended, repealed and expired legislation is available in the report Appendices. Key points include: bringing UK Offshore Combustion Installations (Pollution Prevention and Control) Regulations that govern environmental impact assessment requirements for offshore oil and gas exploration, production, unloading and storage in line with EU regulations; and repealing Commission Decisions that govern the UK's participation in the EU Emissions Trading Scheme (ETS). Repeal of the EU ETS means that since 2021 the UK has operated its own carbon market. As such, it has autonomy to determine its own criteria for assessing the risk of carbon leakage and deciding which sectors should receive free allowances to mitigate this risk.

2.1.3 UK Emissions Trading Scheme

The UK Emissions Trading Scheme (UK ETS) was launched on 1 January 2021, replacing the UK's participation in the EU ETS following Brexit. The UK ETS covers energy-intensive industries, power generation, and aviation, which together account for around one-third of the UK's total emissions.

In the first auction of the UK ETS (May 2021) the clearing price for allowances was £43.99 per tonne of CO2, slightly higher than the £43.48 per tonne clearing price in the EU ETS auction held on the same day. The initial cap for the UK ETS was set at 5 % below the UK's expected notional share of the EU ETS cap for Phase IV (2021-2030), to align with the UK's more ambitious emission reduction targets.

Since the UK government appeared to soften some commitments to net zero policies in 2023 carbon prices in the UK market have fallen considerably, to below their initial clearing price (2021) and less than half of the peak price of £90 set in August 2022 (Figure 2.2). On average, 18 bidders take part in UK ETS auctions, 14 of which are successful. EU prices have followed a similar trajectory, but the fall in EU clearing prices in 2023 was not as sharp and appears to have rebounded more quickly in early 2024 than UK prices.

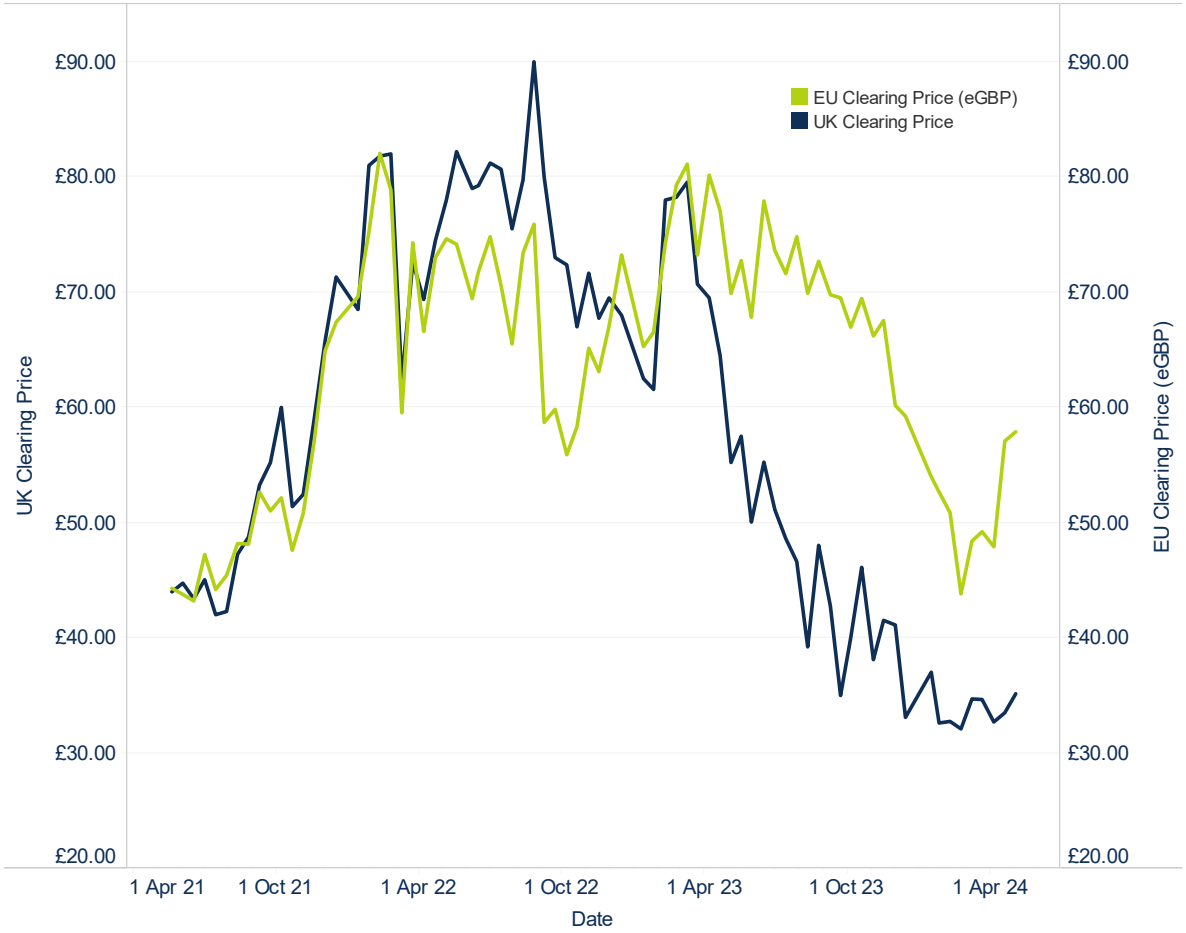


Figure 2.2: Intercontinental Exchange (ICE), European Energy Exchange (EEX)

2.1.4 Cross Border Carbon Adjustment Mechanism

The UK Cross Border Carbon Adjustment Mechanism (CBAM) is a proposed policy measure aimed at addressing carbon leakage and levelling the playing field for domestic industries subject to carbon pricing. Initially explored as a policy option post-Brexit, a CBAM policy has featured consistently in UK energy policy in recent years. Initial consultation was undertaken in 2021, with more detailed technical consultation ongoing. The UK government currently expects to implement a CBAM by 2027 (DESNZ & HM Treasury, 2023) applicable to imports of aluminium, cement, ceramics, fertiliser, glass, hydrogen, iron and steel. The UK CBAM is expected to align closely with the EU's version.

2.2 Regional Framework

Known as the UK's 'Energy Estuary', the Humber region has several unique features that make it a suitable location for developing renewable energy and decarbonisation technologies.

Comprising four Local Authority areas – East Riding of Yorkshire, Hull City, North Lincolnshire and North East Lincolnshire (Figure 2.3) – the cluster area has high industrial density, local renewable energy sources, the UK's largest port complex, a skilled workforce, and access to storage capacity within saline aquifers and depleted gas fields (Figure 2.4)

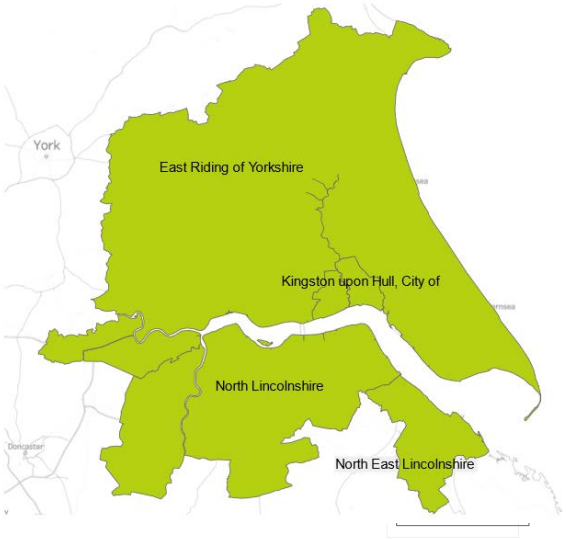


Figure 2.3: Humber Cluster Geography, Humber Industrial Cluster Plan & UKRI, 2021

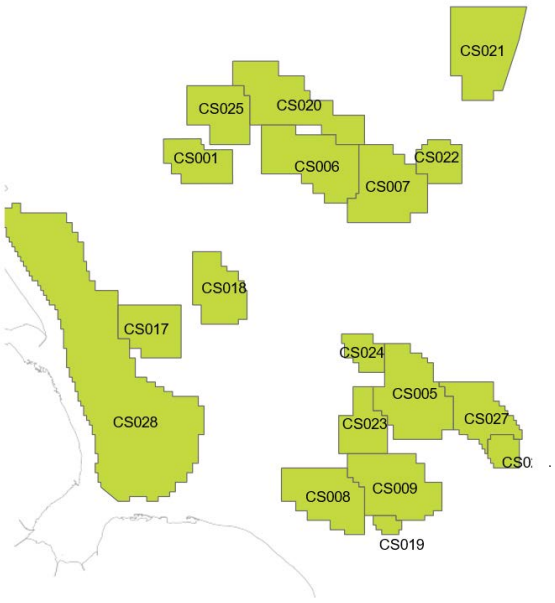


Figure 2.4: NSTA CO_2 storage licence sites 2023

The Humber cluster is estimated to have access to 20 mtCO2e storage capacity per year.

The Humber Industrial Cluster Plan (HICP) is a strategic roadmap designed to transform the Humber region into the world's first net-zero industrial cluster by 2040. Funded by the UK Research and Innovation (UKRI) Industrial Decarbonisation Challenge Fund, the plan seeks to leverage the region's unique assets to decarbonise the Humber's industrial cluster – the single largest carbon-emitting cluster in the UK, contributing nearly 5 % of the national total.

The HICP outlines several mandates for action, including the implementation of CCS and greenhouse gas removal technologies at scale, scaling up low-carbon hydrogen production, (aiming for a capacity of 5.2 GW by 2030), maximising the electrification of industrial processes, and enhancing resource and energy efficiency. The plan estimates a capital investment requirement of c. £10 billion for decarbonisation projects, with the potential to create 22,800 jobs in the Humber region.

3 Market Description & Competition Analysis

This section provides an overview of the market for industrial decarbonisation in the UK. It summarises the size and scale of hard to decarbonise sectors in the UK, provides an illustration of funding and investment trends in decarbonisation and renewable energy technologies, and provides more granular detail on the CDI's technologies of interest.

3.1 Size & Scale of Hard to Decarbonise Sectors (HDS)

This section provides a description of the market for decarbonisation in the UK. In line with the research requirements, it focusses on the energy intensive industries outlined within the ITT and defined in Figure 3.1 below for ease of reference. Definitions are based on the five-digit Standard Industrial Classification (SIC) codes used to define economic sectors within official UK government research[3] .

CDI Sector of Interest	UK SIC Code(s)
Cement	23510 - Manufacture of cement 23520 - Manufacture of lime and plaster 23690 - Manufacture of other articles of concrete, plaster and cement
Chemicals	20110 - Manufacture of industrial gases 20120 - Manufacture of dyes and pigments 20130 - Manufacture of other inorganic basic chemicals 20140 - Manufacture of other organic basic chemicals 20150 - Manufacture of fertilisers and nitrogen compounds 20160 - Manufacture of plastics in primary forms 20170 - Manufacture of synthetic rubber in primary forms 20200 - Manufacture of pesticides and other agrochemical products 20590 - Manufacture of other chemical products n.e.c.
Energy	06100 - Extraction of crude petroleum 06200 - Extraction of natural gas 19201 - Mineral oil refining 19209 - Other treatment of petroleum products 09100 - Support activities for petroleum and natural gas extraction 35110 - Production of electricity 35120 - Transmission of electricity

[3] Note the following caveats apply to the preliminary sectoral analysis: a) companies self-assign SIC codes when they are incorporated, therefore the main SIC codes do not always accurately reflect the main operations of the company; b) postcode data related to registered office addresses and may not therefore fully reflect primary trading locations.

Glass	23110 - Manufacture of flat glass 23120 - Shaping and processing of flat glass 23130 - Manufacture of hollow glass 23140 - Manufacture of glass fibres 23190 - Manufacture and processing of other glass including technical glass
Non-Ferrous Metals	24100 - Manufacture of basic iron and steel and of ferro-alloys 24200 - Manufacture of tubes, pipes, hollow profiles and related fittings, of steel 24310 - Cold drawing of bars 24320 - Cold rolling of narrow strip 24330 - Cold forming or folding 24340 - Cold drawing of wire 2445 - Other non-ferrous metal production 07290 - Mining of other non-ferrous metal ores

Figure 3.1: Definition of Energy Intensive Industries

3.1.1 UK Sector Headlines

In total there are over 20,000 businesses operating across these energy intensive industries in the UK. These businesses employ almost 650,000 people globally, with approximately 55 % employed in Oil and Gas and just under 20 % employed in the chemical industry.

Historic revenue and employment data suggest that these sectors are performing strongly. Revenues across these sectors have rebounded since the COVID-19 pandemic to above previous levels. However, employment within these sectors has not yet reached pre-pandemic levels.

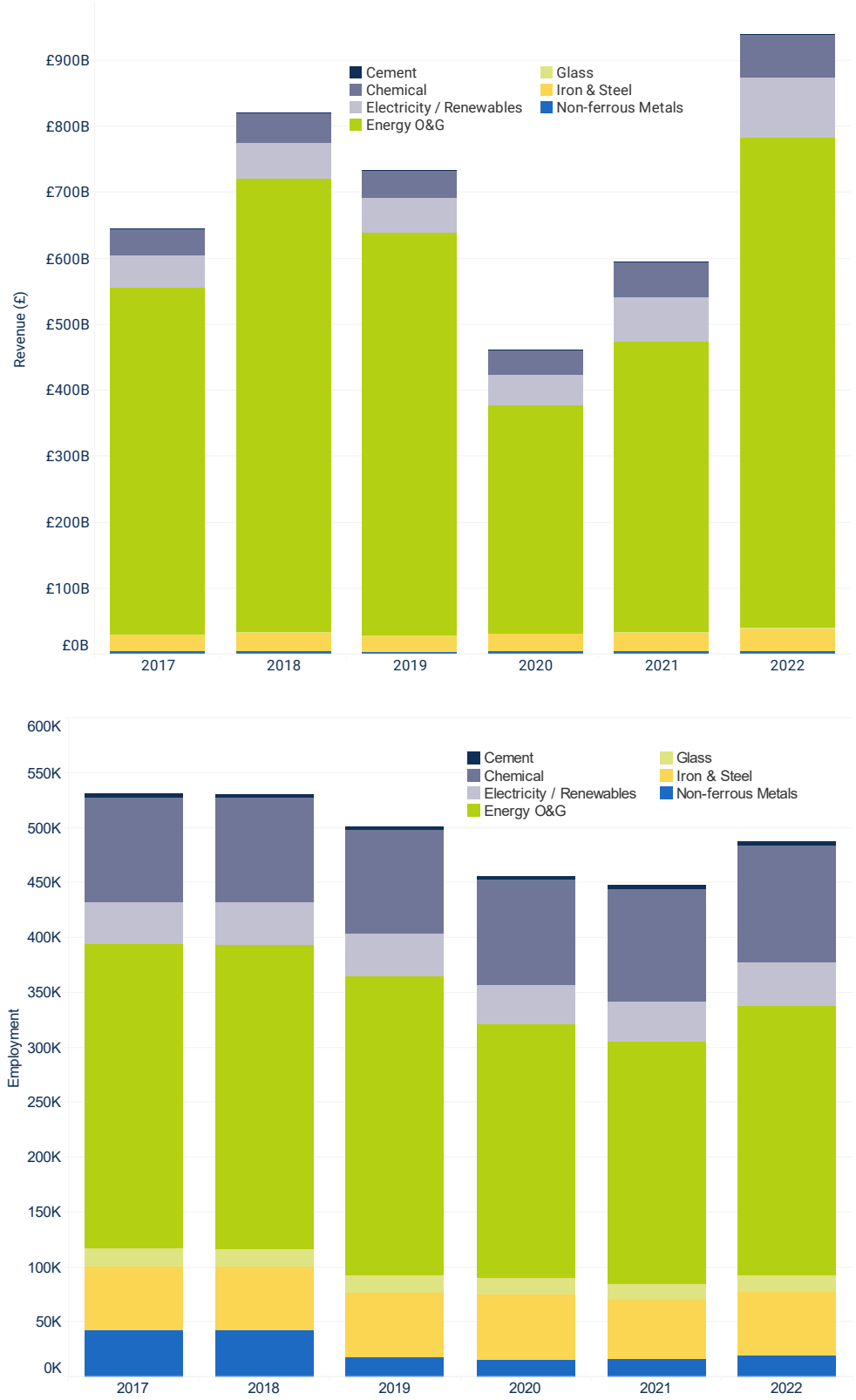


Figure 3.2: Trend in UK HDS Revenue (Top) & Employment (Bottom), Bureau van Dijk[4]

[4] Data for companies that reported revenue and employment data in both 2017 and 2022

3.1.2 Regional & Cluster Sector Headlines

The Humber Cluster is located within the wider 'Yorkshire and Humber' region of the UK and is a main location for heavy industry within the region.

The Yorkshire and Humber region accounts for ~5 % of the HDS businesses identified through this research, and for ~7 % of employment. The chemical and glass sectors are particularly prominent in the Yorkshire and Humber region, with companies in these sectors accounting for just under 20 % of total UK employment in each case. The renewable energy sector in Yorkshire and Humber accounts for ~10 % of total UK employment, supported by major renewable energy projects, such as the Hornsea Wind Farms which employ hundreds of local people in ongoing maintenance and support roles.

Within the Yorkshire and Humber region, the Humber Cluster accounts for just under one fifth of the businesses identified (19 %, n=199), approximately one quarter of employment in hard to decarbonise sectors (24 %, n=10,500). The chemical and glass sectors are also prominent within the Humber Cluster, accounting for 7 % and 3 % of UK employment in those sectors. The Humber Cluster is also a focal point for renewable energy activity, accounting for 27 % of the renewable energy businesses identified. Figure 3.3 shows the largest companies in the Humber Cluster by revenue.

CRODA	Chemical
SALTEND (TRITON POWER)	Electricity Generation
YARA	Chemical
SMITH AND NEPHEW	Chemical
CENTRICA	Electricity Generation
TRONOX PIGMENT	Chemical
PLUSS-STAUFER	Chemical
OMYA UK	Chemical
POLYNT COMPOSITES	Plastics
NIPPON GASES UK LIMITED	Chemical

Figure 3.3: Largest Humber Cluster Companies, Bureau van Dijk

3.2 Investment in Decarbonisation & Renewable Energy Technology

This section presents findings from analysis of data on inward investment projects into CDI's UK sectors of interest, and from data on investment in UK companies involved in the development of clean technology, including hydrogen, carbon capture and renewable energy more broadly.

3.2.1 Foreign Direct Investment

Based on a search for inward investment in the UK, the study has identified more than 400 inward investment projects within related sectors since 2019[5]. 44 % of the inward investment projects concern renewable energy.

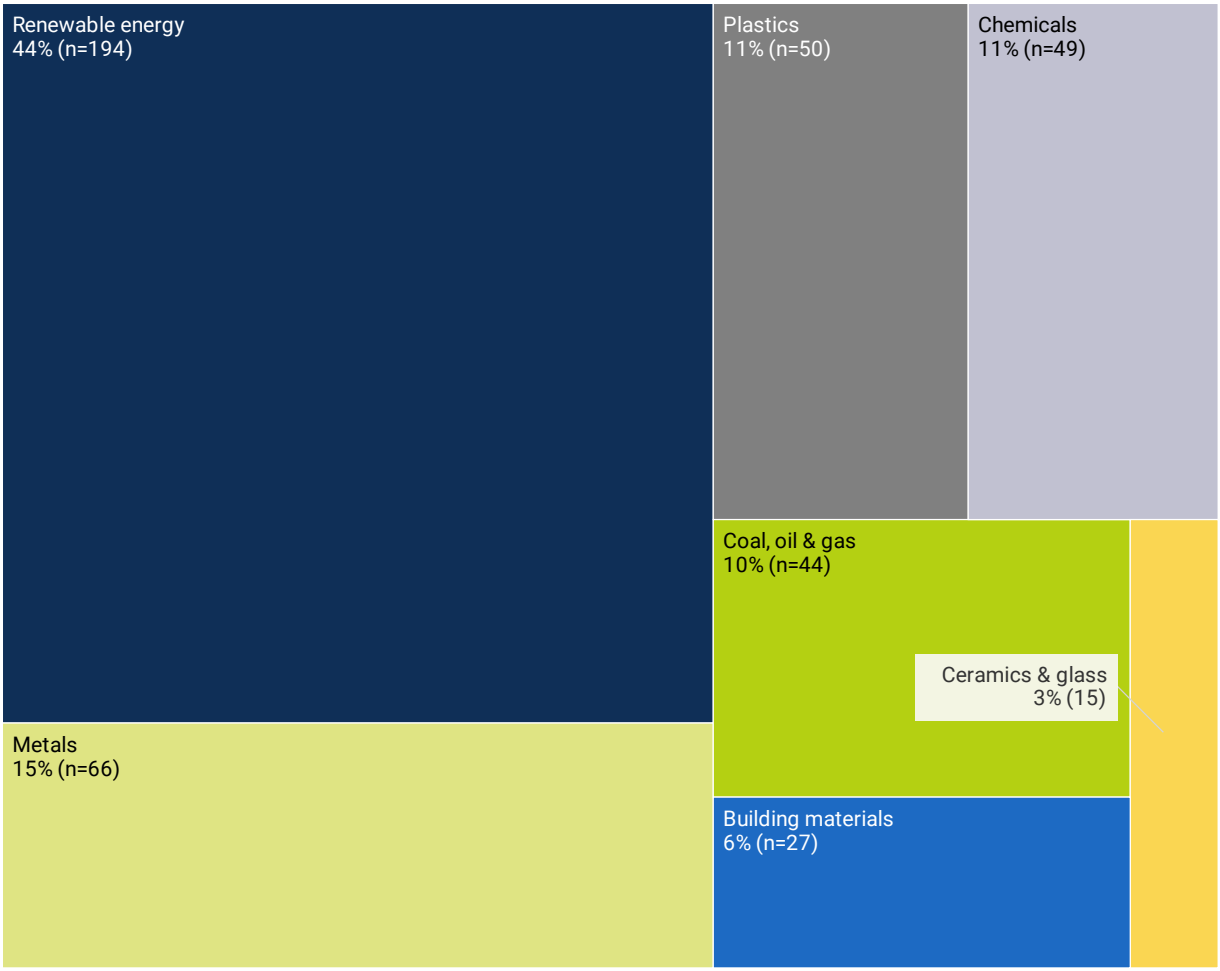


Figure 3.4: UK Inward Investment Projects by Sector, FDI Markets

Approximately 10 % of the total number of inward investment projects have been in the Yorkshire region (n=46). Of this investment in Yorkshire, renewable energy investment accounts for 26 % of the total number of projects (n=12) and for a majority of total capital investment. Orsted and Equinor are among the largest foreign direct investors into the renewable energy sector in Yorkshire – both of which are involved in the Humber Cluster (see

[5] Search uses FDI Markets from the Financial Times – a platform that provides real-time monitoring of foreign direct investment projects including capital investment and job creation. Relevant sectors available within the platform include building materials, ceramics and glass, chemicals, coal, oil and gas, metals, plastics and renewable energy.

Section 3.3). Yorkshire has also seen several smaller FDI projects by German companies across sectors of interest, including BayWa r.e. (renewable energy), Brenntag (chemicals), and EJOT (metals).

Based on inward investment projects for which capital investment values are known (i.e., excluding estimates applied by the data provider) data suggests that there has been a general upward trend in FDI since 2020 across sectors of interest (Figure 3.5). Since 2021 renewable energy investments have accounted for an increasing share of FDI.

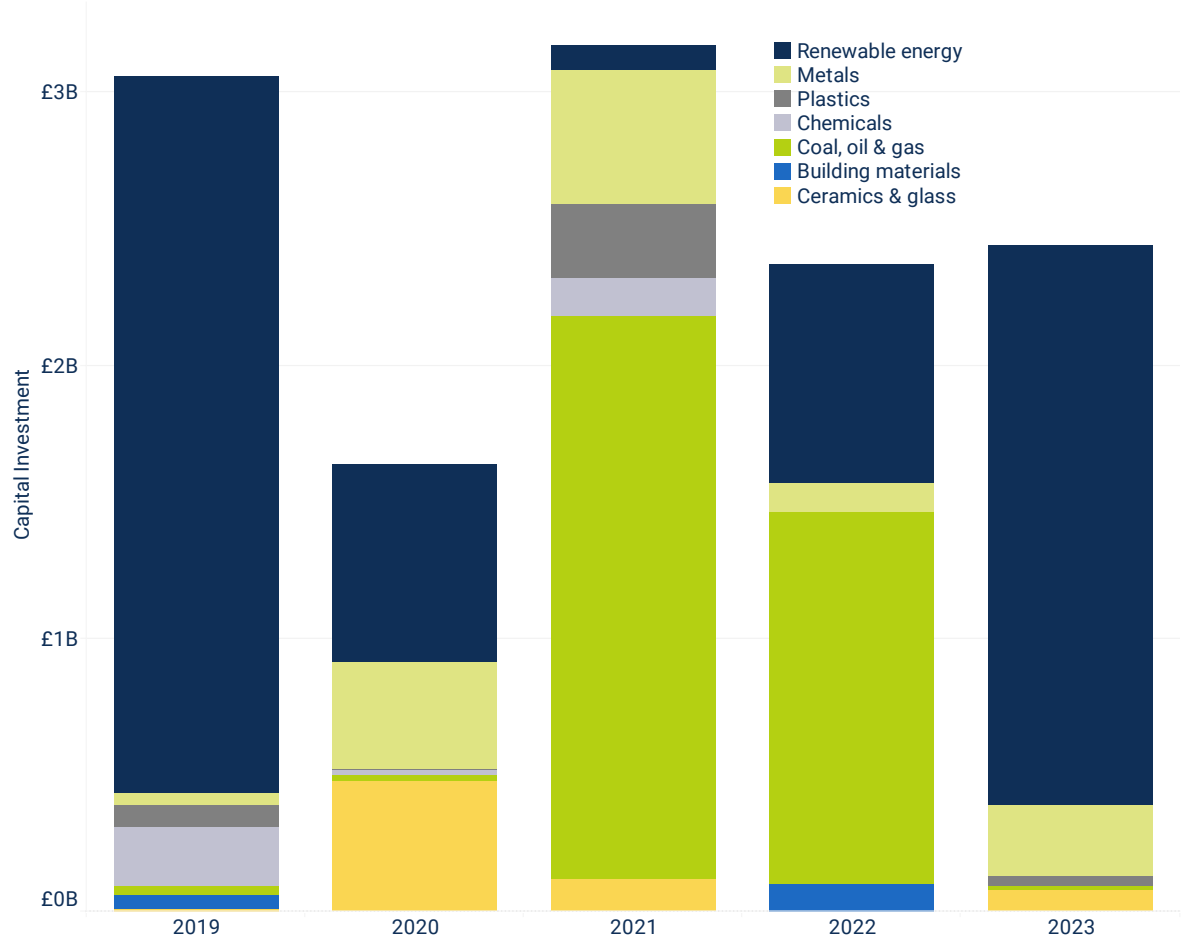


Figure 3.5: Value of Capital Investment by Sector, FDI Markets

3.2.2 Private Investment in UK Clean Technology Companies

According to the investment tracking platform Beauhurst, 844 UK 'CleanTech' companies have secured almost £8 billion in private funding since 2019. There has been an upward trend in CleanTech fundraisings, both in number and value, since 2019. However, in more recent years (2022 and 2023) the trend is towards a smaller number of higher value fundraisings.

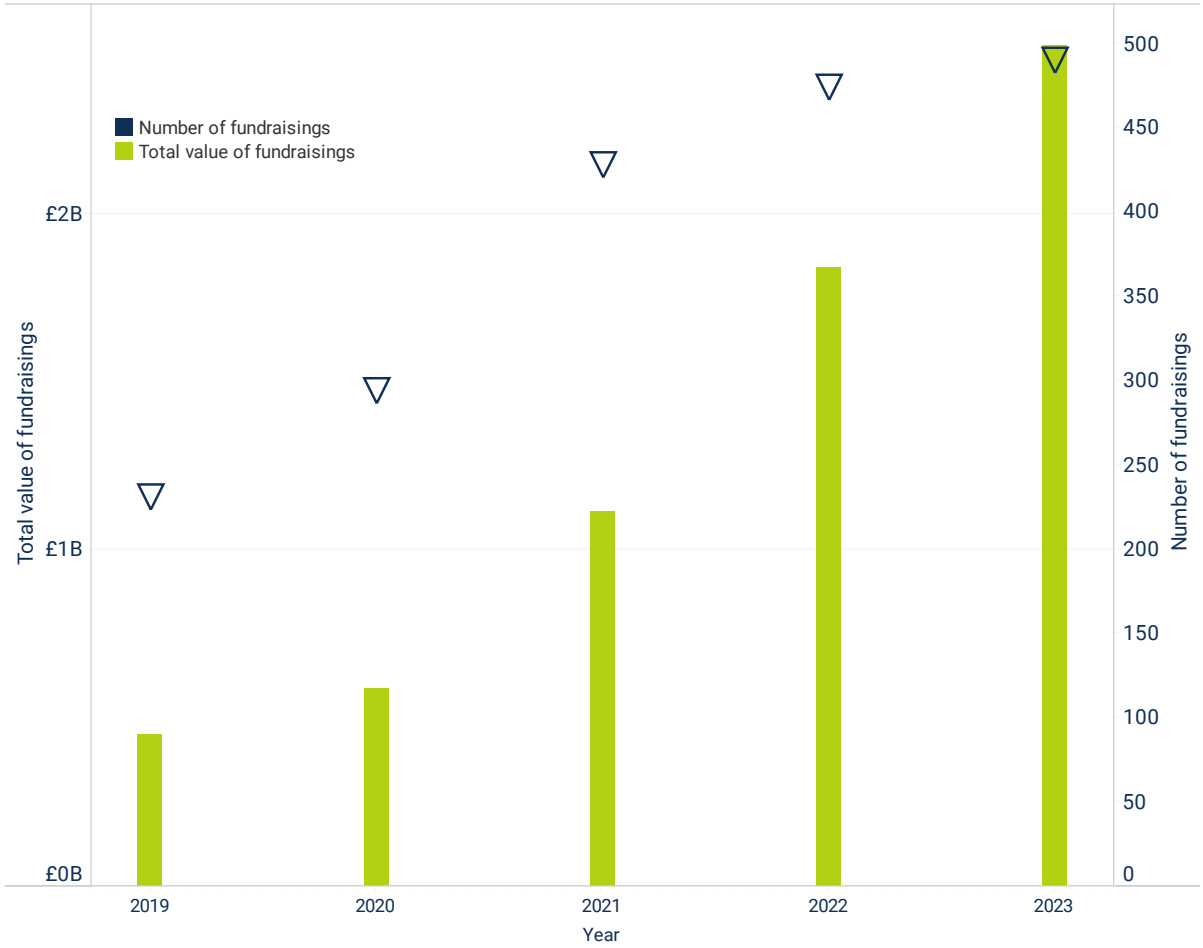


Figure 3.6: Investment in UK CleanTech Companies (2019 – 2023), Beauhurst

The most significant funders of UK CleanTech companies include Infracapital (UK), Zeus Capital (UK) and DIF Capital (Netherlands). Forty-two of the investment raising CleanTech companies identified are involved in the development of hydrogen and / or carbon capture technology including, for example, Carbon Clean, Storegga, GeoPura and HiiROC. More detail regarding funding and investment in technologies of interest within the Humber Cluster is provided in Section 3.3.

3.2.3 Research & Innovation Funding

Since 2018 there have been more than 5,500 research and innovation funding awards made to Lead Research Organisations (ROs) across the Yorkshire and Humber region[6]. Over this period, the share of projects awarded to Lead ROs located within the Humber Industrial Cluster has grown from 2 % to 5 %. The increase in research and innovation activity is evident across all types of research, but particularly with respect to research and innovation in decarbonisation and the environment, where the number of research and innovation projects saw a near five-fold increase between 2018 and 2023.

A notable proportion of this funding has focussed on building the knowledge and skills required to leverage social and economic benefits from renewable energy and

[6] Based on UKRI Gateway to Research data – all projects (active and complete) with start dates between 2018 and 2023.

decarbonisation. For example, since 2019 the University of Hull has hosted the UK's main Centre for Doctoral Training in Offshore Wind Energy and the Environment – representing a £6 million investment by two UK research councils. Figure 3.7 provides an illustration of the scale and location of research and innovation funding for decarbonisation and environment activities within the Cluster[7].

A more detailed review of these funding awards highlights numerous industry-led research and innovation projects including, for example, three projects by Smartflow Couplings (part of the Swedish CEJN Group) regarding the computerised simulation and verification of composite pipe connections for hydrogen and CCUS and the reliability of spill prevention couplings.

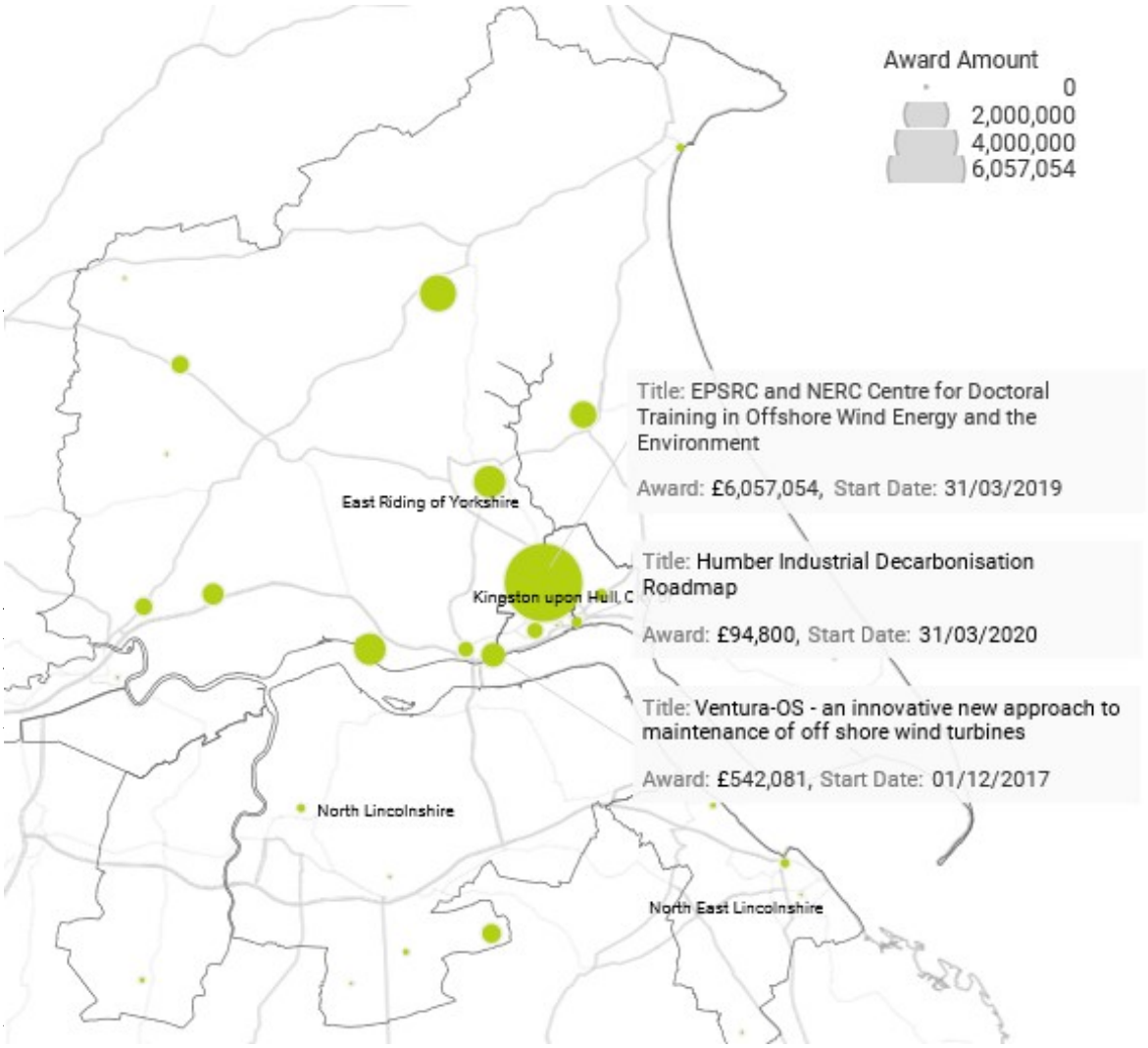


Figure 3.7: UKRI Funded Decarbonisation and Environment Projects (Illustrative)

[7] Analysis based on LLM derived summarisation and classification of c.12,000 project abstracts gathered using the Gateway to Research API.

3.3 CDI Technologies of Interest

This section provides a summary of findings from more detailed desk research into the technologies of particular interest to CDI – specifically hydrogen, carbon capture and storage, offshore wind, electrification and energy storage.

3.3.1 Hydrogen

Hydrogen has been a priority for industrial decarbonisation in the UK under the current Conservative government on the basis that it can decarbonise sectors which cannot easily be electrified. The UK government has set a goal of delivering at minimum 10 GW of hydrogen production capacity by 2030 (50 % from electrolytic hydrogen and 50 % from CCUS-enabled hydrogen) (DESNZ, 2023a).

A series of policy, regulatory and legislative changes have been implemented to support the development of the hydrogen market, summarised in Figure 3.8.

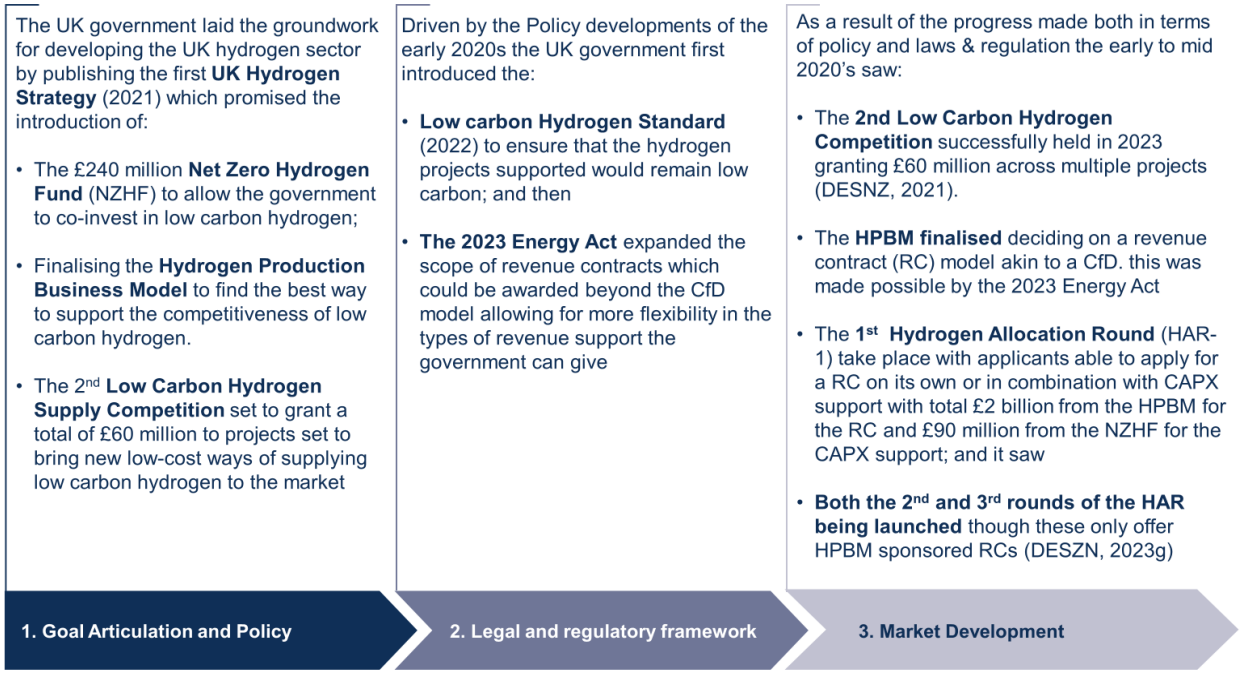


Figure 3.8: Key UK Hydrogen Policy Developments

This policy focus has likely had some bearing on an increase in hydrogen technology projects over the past 5 years. According to the IEA, there has been a 45 % increase in the number of hydrogen projects taken forward between 2018 to 2020 (n=6) and 2021 to 2024 (n=11) (IEA, 2023a).

There are currently 83 hydrogen projects across the UK. Of those with a 'known' progress status (n=80) only 14 % are operational (n=11) (IEA, 2023a).

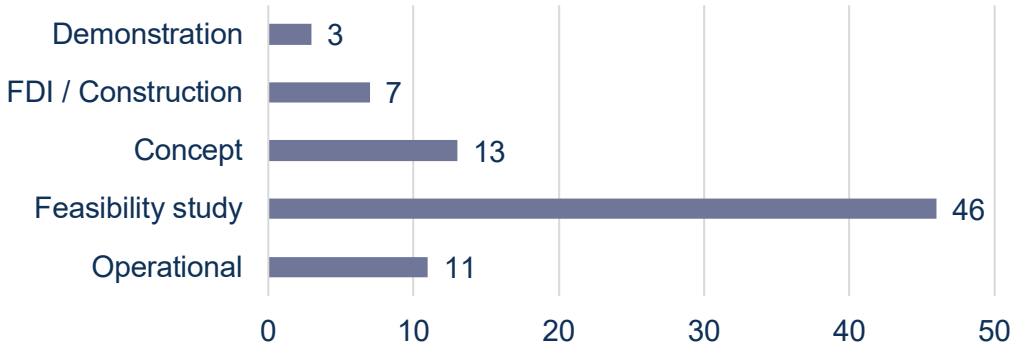


Figure 3.9: Hydrogen Projects in the UK by Readiness Level (IEA, 2023a | n=80)

Of these 83 hydrogen projects 59 % (n=49) are expected to use a dedicated renewable energy source. Most other projects do not specify planned energy sources, with a minority stating that they will rely on energy from the grid / nuclear power (IEA, 2023a).

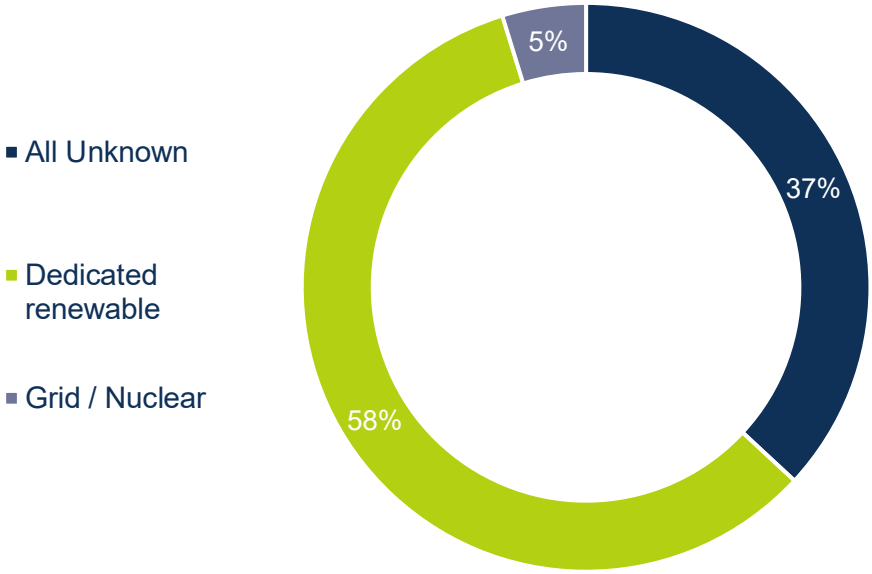


Figure 3.10: UK Hydrogen Projects by Source of energy (IEA, 2023a | n=83)

Fourteen of the UK's 83 hydrogen projects (~17 %) are located within the Humber Cluster, however, as is the case with hydrogen projects across the UK, most projects are still within feasibility and planning phases (90 % or 13/14).

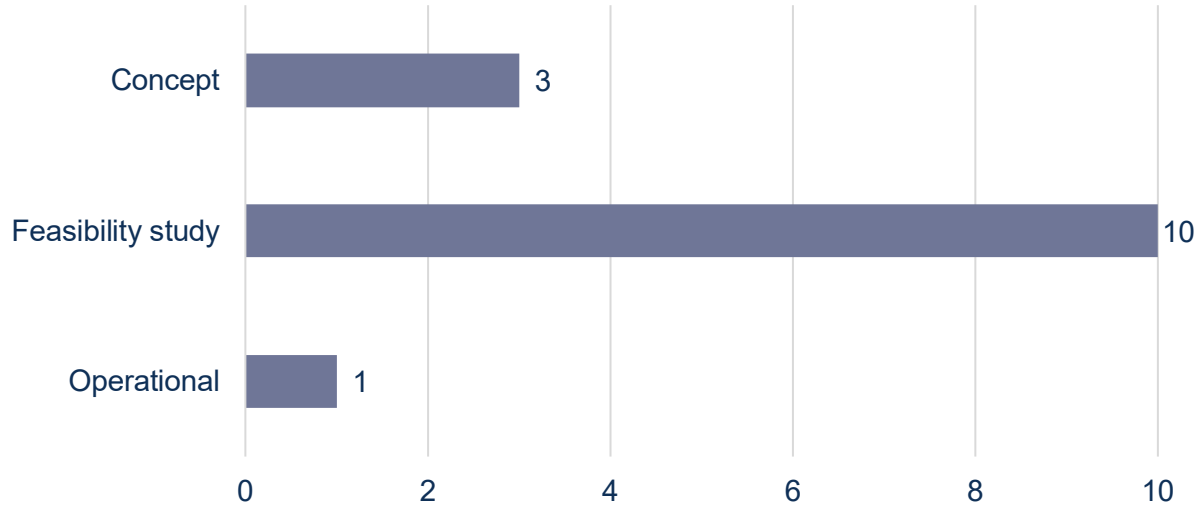


Figure 3.11: Hydrogen Projects in the Humber by Readiness Level (IEA, 2023a | n=14)

Forty-three percent of the Humber hydrogen projects are expected to use a dedicated renewable energy source compared to the national average of 58 % (IEA, 2023a).

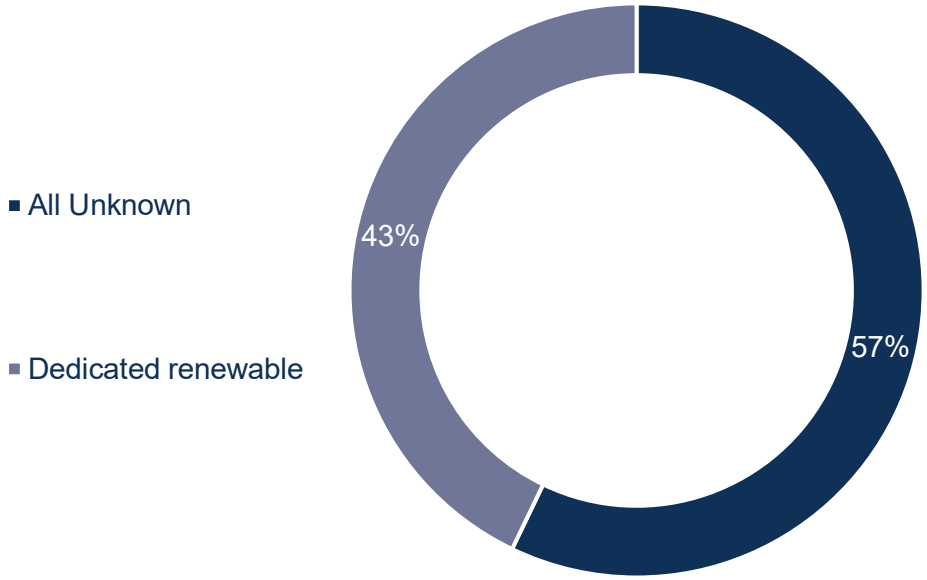


Figure 3.12: UK Hydrogen Projects by Source of Energy (IEA, 2023a | n=14)

When comparing the proportion of CCUS enabled blue hydrogen (fossil fuel based) projects with those that use water electrolysis (green hydrogen) there is a significantly higher proportion of blue hydrogen projects in the Humber region when compared to the rest of the UK (IEA, 2023a).

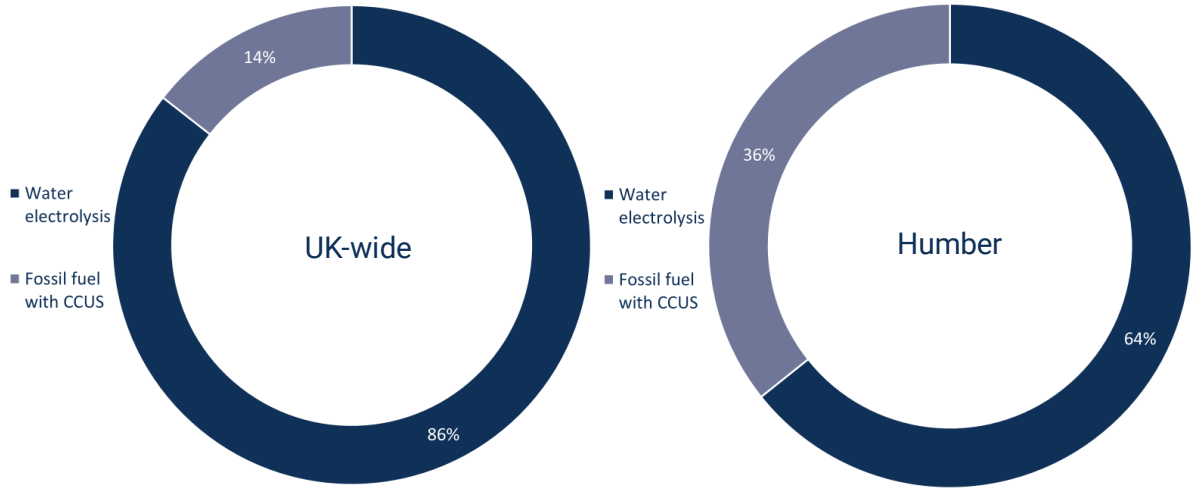


Figure 3.13: Hydrogen Production by Type and Region (IEA, 2023a | UK-wide n=84, Humber n=14)

As explained in Section 3.3.2, all CCUS projects are pre-operational which has a knock-on effect on the development of hydrogen projects in the Humber Cluster (IEA, 2023a).

3.3.2 Carbon Capture Utilisation and Storage

The current UK government set an ambition to become a world leader in CCUS technology, and to establish a self-sustaining, internationally competitive CCUS market which supports decarbonisation, while also providing jobs and economic opportunities (DESNZ, 2023b). The current UK strategy has three phases.

The Phases of UK CCUS Policy

1. Phase 1: Market Creation (now-2030) – strong government intervention to help create an economic environment that supports development of CCUS infrastructure and a self-sustaining CCUS market. At least four fully developed CCUS clusters capable of storing 20-30 $MtCO_2$ per annum (including development of associated capture, transport and storage capacity).

2. Phase 2: Market Transition (2030-2035) – to have the beginnings of a self-sustaining CCUS market by virtue of the infrastructure projects delivered as part of Phase 1. Reduce the amount of government support needed to sustain the market, although some government intervention is still expected to be necessary.

3. Phase 3: Fully Self Sustaining Market (2035 onwards) – to have a fully self-sustaining and sophisticated CCUS market which offers different means for transporting CO_2 and which largely functions without the support of government. Offer CO_2 storage services to foreign emitters as well as the UK's CCUS infrastructure (DESNZ, 2023b, pp.20-22)

The UK has been progressing Phase 1 by expanding CCUS infrastructure since the launch of the industrial decarbonisation and CCUS-cluster sequencing strategy. The UK government has taken a phased approach to the development of CCUS infrastructure clusters over a period of 3-4 years (described in policy documentation as 'Track 1' and 'Track 2').

Current Progress of CCUS Infrastructure

- The first carbon licensing round was held in 2022 where interested companies could apply for a licence to store carbon across a number of pre-selected lots located on the bed of the North Sea off the coast of Aberdeen (Scotland) and Humberside/Teesside (England) as well in the East Irish Sea off the coast of Liverpool (England). The licensing round concluded in September 2023 with a total of 21 licences for storing carbon across a number of depleted oil / gas reservoirs and saline aquifers were allocated across 14 companies. This sits on top of the six licences which were awarded prior to public procurement (NSTA, 2023).

- The two projects in Track-1 moved towards market generation with negotiations with potential carbon capture projects starting in early 2023 and the two Track-2 projects are currently in the process of submitting their 'anchor' (feasibility) plans following their award in 2023 (DESZN, 2023b, p. 24).

Two CCUS clusters in 'Track 1' moved towards market generation, with negotiations on potential carbon capture projects starting in early 2023. Two 'Track 2' clusters are currently in the process of submitting their 'anchor' (feasibility) plans following award in 2023 (DESNZ, 2023b, p.24).

Following the UK's first carbon licensing round (2022 – 2023) 14 interested companies secured a total of 21 licences to store carbon across a number of depleted gas fields and saline aquifers off the coast of Scotland (Aberdeen) and England (Liverpool and Humber/Teesside).

Within the Humber Industrial Cluster there are two CCUS clusters and a total of 14 planned CCUS projects (see Figure 3.13). Five CCUS cluster projects in the Humber area have secured a carbon storage licence.

Project name	Partners	Project type	Operational	Project Status	Cluster Sequencing	CCUS Licence Holder
H2 Teesside	BP and ADNOC	Capture	2030	Planned	Northern Endurance Partnership (Track-1)	No
H21 Leeds City Gate - Teesside hydrogen	Northern Gas Networks	Capture	2035	Planned	-	No
Humberside CCS[8]	Shell and ExxonMobil	Storage	-	Planned	-	Yes
Hydrogen to Humber / H2H Saltend	Equinor, SSE Thermal, Linde, BOC and Jonhson Matthey	Capture	-	Planned	Northern Endurance Partnership (Track-1)	No
Keadby 3 Carbon Capture Power Station	SSE Thermal, Equinor, Aker Solutions, Siemens Energy and Altrad Babcock and Fugro	Capture	2028	Planned	Northern Endurance Partnership (Track-1)	No
Net Zero Teesside Power	BP and Equinor	Capture	2027	Planned	Northern Endurance Partnership (Track-1)	Yes
Northern Endurance Partnership	BP, Equinor, TotalEnergies, Worley and Costain	T&S	-	Planned	Northern Endurance Partnership (Track-1)	Yes
Prax Lindsey Oil Refinery	Prax	Capture	2029	Planned	Viking CCS (Track-2)	No

[8] Was part of Northern Endurance Partnership

Project Tellus	Eni and EEPUKL	Storage	2033	Planned	-	Yes
Humber Hub Blue North Killingholme	Shell and Uniper	Capture	2027	Planned	Northern Endurance Partnership (Track-1)	No
Suez Tees Valley / Haverton Hill Waste to Energy CCS	Suez	Capture	2027	Planned	Northern Endurance Partnership (Track-1)	No
Tees Valley Energy Recovery Facility	Hartlepool Borough Council	Capture	2026	Planned	Northern Endurance Partnership (Track-1)	No
Viking CCS	Harbour Energy, BP and Technip Energies	T&S	2035	Planned	Viking CCS (Track-2)	Yes
VPI Immingham CHP (CCS)	VPI Immingham (Vitol)	Capture	2027	Planned	Viking CCS (Track-2)	No

Figure 3.14: CCUS Projects in the Humber (IEA, 2023b)

3.3.3 Offshore Wind

Having suffered from reduced investment in the 1990s and early 2000s, UK investment into wind technology restarted in earnest in 2006, with the aims of reducing the costs of wind energy and regaining the UK's position as a leader in wind energy technology. Offshore wind is now seen as a key priority for achieving decarbonisation targets (Catapult (n.d.); DESNZ, 2023a).

In 2019, the UK had the highest level of installed wind energy capacity of any country in the world, accounting for over a third of global capacity. The current government has set a goal of increasing the UK's offshore wind capacity to 50 GW by 2030, of which 5 GW should come from floating offshore wind, with the government promising to increase the pace at which offshore wind is deployed by 25 % (DESNZ, 2023a p.16).

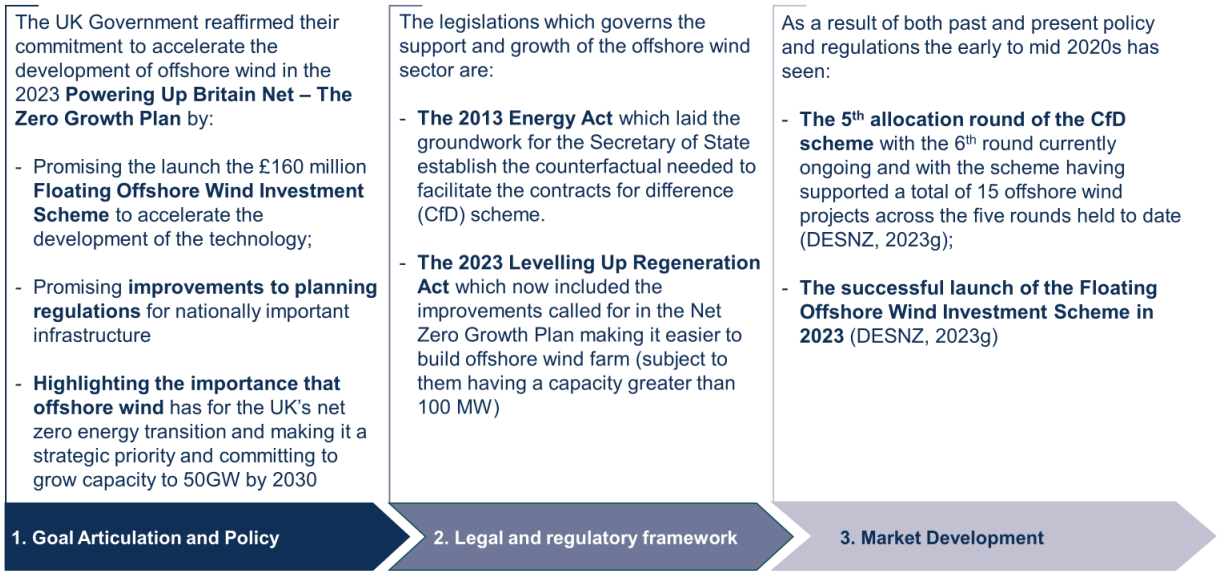


Figure 3.15: Current Offshore Wind Policy and Regulation

The 'Crown Estate' – an independent commercial business established via an Act of Parliament to manage the UK's physical assets – is a key stakeholder in the development of renewable energy and carbon capture technologies. The Crown Estate manages most of the seabed off the coast of England, Wales and Northern Ireland, with the Crown Estate Scotland doing the same for Scotland. It is thus the authority in charge of licensing the areas needed for offshore wind development.

The UK offshore wind market is sizable, with a total of 45 operational windfarms making up around 17 % of the UKs total energy production in 2023. Revenues and employment within the UK's offshore wind sector have grown substantially since 2015. The number of businesses in the offshore wind sector more than doubled between 2015 and 2022, with revenues increasing four-fold and employment increasing three-fold over the period (from £2.4 billion to £12.2 billion and from 3,000 to 11,300 respectively) (ONS, 2024).

Total capacity currently stands at c.14 GW – a marked increase on production capacity 10 years ago (Crown Estate 2023a, DESNZ, 2024c).

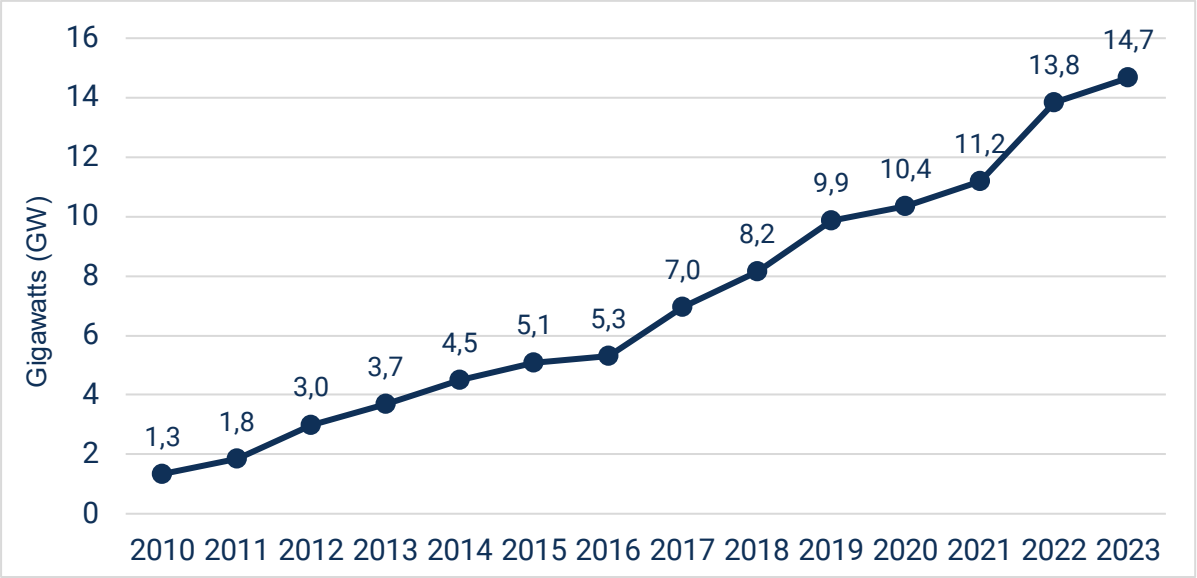


Figure 3.16: UK Cumulative Offshore Wind Capacity Over Time in GW (DESNZ, 2024c)

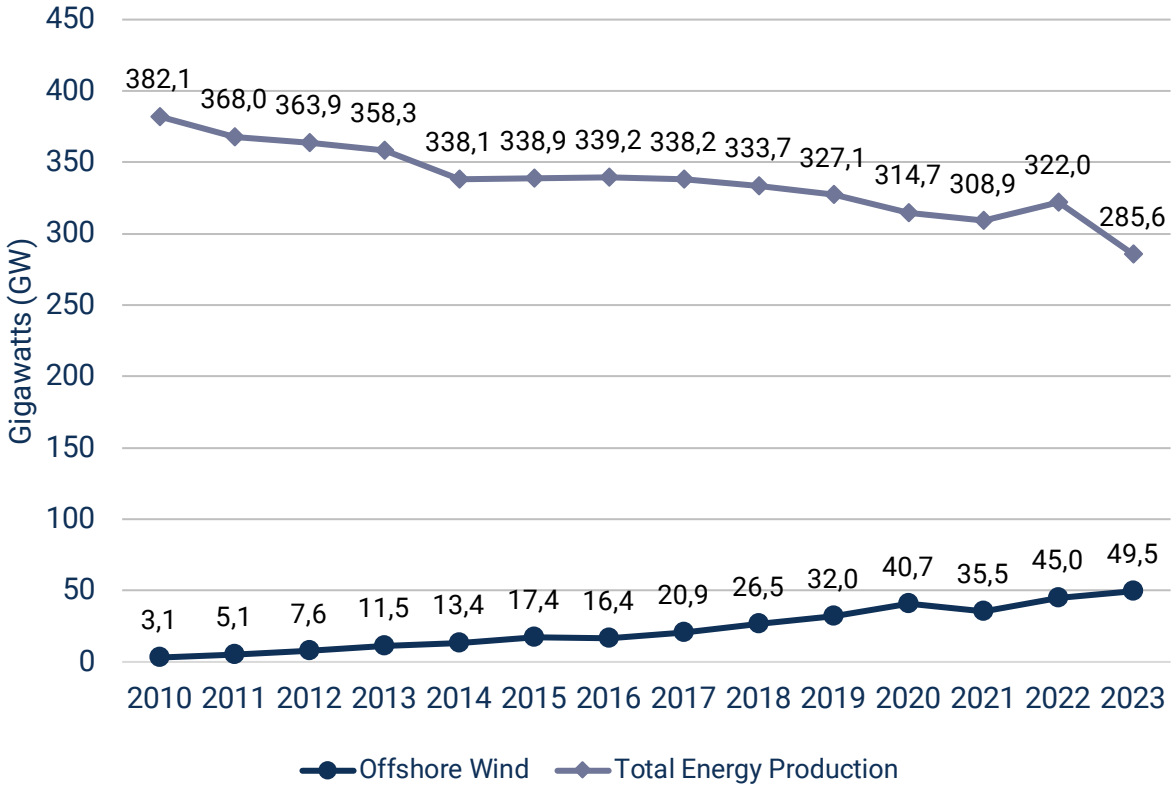


Figure 3.17: Annual Production of Electricity from Offshore Wind in GW (DESNZ, 2024c)

The cost of producing energy from offshore wind has decreased significantly, with strike prices down by 70 % between 2015 (when AR-1 was held) and 2022 (AR-4) (DESNZ, 2023c).

All of the projects which are currently either planned or under construction off the coast of the Humber region have received a Contract for Difference (see Figure 3.5) (Crown Estate, 2023a; DESNZ, 2023c).

Offshore Wind – Technological Progress and the UK

The UK has two operational floating offshore wind farms at a total capacity of 80 MW making it second only to Norway which has a total capacity of 94 MW across 3 operational projects (Renewable UK, 2023). The UK's two floating offshore wind projects are:

1. Hywind, located off the coast of Peterhead in the North-East of Scotland, developed by Equion and Masdar and operational since 2017; and

2. Kincardine Wind Farm, located off the coast of Aberdeen also in the North-East of Scotland. It was developed by Pilot Offshore Renewables (a joint venture between MacAskill Associates and Renewable Energy Ventures) and has been operational since 2021 (House of Commons Library, 2023).

The Humber region is home to several offshore wind projects at various stages of development. These include the world's largest operational offshore wind farms – 'Hornsea 1' and 'Hornsea 2' – and will also include the planned Hornsea 3 development which will overtake its predecessors once completed (Crown Estate, 2023a; Crown Estate 2023b).

Project Name	Company Name(s)	Capacity (MW)	CfD (AR)
Westermost Rough	Ørsted	210	No
Humber Gateway	RWE	219	No
Triton Knoll	RWE	857	Yes (AR-2)
Hornsea 1	Ørsted	1,218	No
Hornsea 2	Ørsted	1,386	Yes (AR-2)

Figure 3.18: Operational Offshore Wind Projects in the Humber (Crown Estate, 2023a.; Crown Estate, 2023b and DESNZ, 2023c)

Project Name	Company Name(s)	Capacity (MW)	CfD (AR)
Hornsea 3	Ørsted	3,000	Yes (AR-4)
Dogger Bank 1	SSE	1,235	Yes (AR-3)
Dogger Bank 2	SSE	1,235	Yes (AR-3)
Dogger Bank 3	SSE	1,200	Yes (AR-3)
Sofia	RWE	1,400	Yes (AR-3)

Figure 3.19: Offshore Wind Projects in the Humber Currently Under Development (Crown Estate, 2023a.; Crown Estate, 2023b and DESNZ, 2023c)

3.3.4 Energy Storage and Electrification

Current UK policy regarding energy storage and electrification is limited, especially compared to current developments in CCUS, Hydrogen and Offshore Wind (House of Lords, 2023; DESNZ, 2023a).

As such, policy is still in the early stages, with the government issuing a call for evidence on how to enable UK industrial electrification in 2023 and a call for evidence how to design its policy framework for long duration energy storage as recently as January 2024 (DESNZ, 2023d DESNZ, 2024a).

Nonetheless, there is some mention of electrification and energy storage within current policy, and some support structures do exist.

Consultation with strategic stakeholders undertaken to inform this market assessment has suggested that DESNZ is currently reviewing all of its decarbonisation pathways. That review, together with upcoming Climate Change Committee (CCC) risk assessments and carbon budgets may result in much greater emphasis on electrification for industrial decarbonisation in future.

3.3.4.1 Long Term Energy Storage

The current energy security strategy sets out plans to develop new long term energy storage solutions and/or use excess energy to produce hydrogen (DESNZ, 2023a). Unlike hydrogen and CCUS, long-term energy storage has not been the focus of major, centrally coordinated infrastructure funding initiatives. However, some investment has been made by a combination of UK research funding agencies, central government and regulatory bodies.

Funding Support for Long Term Energy Storage

- The Faraday Battery Challenge (Faraday Institution and UKRI) is a challenge invest £542 million across a number of projects which aim to grow UK battery businesses (UKRI, 2023).
- The Longer Duration Energy Storage Programme (DESNZ) is set to grant up to £68 million for the development and commercialisation of better long term energy storage solutions. Specifically, the project supports the development of electric and thermal storage as well as power to X solutions (i.e. using excess energy to create hydrogen) (DESNZ, 2023a).
- The Strategic Innovation Fund (Ofgem) is set to grant £450 million as part of the RIIO-2 price control round (2021-2026). The goal of this fund is to support developments which progress the UK energy network towards its net zero goal, including the development of long-term energy storage solutions (BEIS and Ofgem, 2021).

3.3.4.2 Electrification

Electrification is mentioned as a key strategy to accelerate the decarbonisation of the UK industrial sector, and is expected to feature more prominently within UK decarbonisation plans in future. To date, the UK government has sought to support industrial electrification via, for example, the £500 million Industrial Energy Transformation Fund (IETF) launched in 2020 and set to run until 2028 (HM Government, 2021a). The IETF is looking to support businesses in developing and deploying solutions which run on low carbon fuels (DESNZ, 2019).

British Steel Electric Arc Furnace

British Steel is currently in the process of building an electric arc furnace on its Scunthorpe premises as part of its £1.25 billion decarbonisation plan. The goal of the plan and project is to reduce emissions from steel making and future-proof the industry (British Steel, 2024).

Work on the project is still in the early stages but a major milestone was reached earlier this year when the project received planning permission from its relevant local council. British Steel is now in the process of conducting an environmental and technical assessment for the project as well as speaking to the government about potential support for the project (British Steel, 2024)

4 Stakeholder Mapping

This section brings together information regarding key stakeholders involved in decarbonisation activity in the UK, with a particular focus on stakeholders involved in hydrogen, CCUS and offshore wind. The stakeholder map is structured as follows:

Section	Heading	Content
4.1	Framework Stakeholders	Identification of key stakeholders involved in funding / governing decarbonisation activity in the UK
4.1.1	National Government Stakeholders	
4.1.2	Local Government Stakeholders	
4.2	Offshore Wind	Identification of key private sector companies and research organisations / academic institutions involved in developing or deploying offshore wind technology in the UK
4.2.1	Private Sector	
4.2.2	Collaborative Research Assets	
4.3	Hydrogen	Identification of key private sector companies and research organisations / academic institutions involved in developing or deploying hydrogen technology in the UK
4.3.1	Private Sector	
4.3.2	Collaborative Research Assets	
4.4	CCUS	Identification of key private sector companies and research organisations / academic institutions involved in developing or deploying CCUS technology in the UK
4.4.1	Private Sector	
4.4.2	Collaborative Research Assets	
4.5	Key Yorkshire & Humber Stakeholders	Summary of key Yorkshire & Humber stakeholders for ease of reference

4.1 Framework Stakeholders

This section identifies key stakeholders involved in funding / governing decarbonisation activity in the UK. Section 4.1.1 lists key national stakeholders and Section 4.1.2 lists key local stakeholders within the Humber Industrial Cluster.

4.1.1 National Framework Stakeholders

Figure 4.1 below provides details for the main national government / framework stakeholders that have been identified through this study. Links to further information and relevant contacts have been provided in the 'Further Information & Potential Contact(s)' column for ease of reference.

Name	Descriptor	Further Information & Potential Contact(s)
Department of Energy Security and Net Zero (DESNZ)	Department in charge of coordinating all energy security and net zero policy in the as well as running support programmes / distributing funding such as: - Industrial Energy Transformation Fund (IETF) - CCUS Cluster Sequencing Programme (CCUS CSP) - Longer Duration Energy Storage Demonstration Competition (LODES) It is also in charge of running the Hydrogen Allocation Rounds (see ch. 3.2)	IETF: UKRI Innovate UK Phase 3 Funding // https://www.linkedin.com/in/jennimcdonnell/, ietf@energysecurity.gov.uk CCUS CSP: DESNZ Phase 2 Funding Call // power projects – Powerccusphase2@beis.gov.uk; industrial projects – Industrialccusphase2@beis.gov.uk; hydrogen projects – Hydrogenccusphase2@beis.gov.uk ; GGR projects – ggrccuseoi@beis.gov.uk LODES: DESNZ Demonstration Competition // smart.innovation@BEIS.gov.uk, Dr Alan Walker (https://www.linkedin.com/in/alan-walker-63743b38/)
North Sea Transition Authority (NSTA)	Authority in charge of transitioning the existing oil and gas infrastructure in the North Sea to net zero and therefore has the power to: - Distribute licences to store CO2 in depleted oil / gas reservoirs and saline aquifers in existing oil and gas infrastructure in the North Sea (predominantly though repurposing existing oil and gas infrastructure for CCUS and Hydrogen)	Various leadership boards and task forces including the Technology Leadership Board (Nicolas Payer, Co-Chair: https://www.linkedin.com/in/nicolas-payer-1587a186/) and the CO2 Transportation and Storage Task Force (Elle Lashko: https://www.linkedin.com/in/elle-lashko-1201b363/; Ian Barron: https://www.linkedin.com/in/ian-barron-07092a6/; Ben Ward: https://www.linkedin.com/in/ben-ward-3128a1170/) https://www.linkedin.com/in/mhairi-begg-6960b792/

		https://www.linkedin.com/in/kevin-christopherson-253b2418b/
National Grid ESO	In charge of operating the UKs electricity system on behalf of the public. The National grid ESO is regulated by Ofgem and its key responsibility in terms of decarbonisation is to host the CfD rounds.	Anato Chowdhury, Transition Infrastructure Strategy & Development: https://www.linkedin.com/in/anatochowdhury/
Ofgem	Regulatory agency for the UK energy sector and is: - In charge of dealing with disputes when it comes to who qualifies for the CfD scheme. - Set to take over NSTAs current role and become the authority in charge of distributing CCUS licences once processes are more established / net zero transition is completed.	Mike Duncan, Head of Hydrogen Regulated Asset Base (https://www.linkedin.com/in/mike-duncan-22260584/) Mairead Connolly, Hydrogen Strategy Advisor (https://www.linkedin.com/in/mair%C3 %A9ad-connolly-405a36159/)
Low Carbon Contracts Company (LCCC)	The LCCC is the counterparty necessary to run the CfD scheme as well as the revenue support scheme for hydrogen and is an independent limited company wholly owned by the secretary of state.	Low Carbon Hydrogen Scheme: Annabel Sarling, Energy Certification Manager (https://www.linkedin.com/in/annabel-sarling-621822197/) Industrial CCUS Scheme: Saleem Nasir, Senior Hydrogen & Carbon Capture Contract Manager (https://www.linkedin.com/in/m-saleem-nasir-77158b80/)
Crown Estate	In charge of licensing areas of the seabed in Northern Ireland, Wales and England for the development of offshore wind, CCUS and hydrogen infrastructure	Seabed licensing and guidance: Denise Moylan, CCS & Hydrogen Director at the Crown Estate (https://www.linkedin.com/in/denise-moylan-9256271/)
Crown Estate Scotland	In charge of licensing areas of the seabed in Scotland for the development of offshore wind, CCUS and hydrogen infrastructure	Hannah Evans, Asset Manager (https://www.linkedin.com/in/hannah-evans-41461688/) Mark McKean, Head of Offshore Assets (https://www.linkedin.com/in/mark-mckean-a482571b/)

UK Research and Innovation (UKRI)	Arm's length government body overseen by DESNZ charged with distributing funding research and innovation funding to relevant academic and industrial projects.	Industrial Decarbonisation Challenge: Kelly Aldis, IDC Programme Manager at Innovate UK (https://www.linkedin.com/in/kelly-aldis-869a3321b/)
Hydrogen UK	Trade association committed to the development and deployment of hydrogen solutions.	Claire Jackson, CEO: (https://www.linkedin.com/in/clare-jackson-55421681/)
National Gas	Leading role in the transition to a clean energy future. Owns and operates the national gas network.	Emily Ly, Hydrogen Strategy Manager, National Gas Transmission: (https://www.linkedin.com/in/e-ly/). For more information see: https://www.nationalgas.com/news/hydrogen-production-technology
UK Hydrogen Energy Association	UK leader in advocating for and accelerating the transition to Net Zero through the deployment of hydrogen solutions	Celia Greaves, CEO: (https://www.linkedin.com/in/celia-greaves-4928785/)

Figure 4.1: National Government / Framework Stakeholders

4.1.2 Local Framework Stakeholders

Figure 4.2 below provides details for the main local government / framework stakeholders identified through the study.

Name	Descriptor	Further Information & Potential Contact(s)
Hull City Council and East Riding of Yorkshire Council	Local Authorities within the Humber Industrial Cluster. Currently in the process of securing devolution powers via the 'Hull and East Yorkshire (HEY) Devolution Deal'.	The HEY Devolution Deal devolves administrative powers from Westminster (London) to the new Hull and East Yorkshire Mayoral Combined Authority (HEYCA). It includes funding for green economy activities including £5 million to support economic growth including the expansion of Siemens Gamesa's offshore wind facilities. The HEYCA is also a stakeholder in the Humber Industrial Cluster Plan. Contact: Alex Codd, Hull City Council Assistant Director Economic Development & Regeneration (01482 613089, https://investhull.co.uk/contact-us) || Claire Watts, East Riding Director of Economic Development (https://www.linkedin.com/in/claire-watts-91142615/)

North Lincolnshire and North East Lincolnshire	Local Authorities within the Humber Industrial Cluster. Currently in the process of securing devolution powers via the Greater Lincolnshire Devolution Combined Authority.	The GLCA Devolution Deal secures £750 million of funding that will support (among other things) projects that improve the environment and help to achieve net zero. Contact: Justine Duhrkoop, Inward Investment Business Specialist, Invest in North Lincolnshire (https://www.linkedin.com/in/justine-d%C3 %BChrkoop-482653143/) || Margaret Johnson, Head of Economy and Funding, Invest NEL (https://www.linkedin.com/in/margaret-maggie-johnson-7843a239/)
Humber Industrial Cluster Plan	A 2-phase decarbonisation plan for the Humber cluster including a Phase 1 feasibility study and implementation of the HCIP in Phase 2.	HCIP team comprises 7 industry experts and is led by Jonathan Oxley and co-ordinated by Andrea Dewick. Contact: Jonathan Oxley, HCIP Manager (https://www.linkedin.com/in/oxleyjc/) || Andrea Dewick, HCIP Co-Ordinator (https://www.linkedin.com/in/andrea-dewick-llb-08b15ba7/)

Figure 4.2: Local Government / Framework Stakeholders

4.2 Offshore Wind

This section provides details regarding key private sector companies and research organisations / academic institutions involved in developing or deploying offshore wind technology in the UK. All of the companies have been identified as active participants in technology projects named elsewhere in the report. Collaborative research organisations / academic institutions (referred to collectively as 'Collaborative Research Assets') are deemed to be relevant on the basis that desk research has identified relevant research activity; however, it has not been possible to confirm that all are actively involved in local projects.

4.2.1 Private Sector Offshore Wind Companies

Figure 4.3 lists key private sector companies involved in the offshore wind developments identified through this study.

Energy Producers		
Name	**Description**	**UK Contact(s)**
Ørsted	A Danish multinational power company developing and deploying renewable energy solutions with a particular focus on offshore wind.	Benji Sykes, VP Offshore: https://www.linkedin.com/in/benj-sykes-offshorewind/
RWE	A German energy company focused on electricity generation and supply.	Matthew Swanwick: matthew-swanwick-6aa993264
SSE	A British energy company involved in the generation, transmission, distribution, and supply of electricity, as well as the production, storage, distribution and supply of gas.	Mo Sandy: mo-sandy-9a2a48134
Vattenfall	A Swedish state-owned power company that generates and sells electricity and heat with an increasing focus on renewable energy sources.	John Price: john-price-55801620
Equinor	Norwegian state-owned energy company primarily engaged in the exploration and production of both oil and gas.	Chris Leppard: https://www.linkedin.com/in/cleppard
EDF	A French multinational energy utility company that generates, transmits, and distributes electricity and gas.	Nigel Williams: https://www.linkedin.com/in/nigel-williams-96148b191
ScottishPower Renewables	A subsidiary of the Spanish utility company Iberdrola, focusing on the development, construction, and operation of renewable energy projects in the UK with a focus on onshore and offshore wind farms.	Matthew Harwood: matthew-harwood-b82aba14

Engineering and Manufacture		
Siemens Gamesa	A company focused on the design, manufacture, and installation of wind turbines for both onshore and offshore wind farms as well as green hydrogen solutions.	Chris Ventre: https://www.linkedin.com/in/chris-ventre-beng-chpp-mapm-mei-67a09117
Mitsubishi Heavy Industries Ltd	Japanese engineering, electrical equipment, and electronics company that manufactures a wide range of products, including CCUS solutions and wind turbines.	Narayanaswamy (Swamy) KV (https://www.linkedin.com/in/narayanaswamy-kv-61267b11/)

Figure 4.3: Private Sector UK Offshore Wind Stakeholders

4.2.2 Offshore Wind Collaborative Research Assets

Figure 4.4 lists key collaborative research assets focussed on offshore wind across the UK.

Name	Description	Contact(s)
Green Port Hull	Renewable energy hub in Hull, home to Siemens Gamesa's offshore wind turbine blade manufacturing, assembly and servicing facilities, supported by a significant investment from the Associated British Ports (ABP) and Siemens Gamesa. The centre also explores opportunities in hydrogen, carbon capture, biofuels, and other renewable energy sources. (https://greenporthull.co.uk/what-we-do/humber-offshore-wind-cluster).	C/O Hull City Council (see local stakeholder contacts): info@greenporthull.co.uk
University of Sheffield Advanced Manufacturing Research Centre (AMRC)	Supports collaborative projects in offshore wind, focusing on decarbonising the Humber region's industrial cluster (https://www.amrc.co.uk/news/1-25m-project-will-advance-wind-turbine-blade-production).	Industry Account Manager John Dale +44(0)7725 603867, j.dale@sheffield.ac.uk
Aura Innovation Centre	Based in the Green Port Hull initiative, this centre drives innovation in the offshore wind sector through research and collaboration with industry stakeholders (https://aura-innovation.co.uk/).	Louise Smith, Director (https://www.linkedin.com/in/louise-smith-3761b8122/) || Sarah Clark, Head of Operations (https://www.linkedin.com/in/sarah-clark-1670aa170/) || Prof. James Gilbert (https://www.hull.ac.uk/staff-directory/james-m-gilbert)
Offshore Renewable Energy (ORE) Catapult	With a significant presence in the Humber, the ORE Catapult leads the development of new	Andrew Macdonald, Director of Offshore

	technologies for the offshore wind sector, including a 5G Testbed project for operations and maintenance improvements (https://ore.catapult.org.uk/)	Wind Development & Operations (tel: 0333 004 1339, andrew.macdonald@ore.catapult.org.uk)
University of Hull	The University of Hull is deeply involved in offshore wind research through its Aura Centre for Doctoral Training and other initiatives. The university collaborates with industry partners to advance offshore wind technologies and train future talent in this field (https://www.hull.ac.uk/special/offshore-wind)	Prof. James Gilbert (https://www.hull.ac.uk/staff-directory/james-m-gilbert)
Humber Marine Renewables	Supports the offshore wind sector by matching business opportunities with supply chain capabilities and promoting regional expertise at international conferences (https://www.humber-marine-renewables.co.uk/sectors/offshore-wind/)	Graham Billany, Director: +44 (0) 1482 485271, owc@humber-marine-renewables.co.uk
Associated British Ports (ABP)	ABP's Port of Grimsby is part of the world's largest offshore wind 'living lab' that integrates advanced digital technologies for offshore wind operations and maintenance (https://www.abports.co.uk/locations/grimsby/)	Simon Bird, Humber Regional Director (https://www.linkedin.com/in/simon-bird-6b4a43163/)
The Humber Offshore Wind Cluster	A collaborative effort that includes various stakeholders in the region, focusing on building capabilities, strengthening knowledge, and increasing employment in the offshore wind sector (https://www.humberoffshorewindcluster.co.uk/)	Graham Billany, Director: +44 (0) 1482 485271, owc@humber-marine-renewables.co.uk
Innovate UK Offshore / Renewables	Innovate UK Business Connect supports the offshore wind industry as a major contributor to the ORE Catapult innovation hub funded by BEIS, as well as supporting the companies who are making applications for funding for offshore renewables.	John Ransford, Offshore Wind Expert (https://www.linkedin.com/in/john-ransford-bb57118/)
Offshore Wind Innovation Hub	The Offshore Wind Innovation Hub is the UK's primary coordinator for innovation, focusing on offshore wind energy cost reduction and maximising UK economic impact. The Hub is Funded by the Department for Business, Energy and Industrial Strategy (BEIS) and delivered jointly by the Offshore Renewable Energy (ORE) Catapult and the Knowledge Transfer Network (KTN).	C/O ORE Catapult, 0333 004 1339, andrew.macdonald@ore.catapult.org.uk)
Wind Blades Research Hub (WBRH) University of Bristol	Individual research programmes supported by the ORE	https://ore.catapult.org.uk/what-we-do/offshore-renewable-energy-

		research/research-hubs/
Electrical Infrastructure Research Hub (EIRH) Universities of Strathclyde and Manchester	Individual research programmes supported by the ORE	https://ore.catapult.org.uk/what-we-do/offshore-renewable-energy-research/research-hubs/
Powertrain Research Hub (PRH) University of Sheffield	Individual research programmes supported by the ORE	https://ore.catapult.org.uk/what-we-do/offshore-renewable-energy-research/research-hubs/

Figure 4.4: Offshore Wind Research Assets

4.3 Hydrogen

This section provides details regarding key private sector companies and research organisations / academic institutions involved in developing or deploying hydrogen technology in the UK. All of the companies have been identified as active participants in technology projects named elsewhere in the report. Collaborative research organisations / academic institutions (referred to collectively as 'Collaborative Research Assets') are deemed to be relevant on the basis that desk research has identified relevant research activity, however it has not been possible to confirm that all are actively involved in local projects.

4.3.1 Private Sector Hydrogen Companies

Figure 4.5 lists key private sector companies identified through this study as being involved in hydrogen projects.

Energy Producers

Name	Descriptor	Contact(s)
Shell	British-Dutch company involved in exploration, production and refining of oil and gas.	Rob Jansen, Acorn Project Director: https://www.linkedin.com/in/rdwjansen
Equinor	Norwegian state-owned energy company primarily engaged in the exploration and production of both oil and gas.	Anthony Millar, Commercial Lead: https://www.linkedin.com/in/antony-d-miller/
SSE Thermal	British energy company, focused on thermal energy generation and storage solutions.	Jack Davies, Head of Hydrogen Projects: (https://www.linkedin.co

		m/in/jack-davies-7417b426/)
Uniper	German energy company focused on power generation, energy trading, and energy storage.	John Curtis: https://www.linkedin.com/in/john-curtis-8a108b91
BP	British company engaged in the exploration, production and refining of oil and gas.	Aminta Hall, Senior Business Developer (https://www.linkedin.com/in/aminta-hall-132385120/)
ScottishPower	A subsidiary of the Spanish utility company Iberdrola, operating in the United Kingdom. It is involved in electricity generation, transmission, and distribution, as well as the supply of gas and electricity to homes and businesses.	Gary Jenkins, Head of Hydrogen Projects: (https://www.linkedin.com/in/gary-jenkins-98b25656/)
Octopus Energy	UK-based renewable energy company, focused on developing innovative energy solutions, including but not limited to hydrogen solutions.	Will Rowe, Innovation Lead: https://www.linkedin.com/in/will-rowe-55ab9816/
Statkraft	A Norwegian state-owned power company with a focus on hydropower, wind power and solar power.	Will Watson, Business Development Director: https://www.linkedin.com/in/will-watson-6310791a6/
Engineering, Manufacture and Infrastructure		
Protium	A UK-based green hydrogen energy services company that focuses on project development and delivery.	Sarah Finnie, Project Development Consultant: https://www.linkedin.com/in/sarah-finnie-30ab9812b/
ITM Power	A UK-based manufacturer of polymer electrolyte membrane (PEM) electrolysers for green hydrogen production.	Ross Paton, Projects Director: https://www.linkedin.com/in/ross-g-d-paton/
Kellas Midstream	A UK-based independent midstream company that owns and operates key gas infrastructure assets in the North Sea.	Jeremy Skedge, Hydrogen Opportunity Lead: https://www.linkedin.com/in/jeremy-skedge/

Storegga	A UK-based company that develops and operates carbon capture and storage (CCS) projects to help reduce greenhouse gas emissions and combat climate change.	David Clarkson, COO: https://www.linkedin.com/in/david-clarkson-38642a167
Carlton Power	A UK-based developer of energy infrastructure projects, including gas-fired power stations and battery storage facilities.	Henrique Machado Santos, Senior Project Lead (Hydrogen): https://www.linkedin.com/in/henrique-machado-santos-46377824
First Hydrogen	A Canadian company that develops hydrogen powered vehicles.	Daniel Bonilla, Supply Chain Lead: https://www.linkedin.com/in/danielbonillah/
H2 Green	A UK-based company offering hydrogen storage and infrastructure solutions.	Tom Morris, Managing Director: https://www.linkedin.com/in/tgmorris/
Siemens Gamesa	A company focused on the design, manufacture, and installation of wind turbines for both onshore and offshore wind farms as well as green hydrogen solutions.	Tom Baxter, Head of HSE: https://www.linkedin.com/in/tom-baxter-bsc-hons-cmiosh-piema-siirsm-00a66b18/

Figure 4.5: Private Sector Hydrogen Stakeholders

4.3.2 Hydrogen Collaborative Research Assets

Figure 4.6 lists key collaborative research assets focussed on hydrogen across the UK.

Name	Description	Contact(s)
Humber Hydrogen Hub	Uniper has ambitious plans for its operations in the Humber. It aims to develop a hydrogen hub at its Killingholme site, with up to 720 MW blue hydrogen and 100 MW green hydrogen production to be operational later this decade	Diana Taylor, Managing Director Future Humber: (https://www.linkedin.com/in/diana-taylor/)
Hydrogen Innovation Initiative	Group of organisations bringing together industry, government, and academia to create an investible, globally competitive hydrogen technology and services sector in the UK. Committed to a vision of UK technology powering the global hydrogen economy – transforming UK industry into a net zero powerhouse. Including bp, H2Go, Hydrogen UK, Johnson Matthey, National Gas, UK Hydrogen Energy Association.	Steve Scrimshaw, former Vice President for Siemens Energy UK&I (https://www.linkedin.com/in/steve-scrimshaw-1340601a/)

Net Zero Technology Centre	A not-for-profit organisation working with industry, government and academia driving technology innovation to accelerate the energy transition to net zero.	Myrtle Dawes, CEO: (https://www.linkedin.com/in/myrtledawes/)
UK HyRES Hub & Grantham Centre for Sustainable Futures, University of Sheffield	UK-HyRES will drive forward the national effort in hydrogen research that is needed to facilitate this critical area of technology to meet industry and government needs.	Professor Rachael Rothman (https://www.linkedin.com/in/rachael-rothman-9397b415/)
Energy Leeds	Community of energy researchers equipped to tackle the energy challenge by drawing on scientific, technical, environmental, economic, political, societal and behavioural expertise.	Professor Tim Cockerill, Co-Director: +44(0)113 343 7678 T.Cockerill@leeds.ac.uk
Centre for Energy Efficient Materials (CEEM), York University	CEEM's researchers are taking the centuries-old process of catalysis and making it fit for purpose in the 21st century, by combining fundamental research and experimental science using advanced microscopy with first principles modelling techniques.	Keith McKenna, Director CEEM: keith.mckenna@york.ac.uk, +44(0)1904 322251
Project Bluegen research, University of Hull	To investigate the possibility of producing hydrogen from the waste streams produced by biorefineries.	Dr Martin Taylor University of Hull, Martin.Taylor@hull.ac.uk

Figure 4.6: Hydrogen Research Assets

4.4 CCUS

This section provides details regarding key private sector companies and research organisations / academic institutions involved in developing or deploying CCUS technology in the UK. All of the companies have been identified as active participants in technology projects named elsewhere in the report. Collaborative research organisations / academic institutions (referred to collectively as 'Collaborative Research Assets') are deemed to be relevant on the basis that desk research has identified relevant research activity, however it has not been possible to confirm that all are actively involved in local projects.

4.4.1 Private Sector CCUS Companies

Figure 4.7 lists key private sector companies identified through this study as being involved in named CCUS projects.

Energy Producers		
Stakeholder Name	**Descriptor**	**Contact(s)**
Uniper	German energy company focused on power generation, energy trading, and energy storage.	See Figure 4.5
Equinor	Norwegian state-owned energy company primarily engaged in the exploration and production of both oil and gas.	See Figure 4.5
Shell	British-Dutch company involved in exploration, production and refining of oil and gas.	See Figure 4.5
SSE Thermal	British energy company, focused on thermal energy generation and storage solutions	See Figure 4.5
BP	British company engaged in exploration, production and refining of oil and gas.	See Figure 4.5
Eni	Italian oil and gas company involved in exploration, production, refining, and marketing.	Martin Currie, Energy Transition Manager: https://www.linkedin.com/in/martin-currie-26056429/
RWE	A German energy company focused on electricity generation and supply.	See Figure 4.3
Enfinium	British waste-to-energy company that operates energy recovery facilities, converting waste into electricity and heat.	Julian Harrison, Project Director: https://www.linkedin.com/in/julian-harrison-b72a322a/
ExxonMobil	American multinational oil and gas company engaged in exploration, production and refining.	Ian Taylor, Low Carbon Solutions Lead (https://www.linkedin.co

		m/in/ian-taylor-614741214/)
Wintershall DEA	German oil and gas company focused on exploration and production.	Dawn Summers, COO (Germany-based): https://www.linkedin.com/in/dawnsummerswintershalldea/
Solar 21 Renewable Energy Limited	Irish renewable energy company that develops, owns, and operates solar photovoltaic (PV) projects.	Neil Manning, Commercial Manager: https://www.linkedin.com/in/neil-manning-0a5897a7/
Perenco	British company engaged in the exploration, production and refining of oil and gas.	Marta Puig, CCS Subsurface Team Leader: https://www.linkedin.com/in/marta-puig-30b053121/
Engineering, Manufacture and Infrastructure		
Mitsubishi Heavy Industries Ltd	Japanese engineering, electrical equipment, and electronics company that manufactures a wide range of products, including CCUS solutions and wind turbines.	See Figure 4.3
Technip Energies	A global engineering and technology company that provides project management, engineering, and construction services for the energy industry, focusing on the transition to a low-carbon future.	Nick Rogers, Technology Manager (UKOC) at Technip Energies: https://www.linkedin.com/in/nick-rogers-154764a5/
Storegga	A UK-based company that develops and operates carbon capture and storage (CCS) projects to help reduce greenhouse gas emissions and combat climate change.	See Figure 4.5
Bechtel	A global engineering, construction and project management company that offers services in various sectors, including offering CCUS solutions to businesses in the energy sector.	Mark Johnson, Innovation Lead: https://www.linkedin.com/in/markjohnsoniengmiet/
Aker Carbon Capture	A Norwegian company that provides carbon capture technologies and solutions to reduce CO2 emissions from industrial processes.	David Phillips, New Market Strategy: https://www.linkedin.com/in/david-phillips-31a93137/

Peel NRE (Natural Resources and Energy)	A UK-based company that develops and operates low-carbon energy projects including the development of CO2 CCUS networks.	Michael Humphreys, Operations Manager: https://www.linkedin.com/in/michael-humphreys-8905491a
Altrad Babcock	A UK-based company that provides engineering, aftermarket and upgrade services for the power generation, oil and gas, and petrochemical industries.	Chris Williams, Project Manager: https://www.linkedin.com/in/chris-williams-08991965/
Carbon Catalyst Ltd	A UK-based company focusing on developing carbon capture, utilisation, and storage (CCUS) technologies.	Nick Terrell, Co-Founder: https://www.linkedin.com/in/nick-terrell-a6a564a/
Progressive Energy	A UK-based company that develops and delivers low-carbon energy projects, focusing on hydrogen production, carbon capture, and storage technologies.	Charles Perez-Storey, Principal Engineer involved in HyNet: https://www.linkedin.com/in/charles-perez-storey-8a300937

Figure 4.7: Private Sector CCUS Stakeholders

4.4.2 CCUS Collaborative Research Assets

Figure 4.8 lists key collaborative research assets focussed on CCUS across the UK.

Name	Description	Contact(s)
Imperial College London	Imperial College has the UK's largest CCS research programme, focusing on engineering and industrial CCS, subsurface CO2 behaviour, and legal and regulatory research. They are also part of the UK CCS Research Centre and several EU collaborative programs.	Professor Fennell, Industrial CCUS Lead: 020 7594 6637, p.fennell@imperial.ac.uk
University of Cambridge Energy Interdisciplinary Research Centre (IRC)	The Energy IRC includes Carbon Capture, Storage, and Use research. This programme focuses on a variety of innovative CCUS technologies and public awareness initiatives.	Dr Shafiq Ahmed, IRC Co-ordinator: shafiq.ahmed@admin.cam.ac.uk
Oxford Institute for Energy Studies	Independent energy research institute with interest in CCUS including recent research to evaluate the status quo of the decarbonisation of the cement sector via CCUS.	Bassam Fattouh, Director: bassam.fattouh@oxfordenergy.org
Grantham Research Institute on Climate Change &	Multidisciplinary centre for policy-relevant research and training on climate change and the environment, bringing together international expertise on economics, finance, geography, the environment, science, law,	Elizabeth Robinson, Institute Director: E.J.Z.ROBINSON@lse.ac.uk, https://www.lse.ac.uk/granth

the Environment, LSE	international relations, development and political science. Includes CCUS policy research.	aminstitute/?s=carbon+capture
University of Sheffield Translational Energy Research Centre (TERC)	Part of various collaborative efforts and projects aimed at advancing CCUS technologies and their applications in industrial settings.	Professor Pourkashanian, TERC Managing Director: m.pourkashanian@sheffield.ac.uk
Cranfield University HyPER	Offers extensive research and practical applications in industrial CCUS. Runs courses and provides hands-on experience through facilities like its 1 MWt HyPER demonstration for natural gas reforming with carbon capture.	Professor John Oakey: J.E.Oakey@cranfield.ac.uk Professor Philip Longhurst: P.J.Longhurst@cranfield.ac.uk
UK Carbon Capture and Storage Research Centre	Supports a comprehensive programme of research and networking in CCS, including CO2 storage and utilisation. It connects researchers across the UK and internationally to foster advances in CCUS technologies.	Professor Jon Gibbins, Director: j.gibbins@sheffield.ac.uk
Carbon Capture and Storage Association (CCSA)	CCSA plays a pivotal role in promoting and advancing CCS projects in the UK by facilitating collaborations between research entities, industry, and policymakers.	Rebecca Bell, UK Research and Projects Manager: https://www.linkedin.com/in/rebecca-bell-477bb925a/ See more at https://www.ccsassociation.org/about-us/people/
Centre for Energy Efficient Materials (CEEM), York University	CEEM's researchers are taking the centuries-old process of catalysis and making it fit for purpose in the 21st century, by combining fundamental research and experimental science using advanced microscopy with first principles modelling techniques.	Keith McKenna, Director CEEM: keith.mckenna@york.ac.uk, +44(0)1904 322251
Renewable Energy & Storage Technologies Group, University of Hull	Research from fundamental concepts through to commercial exploitation using a wide range of experimental and modelling techniques. Work with academic and industry collaborators in the UK and worldwide to bring together teams with world leading expertise in their respective fields to tackle these challenges.	Professor James Gilbert: J.M.Gilbert@hull.ac.uk
Humber Zero	Through Humber Zero, VPI and Phillips 66 Limited are on a mission to deliver one of the world's largest carbon capture projects. Delivering two carbon capture projects at VPI's Immingham plant and the Phillips 66 Limited Humber Refinery as part of the Viking CCS Cluster.	Simon Holt, Emerging Energy Manager Phillips 66: https://www.linkedin.com/in/simon-holt-1b26474a/ Pezhmon Nassiri, Innovation Lead Phillips 66: https://www.linkedin.com/in/pezhmon-nassiri-11aba352/ Stanley Joseph, Chief Technology Officer VPI:

		https://www.linkedin.com/in/stanley-joseph-72537944/ Rob Labinski, Director of Growth VPI: https://www.linkedin.com/in/rob-labinski-4b636130/

Figure 4.8: CCUS Research Assets

4.5 Key Yorkshire & Humber Stakeholders

Drawn from the content of previous tables, Figure 4.9 provides a list of suggested key stakeholders believed to be closely involved in technologies of interest within the Humber Cluster and surrounding Yorkshire and Humber region. Stakeholders are organised according to whether they are in local government, industry or research and whether they have been identified as being predominantly involved in offshore wind, hydrogen or CCUS.

Name	Description	Contact(s)
Government / Framework		
Hull City Council and East Riding of Yorkshire Council	Local Authorities within the Humber Industrial Cluster. Currently in the process of securing devolution powers via the 'Hull and East Yorkshire (HEY) Devolution Deal'.	Contact: Alex Codd, Hull City Council Assistant Director Economic Development & Regeneration (01482 613089, https://investhull.co.uk/contact-us) || Claire Watts, East Riding Director of Economic Development (https://www.linkedin.com/in/claire-watts-91142615/)
North Lincolnshire and North East Lincolnshire	Local Authorities within the Humber Industrial Cluster. Currently in the process of securing devolution powers via the Greater Lincolnshire Devolution Combined Authority.	Contact: Justine Duhrkoop, Inward Investment Business Specialist, Invest in North Lincolnshire (https://www.linkedin.com/in/justine-d %C3 %BChrkoop-482653143/) || Margaret Johnson, Head of Economy and Funding Invest NEL (https://www.linkedin.com/in/margaret-maggie-johnson-7843a239/)
Humber Industrial Cluster Plan	A 2-phase decarbonisation plan for the Humber cluster including a Phase 1 feasibility study and implementation of the HCIP in Phase 2.	Contact: Jonathan Oxley, HCIP Manager (https://www.linkedin.com/in/oxleyjc/) || Andrea Dewick, HCIP Co-Ordinator (https://www.linkedin.com/in/andrea-dewick-llb-08b15ba7/)
Industry		

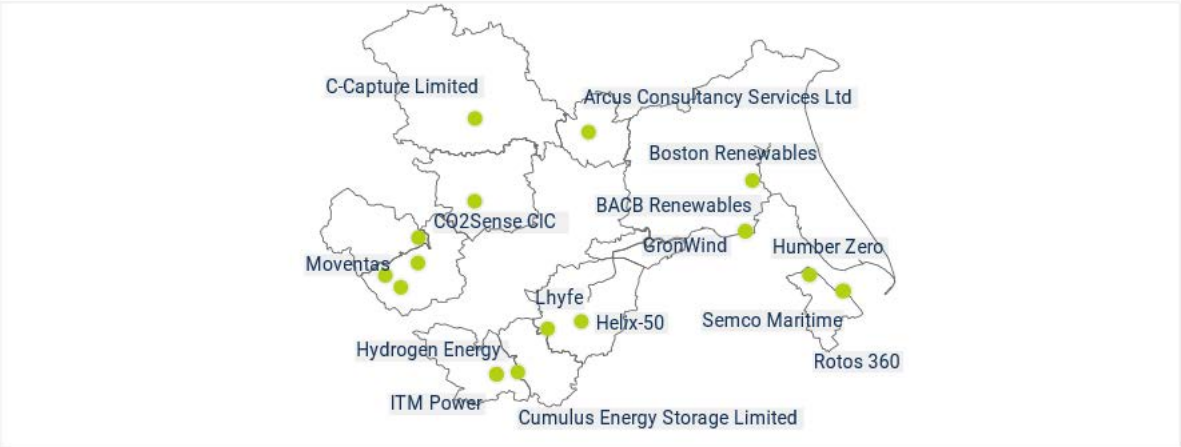
Green Port Hull (Offshore Wind)	Renewable energy hub in Hull, home to Siemens Gamesa's offshore wind turbine blade manufacturing, assembly and servicing facilities, supported by a significant investment from Associated British Ports (ABP) and Siemens Gamesa. The centre also explores opportunities in hydrogen, carbon capture, biofuels, and other renewable energy sources. (https://greenporthull.co.uk/what-we-do/humber-offshore-wind-cluster).	C/O Hull City Council (see local stakeholder contacts): info@greenporthull.co.uk
Humber Marine Renewables (Offshore Wind)	Supports the offshore wind sector by matching business opportunities with supply chain capabilities and promoting regional expertise at international conferences (https://www.humber-marine-renewables.co.uk/sectors/offshore-wind/)	Graham Billany, Director: +44 (0) 1482 485271, owc@humber-marine-renewables.co.uk
Associated British Ports (ABP) (Offshore Wind)	ABP's Port of Grimsby is part of the world's largest offshore wind 'living lab' that integrates advanced digital technologies for offshore wind operations and maintenance (https://www.abports.co.uk/locations/grimsby/)	Simon Bird, Humber Regional Director (https://www.linkedin.com/in/simon-bird-6b4a43163/)
The Humber Offshore Wind Cluster (Offshore Wind)	A collaborative effort that includes various stakeholders in the region, focusing on building capabilities, strengthening knowledge and increasing employment in the offshore wind sector (https://www.humberoffshorewindcluster.co.uk/)	Graham Billany, Director: +44 (0) 1482 485271, owc@humber-marine-renewables.co.uk
Humber Hydrogen Hub (Hydrogen)	Uniper has ambitious plans for its operations in the Humber. It aims to develop a hydrogen hub at its Killingholme site, with up to 720MW blue hydrogen and 100MW green hydrogen production to be operational later this decade	Diana Taylor, Managing Director Future Humber: (https://www.linkedin.com/in/diana-taylor/)
Humber Zero (CCUS)	Through Humber Zero, VPI and Phillips 66 Limited are on a mission to deliver one of the world's largest carbon capture projects. Delivering two carbon capture projects at VPI's Immingham plant and the Phillips 66 Limited Humber Refinery as part of the Viking CCS Cluster.	Simon Holt, Emerging Energy Manager Phillips 66: https://www.linkedin.com/in/simon-holt-1b26474a/ Pezhmon Nassiri, Innovation Lead Phillips 66: https://www.linkedin.com/in/pezhmon-nassiri-11aba352/ Stanley Joseph, Chief Technology Officer VPI: https://www.linkedin.com/in/stanley-joseph-72537944/ Rob Labinski, Director of Growth VPI: https://www.linkedin.com/in/rob-labinski-4b636130/
Research		

University of Sheffield Advanced Manufacturing Research Centre (AMRC) (Offshore Wind)	Supports collaborative projects in offshore wind, focusing on decarbonising the Humber region's industrial cluster (https://www.amrc.co.uk/news/1-25m-project-will-advance-wind-turbine-blade-production).	Industry Account Manager John Dale +44(0)7725 603867, j.dale@sheffield.ac.uk
University of Sheffield Energy 2050 (Various)	One of the UK's largest energy research institutes with over 120 academics and more than 250 PhD students undertaking energy research and innovation.	Professor Pourkashanian, TERC Managing Director: m.pourkashanian@sheffield.ac.uk
Aura Innovation Centre (Offshore Wind)	Based in the Green Port Hull initiative, this centre drives innovation in the offshore wind sector through research and collaboration with industry stakeholders (https://aura-innovation.co.uk/).	Louise Smith, Director (https://www.linkedin.com/in/louise-smith-3761b8122/) || Sarah Clark, Head of Operations (https://www.linkedin.com/in/sarah-clark-1670aa170/) || Prof. James Gilbert (https://www.hull.ac.uk/staff-directory/james-m-gilbert)
Offshore Renewable Energy (ORE) Catapult (Offshore Wind)	With a significant presence in the Humber, the ORE Catapult leads the development of new technologies for the offshore wind sector, including a 5G testbed project for operations and maintenance improvements (https://ore.catapult.org.uk/)	Andrew Macdonald, Director of Offshore Wind Development & Operations (tel: 0333 004 1339, andrew.macdonald@ore.catapult.org.uk)
Innovate UK Offshore / Renewables (Offshore Wind)	Innovate UK Business Connect supports the offshore wind industry as a major contributor to the ORE Catapult innovation hub funded by BEIS, as well as supporting the companies who are making applications for funding for offshore renewables.	John Ransford, Offshore Wind Expert (https://www.linkedin.com/in/john-ransford-bb57118/)
Offshore Wind Innovation Hub (Offshore Wind)	The Offshore Wind Innovation Hub is the UK's primary coordinator for innovation, focusing on offshore wind energy cost reduction and maximising UK economic impact. The Hub is funded by the Department for Business, Energy and Industrial Strategy (BEIS) and delivered jointly by the Offshore Renewable Energy (ORE) Catapult and the Knowledge Transfer Network (KTN).	C/O ORE Catapult, 0333 004 1339, andrew.macdonald@ore.catapult.org.uk)
UK HyRES Hub & Grantham Centre for Sustainable Futures, University of Sheffield (Hydrogen)	UK-HyRES will drive forward the national effort in hydrogen research that is needed to facilitate this critical area of technology to meet industry and government needs.	Professor Rachael Rothman (https://www.linkedin.com/in/rachael-rothman-9397b415/)

Energy Leeds (Hydrogen)	Community of energy researchers equipped to tackle the energy challenge by drawing on scientific, technical, environmental, economic, political, societal and behavioural expertise.	Professor Tim Cockerill, Co-Director: +44(0)113 343 7678 T.Cockerill@leeds.ac.uk
Centre for Energy Efficient Materials (CEEM), York University (Hydrogen)	CEEM's researchers are taking the centuries-old process of catalysis and making it fit for purpose in the 21st century, by combining fundamental research and experimental science using advanced microscopy with first principles modelling techniques.	Keith McKenna, Director CEEM: keith.mckenna@york.ac.uk, +44(0)1904 322251
Project Bluegen research, University of Hull (Hydrogen)	To investigate the possibility of producing hydrogen from the waste streams produced by biorefineries.	Dr Martin Taylor University of Hull, Martin.Taylor@hull.ac.uk
University of Sheffield Translational Energy Research Centre (TERC) (CCUS)	Part of various collaborative efforts and projects aimed at advancing CCUS technologies and their applications in industrial settings.	Professor Pourkashanian, TERC Managing Director: m.pourkashanian@sheffield.ac.uk
UK Carbon Capture and Storage Research Centre	Supports a comprehensive programme of research and networking in CCS, including CO2 storage and utilisation. It connects researchers across the UK and internationally to foster advancements in CCUS technologies.	Professor Jon Gibbins, Director: j.gibbins@sheffield.ac.uk

Figure 4.9: Key Yorkshire & Humber Stakeholders

Lastly with respect to potential partners for collaboration, the study has identified a further 16 companies that are located in the Yorkshire and Humber region but that have not been identified as being involved in the main technology projects presented in previous sections. Figure 4.10 provides further details of those additional companies including specialisms and websites. A further list of 173 potentially relevant companies has been provided in the dataset that accompanies this report.



Semco Maritime	Offshore Substations	semcomaritime.com
Lhyfe	Green Hydrogen	lhyfe.com
Moventas	Offshore Wind	moventas.com
Arcus Consultancy Services Ltd	Planning & Consenting	arcusconsulting.co.uk
Rotos 360	Offshore Wind	rotos360.co.uk
Boston Renewables	Energy Storage	boston-renewables.co.uk
Hydrogen Energy	Hydrogen Infrastructure	hydrogenenergy.co.uk
CO2Sense CIC	Private Investment	co2sense.co.uk
Helix-50	Private Investment	helix50.co.uk
BACB Renewables	Decarbonisation Consultancy	bacbrenewables.com
GronWind	Offshore Wind	gronwind.com
Evoco Wind Energy	Offshore Wind	evocoenergy.com
Sun & Earth Renewables Ltd	Offshore Wind	sunearthrenewables.co.uk
ITM Power	Green Hydrogen	itm-power.com
Cumulus Energy Storage Limited	Energy Storage	cumulusenergystorage.com
C-Capture Limited	Carbon Capture	c-capture.co.uk

Figure 4.10: Additional Potential Businesses for Collaboration

5 Conclusions

The Humber region has been at the forefront of the UK's offshore wind technology and talent development for many years. More recently, considerable progress has also been made on the development of numerous hydrogen and CCUS projects, making the Humber Industrial Cluster (HIC or 'the Cluster') an internationally significant testbed for decarbonisation technologies. The Cluster is also ideally placed for carbon infrastructure and storage development projects given the concentration of heavy industry / decarbonisation incentives and its proximity to storage capacity.

Heavy industries in the UK have shown strong economic performance in recent years, with revenues rebounding to pre-pandemic levels. There has also been an upward trend in FDI into the UK in recent years, driven by renewable energy and metals. This strong economic performance should provide a foundation for investment in decarbonisation technology development in future.

There have been substantial levels of public investment in decarbonisation within the Cluster in recent years, across at least 20 significant decarbonisation projects[9]. Strategically significant global businesses including Phillips 66, Shell, Uniper, RWE and Orsted have pledged to invest c. £15 billion into Humber-based energy transition activities[10]. However, despite major investment from the UK government and strategically significant global businesses, the level of private investment into smaller clean technology supply chain businesses has been more modest, suggesting that the Cluster may offer unrealised investment opportunities.

The Humber Industrial Cluster is also a key location for research and development activity in renewable energy and decarbonisation. The Humber Industrial Cluster was formed following a 2019 industrial clusters funding competition run by UKRI. Since 2018, the total number of research and innovation funding awards within the cluster has more than trebled, and the number of awards focussing specifically on decarbonisation and the environment has seen an almost five-fold increase. A notable proportion of this funding has focussed on building the knowledge and skills required to leverage social and economic benefits from renewable energy and decarbonisation. For example, since 2019 the University of Hull has hosted the UK's main Centre for Doctoral Training in Offshore Wind Energy and the Environment – representing a £6 million investment by two UK research councils.

With the exception of the new UK ETS, the level of divergence between UK and EU decarbonisation policy and legislation in recent years has been limited, and should therefore not present a major barrier to international co-operation on decarbonisation activities. More recent UK policies and legislative developments focus on accelerating the planning process for major infrastructure projects, which should further benefit decarbonisation activity within the Humber region.

In recent years UK decarbonisation policy has favoured hydrogen and CCUS for industrial decarbonisation. Both of these technology areas have received substantial investment in

[9] https://investhumber.com/industrial-decarbonisation
[10] Humber Energy Board, 'Humber 2030 Vision', Invest Humber

recent years. At the time of writing the Department for Energy Security and Net Zero (DESNZ) is reviewing all decarbonisation pathways, and the Climate Change Committee will soon publish updated progress and risk assessments, and new carbon budgets. This may result in greater emphasis on electrification and could present some risk to early-stage hydrogen and CCUS activity. However, regardless of nuances in the specific technology focus, the Humber Industrial Cluster will continue to be a major focal point for industrial decarbonisation in future.

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