# Capturing Carbon at Drax: Delivering Jobs, Clean growth and Levelling up the Humber

Report prepared for Drax

November 2020

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# Executive Summary

Background

- In November 2019, Drax Group plc (Drax) announced its ambition to become the **world's first carbon negative energy company by 2030**.

- To achieve this, it is looking to convert its four existing biomass operations at Drax Power Station to carbon capture and storage (CCS). This technology, also known as BECCS, would generate up to 16 million tonnes of 'negative emissions' per year – **equivalent to the total industrial emissions from the Humber region today.**

- Vivid Economics was commissioned by Drax to quantify the social and economic benefit of deploying BECCS at Drax Power Station. It was also commissioned to provide an estimate for Drax of the socio-economic benefits of deploying CCS and hydrogen technologies at scale across the wider Humber industrial cluster.

- Harnessing hydrogen and CCS technology represents a unique opportunity to **build back better as part of the Covid-19 recovery** and transform the UK's most carbon intensive industrial cluster into the **world's first carbon neutral industrial cluster by 2040**.

- The Zero Carbon Humber Partnership, comprised of 12 leading companies and organisations across the Humber including Drax, have recently submitted a joint public-private sector funded bid worth around £75m to support the deployment of CCS and hydrogen technologies in the region[1]. **This bid illustrates the significant potential CCS and hydrogen projects present to safeguarding existing jobs and creating new, highly skilled jobs in the region.**

- Vivid Economics's analysis of the socio-economic benefits of deploying CCS and hydrogen technologies in the Humber seeks to further develop industry and government's understanding of the economic opportunity in the region. It complements the Hy-Deploy analysis undertaken by Element Energy for Equinor (Element Energy, 2019) and the forthcoming analysis the Humber LEP and CATCH will undertake as part of their joint Humber Cluster Plan (Humber LEP, 2019b).

Building back better at Drax and the Humber industrial cluster

- **As many as 49,700 direct, indirect and induced jobs** will be created as a result of deploying CCS and hydrogen technologies in the Humber region. Working in partnership with the UK Government, these new jobs could begin to be realised in as little as four years' time (2024), peaking at 49,700 jobs in 2027.

- These jobs include up to 25,200 high quality jobs in construction, such as welders, pipe fitters, machine installers and technicians; with a further 24,500 supported across the supply chain and wider economy.

- **Developing BECCS at Drax itself** would support on average 10,500 direct, indirect and induced jobs per year during construction between 2024 to 2031, peaking at 16,800 jobs in 2028.

[1] The Zero Carbon Humber Partnership currently comprises of Associated British Ports, British Steel, Centrica Storage Ltd, Drax Group, Equinor, Mitsubishi Power, National Grid Ventures, px Group, SSE Thermal, Saltend Cogeneration Company Limited, Uniper, and the University of Sheffield's Advanced Manufacturing Research Centre (AMRC). Further information can be found at https://www.zerocarbonhumber.co.uk.

- BECCS at Drax would also generate an additional £370 million on average in direct GVA each year during the construction period (2024 to 2031) – and an additional £170 million per year and £210 million per year in indirect and induced GVA respectively. Total GVA peaks at £1.1bn in 2028.

- Deploying CCS and hydrogen technologies in the Humber would also **deliver a peak of over £3.2 billion per year in direct, indirect and induced GVA in 2027 for the Humber economy**.

Realising the joint opportunity of Humber and Teesside

- As part of its commission, Vivid Economics also considered the benefits of **rolling out CCS and hydrogen technologies in the Humber and Teesside industrial clusters, utilising shared $CO_2$ transport and storage infrastructure in the Southern North Sea.**

- Developing the Humber and Teesside industrial clusters in parallel would on average support 19,000 direct jobs per year during the period 2024 to 2031 (peaking at 30,200 in 2027).

Levelling up through CCS and hydrogen

- At its peak, the Humber and wider UK deployment of CCS and hydrogen technologies could support over **205,000 direct, indirect and induced jobs and almost £15 billion in direct, indirect and induced GVA.**

- Developing CCS and hydrogen technologies at Drax and across the wider Humber industrial cluster can help reverse **a growing skills and investment gap in the region**.

- CCS and hydrogen technologies have the opportunity to create high quality jobs in the low carbon economy, during both the construction of projects and their subsequent operation and maintenance. These jobs include welders, pipe fitters and machine installers.

**Defining jobs**

1. **Direct jobs** are jobs supported from *direct project expenditure*, such as jobs supported when a compressor is purchased for installation on site.
2. **Indirect jobs** are those which are supported from *spending in the wider supply chain*, such as those supported when the manufacturer of the compressor pays for instrumentation to install on the compressor before it is sent to site for installation.
3. **Induced jobs** are those which are supported from *spending in the local economy by employees*, such as when the technician commissioning the compressor on site purchases a coffee at the local sandwich shop.

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# Acronyms

| | |
|---|---|
| BECCS | Bioenergy with carbon capture and storage |
| CAPEX | Capital expenditure |
| CCC | Climate Change Committee |
| CCGT | Combined-cycle gas turbine |
| CCS | Carbon capture and storage |
| CCUS | Carbon capture utilisation and storage |
| DEVEX | Development expenditure |
| EPCm | Engineering, Procurement, Construction management |
| ETP | Energy Technology Perspectives |
| EU | European Union |
| FOAK | First-of-a-kind |
| GVA | Gross value added |
| IEA | International Energy Agency |
| IIM | Investment Impact Model |
| M&R | Mitigation and remediation |
| MMV | Measuring, monitoring and verification |
| Mtpa | Million tonnes per annum |
| NACE | Nomenclature of Economic Activities |
| NOAK | Nth-of-a-kind |
| NZT | Net Zero Teesside |
| O&M | Operations and maintenance |
| OPEX | Operating expenditure |
| RD&D | Research, design, and development |
| RoW | Rest of the world |
| SAM | Social Accounting Matrix |
| SSV | Skills shortage vacancy |
| ZCH | Zero Carbon Humber |

# 1 Introduction

**In December 2019, Drax Group announced its ambition to become the world's first carbon negative energy company by 2030** (Drax, 2019). Drax has already invested substantially to convert four of its units from coal to biomass and began piloting bioenergy with carbon capture and storage (BECCS) in October 2018 at Drax Power Station inside the Humber industrial cluster (Drax, 2018). Since Drax has the largest biomass power generation units in the UK, retrofitting its four biomass units with CCS can help accelerate the switch to BECCS-based carbon negative power in the UK. Additionally, Drax provides the opportunity for four units of refurbished biomass generation at low cost, enabling innovation to spill over to future projects. Achievability of its company-wide target is dependent on an effective negative emissions policy and investment framework. Formulating the socio-economic implications of the use of CCS specifically at Drax Power Station therefore forms a key objective of this study.

**Several independent experts including the Climate Change Committee, National Infrastructure Commission and the Electricity System Operator have identified a critical role for BECCS in achieving Net Zero.** This is because BECCS is the most scalable of all technology options that can deliver 'negative emissions' to offset hard-to-decarbonise sectors such as agriculture and aviation (CCC, 2019),(National Grid, 2020),(National Infrastructure Commission, 2020).

**BECCS is also important to the decarbonisation and stability of the power system**. This is because of a large requirement for "zero carbon firm capacity", to provide the necessary system needs (inertia, adequacy, frequency and reserve), and constraints on the roll out of alternative technologies such as nuclear (site constrained), hydro (site constrained), storage/renewables (constrained by intermittency) and gas (constrained by emissions limits).

**BECCS can play an important role in supporting the development of industrial clusters**. By generating a large, stable source of biogenic $CO_2$, BECCS projects can help de-risk $CO_2$ transport and storage networks by creating economies of scale and reliable volumes of $CO_2$ for the network operators.

**This report sets out the direct and wider economic benefits of the project, along with an analysis of skills and labour required to achieve the vision of the project.** The remainder of the report is structured as follows:

- Section 4 discusses the direct jobs and Gross Value Added (GVA) benefits of the project at the level of Drax, the Humber, the East Coast (combination of Humber and Teesside) and UK-wide deployment of CCS and hydrogen technologies.
- Section 5 discusses the indirect and induced jobs and GVA benefits of the project at the Drax, Humber and UK-wide levels. These are jobs and GVA created as a result of spending in the wider supply chain and in the local economy.
- Section 6 discusses the labour, skills and investment gaps in the Humber and ways to fill these gaps in order to support CCS and hydrogen deployment in the Humber industrial cluster, including on the quality of the jobs and their ability to help achieve a post-COVID recovery.

# 2 The role of BECCS in reaching net zero and regional regeneration

**The UK needs to decarbonise rapidly if it is to meet its legally binding net zero target.** This was legislated in June 2019, as an amendment to the Climate Change Act 2008 by introducing a target for at least a 100% reduction of greenhouse gas emissions (compared to 1990 levels) in the UK by 2050 (HM Government, 2019).

**A common finding across scenarios for UK decarbonisation is the requirement for at-scale negative emissions** (Vivid Economics, 2019a)(Vivid Economics, 2019c)(CCC, 2019). Recent estimates put the scale of these negative emissions at around 90-110 $MtCO_2$-e per annum (CCC, 2018). The ability to achieve this amount of negative emissions by growing trees that absorb $CO_2$ still leaves a large gap[2] which will need to be met through biomass with carbon capture and storage (BECCS) as well as other technologies such as direct air capture with carbon capture and storage (DACCS). The CCC therefore has recognised the need for BECCS and DACCS, stating that 'all scenarios require some active removal of GHG from the atmosphere. This enables net emissions to fall faster than gross emissions can be reduced and compensates for residual sources of emissions' (CCC, 2019).

**Using sustainably sourced biomass, BECCS has the potential to deliver a significant volume of negative emissions needed by the UK to offset emission in hard-to-decarbonise sectors like agriculture and aviation**. The CCC in its 2018 bioenergy review state that biomass can be produced and used in ways that are both low-carbon and sustainable, subject to robust monitoring and governance. (CCC, 2018).

**BECCS can also provide zero carbon firm power, for which there is large demand in the run up to 2050.** The CCC forecasts that around 150 TWh of firm power will be required by 2050. Firm power is production which can be scheduled with confidence well in advance and may continue to play an important role in the UK's power sector. Alternative sources of firm power are likely to be limited:

- renewables: land and sea area and feasible deployment rates constrain deployment
- nuclear and hydro: limited by site availability
- unabated gas: limited by emissions constraints
- demand side flexibility: limited by the feasibility of demand side participation.

**An at-scale BECCs plant is therefore a cost-effective choice for the late 2020s on the path to delivering 2050 climate targets.** BECCS goes beyond the power sector with negative emissions. Negative emissions are likely to be important in decarbonising Aviation and Agriculture, bridging the gap between these sectors and the power sector. Without deployment of BECCS at scale, the decarbonisation of industry, buildings and transport (via CCS and Hydrogen), is likely to face higher costs and more constraints in rollout, ultimately potentially delaying the achievement of the net zero target.

*Innovation spillovers for CCS*

**Achieving the UK's net zero emissions target will involve a major role for industrial clusters.** The Government's Industrial Clusters Mission aims to create the world's first net-zero industrial cluster by 2040 (BEIS, 2019). Having set the 2050 net zero emissions target, BEIS are now redesigning decarbonisation and industrial policy to support industrial decarbonisation. Key pillars relevant to the Humber are:

[2] The CCC has indicated that 30,000 hectares of trees will need to be planted every year in order to achieve negative emissions consistent with the net zero target by 2050 and UK Prime Minister Boris Johnson has committed to planting 75,000 acres (31,000 hectares) per annum as part of the COVID-19 'new deal' (BBC News, 2020). However, even with 30,000 hectares being planted, there will be a large gap in negative emissions which will need to be filled by negative emissions technologies.

- The development of CCS policy support across both power and industrial sectors. Specific CCS policy could raise investment in BECCS
- Industrial decarbonisation policy, including design of a UK ETS (or similar) and funding for innovative decarbonisation technologies through, for example, the Industrial Strategy Challenge Fund (HM Government, 2017).
- The broader industrial strategy – which considers decarbonisation but is heavily focused on improving UK industrial competitiveness and 'levelling up' the UK's regions.
- Leveraging the UK Government's climate leadership ambitions for COP 26 through exporting CCS skills, expertise, and technology globally

**BECCS projects can play a critical role in supporting CCS and hydrogen clusters around the UK.** In the case of the Humber industrial cluster, the scale of the Drax BECCS plant would create a significantly larger CCS transmission and distribution network in the region. In conjunction with other projects in the region that can serve as 'anchor' loads, they can help de-risk the development of these networks. The development of the CCS infrastructure can in turn facilitate the use of hydrogen in industry, for those plants where electrification is not possible and fuel-switching to hydrogen is the preferred and most economically viable option. Additionally, development of the CCS infrastructure can facilitate DACCS, another important negative emissions technology which the CCC believes could play a role in meeting 2050 climate targets. Finally, taken together, the Humber and Teesside CCS clusters can reduce costs and build supply chains to underpin an industry and more clusters right across the UK.

*Regional regeneration*

**The Humber, like much of the industrial North, has suffered from the decline of heavy industries such as steel, oil and chemicals, but the low carbon transition provides economic opportunities for the region.** The region has recently faced high unemployment and low levels of economic activity, with heavy industry reducing activity and closing plants. This in part reflects a general loss of competitiveness of heavy manufacturing in the UK. However, transitioning to zero-carbon emissions will safeguard jobs and provide a variety of new employment opportunities. As the largest $CO_2$ emitter (at least 18 Mt $CO_2$/year)[3], decarbonisation of the Humber cluster is essential to protect the region's 55,000 manufacturing jobs (Zero Carbon Humber, 2019).

**With the goal of building the world's first zero carbon industrial cluster, the Humber embodies the economic opportunities associated with 'building back better'**. Locally, the creation of the CCS and hydrogen projects can create new jobs, attract investment, and raise the skills and qualifications of the local population. By attracting new low carbon industry, the Humber will increase the number of green collar[4], higher productivity and wage jobs, along with increasing investments into physical infrastructure and new technologies in the area. The Humber will also grant momentum in building local skills and increasing the qualifications rate of the population through specialised vocational training.

**Ground truth**: How a decarbonised Humber industrial cluster could help power the UK's green economic recovery

Comment from Andrew Percy, Conservative MP for Brigg and Goole, October 2020

[3] The power sector emissions encompassed within this includes 2.8 Mt$CO_2$/year from the Saltend power plant, 3.1 Mt $CO_2$ from the VPI Immingham combined heat and power plant, 0.9 Mt $CO_2$ from the Keadby power plant and 1.1 Mt $CO_2$ from the South Humber Bank power station.
[4] Green collar jobs include those whose tasks seek to increase sustainability and to decrease waste, energy use, and pollution. This workforce includes newly created jobs and also encompasses the "greening" of existing jobs to improve their impact on both the environment and the worker (McClure et al., 2017)

- The Covid-19 crisis has intensified pressures on businesses and industry in across the region, with employment volatility and economic uncertainty increasingly concerning. The UK Government has made clear that the UK's economic recovery will be underpinned by keeping businesses in operation, supporting jobs and re-skilling the workforce. **We must ensure we are not left behind in this journey to recovery**.
- CCUS and hydrogen promises to bring resilience to industries in the region and ensure they are fit for purpose as the UK embarks on greening the economy. It can unlock the opportunity to build the world's first net zero industrial cluster and decarbonise the north of England. Industry in Yorkshire and the Humber are essential to the UK economy, but are the highest emitters of $CO_2$, so decarbonising industry in the north will be crucial to reaching the UK's 2050 net zero target, as highlighted by the UK's Climate Change Committee.
- **CCUS and hydrogen can help deliver on this ambition in a way which ensures that the whole region benefits during the transition**, through job creation and economic prosperity. A net zero cluster in the region will create a large-scale negative emissions infrastructure in the Humber and Teesside, boosting the local supply chain and supporting jobs. This will place the north of England at the forefront of the global energy revolution, simultaneously establishing an industry that will lead in clean technologies. **We can turbo-charge economic growth in the region, attract investment, create skills and thousands of jobs for now and for the future**.
- The pandemic has highlighted the need for resilience, which calls for the safeguarding of jobs and addressing the burgeoning skills gap. **A decarbonised Humber industrial cluster can seize the opportunity now to create a prosperous economic, social and environmental post-Covid regeneration of the Yorkshire and Humber region which will power the UK's economic green recovery.**

**A number of viable, shovel-ready[5] projects stand ready in the Humber to deliver jobs and growth as part of the COVID-19 recovery.** The UK economy shrunk by 20.4% year-on-year in Q2 2020, as the impact of the coronavirus on economic activity weighed on all sectors. In particular, as lockdown restrictions decreased demand for energy, output in the 'electric, gas, steam and air' sub-sector contracted by 8.8% year-on-year, challenging the economics of this vital industry (The Financial Times, 2020). As the UK government now looks to move beyond the immediate fiscal relief provided during the early stages of the lockdown and put in place a fiscal and economic package to stimulate a sustainable medium and long-term economic recovery, CCS provides a means to create well-paying jobs to help stimulate spending in the wider economy.

**In December 2019, Drax announced its aim of becoming the world's first carbon negative company by 2030.** Drax has played a leading role in decreasing regional emissions. It has invested substantially to convert four of its units from coal to biomass and began piloting BECCS in January 2019 at Drax Power Station inside the Humber industrial cluster. With the right investment framework and business model for BECCS, Drax could deliver BECCS at scale by 2027, which would be world leading. Formulating the socio-economic implications of the use of CCS specifically at Drax Power Plant therefore forms a key objective of this study.

5 A project that is considered to be at an advanced enough stage of development for building to begin soon

# 3 Deployment Pathways

## 3.1 Deployment pathways

**The Zero Carbon Humber (ZCH) Partnership brings together leading companies across the Humber with a shared plan to create the world's first net zero industrial cluster by 2040**. This would be realized through the deployment of low carbon hydrogen, carbon capture and negative emissions, known as carbon removal technology.

The scheme is enabled by shared infrastructure that includes a pipeline network to carry hydrogen to industrial customers and carbon dioxide from power generation and industrial emitters to permanent storage in an offshore aquifer below the seabed in the UK's Southern North Sea.

This would result in the capture of **over 30 $MtCO_{2\text{-}e}$ per annum of emissions by 2040**, as the scale-up of the cluster continues and additional projects avail of the opportunity to join the CCS network or fuel switch.

BECCS

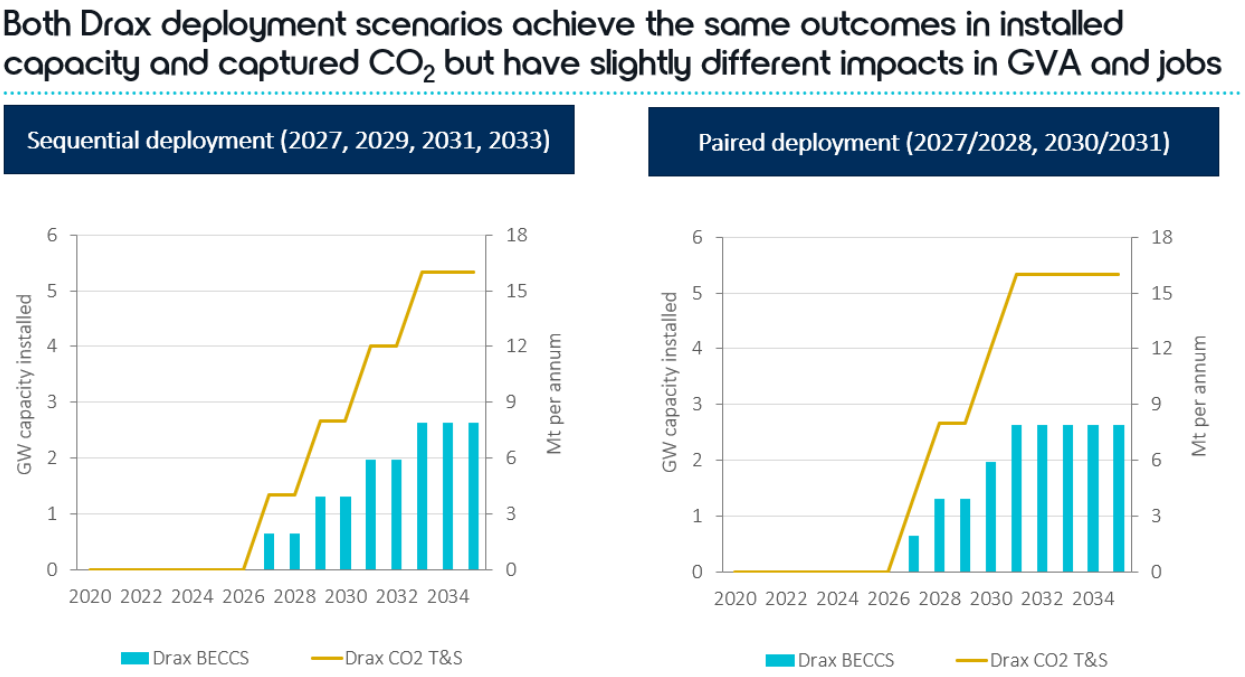
**As part of the Zero Carbon Humber proposition, Drax is proposing to convert its four existing biomass units at Drax Power Station to CCS or BECCS**. This would enable Drax to become the world's first carbon negative power station.

To realise this ambition, Drax could pursue the development of BECCS through two different scenarios:

- A sequential build-out of CCS at Drax Power Station, with CCS units deployed in 2027, 2029, 2031 and 2033
- A 'paired' approach to building CCS, with two units each being deployed in 2027-2028 and 2030-2031

Although both scenarios result in the same GW of BECCS capacity and $MtCO_{2\text{-}e}$ per annum of $CO_2$ captured - as shown in Figure 1 – the key difference is that in the ''paired deployment' scenario, synergies result in the labour force and deployment of working capital, thereby also helping support operational and maintenance (O&M) jobs from elsewhere on the Drax plant.

Figure 1 Comparison of Drax BECCS deployment scenarios




Source: Vivid Economics based on Drax assumptions

**Deploying the BECCS units in pairs creates a range of synergies**. This is because of the scheduling, commissioning, logistics and cost synergies associated with maintaining crews on site to build two units at the same time. This scenario has an implication for labour demands due to a more intense construction and commissioning phase.

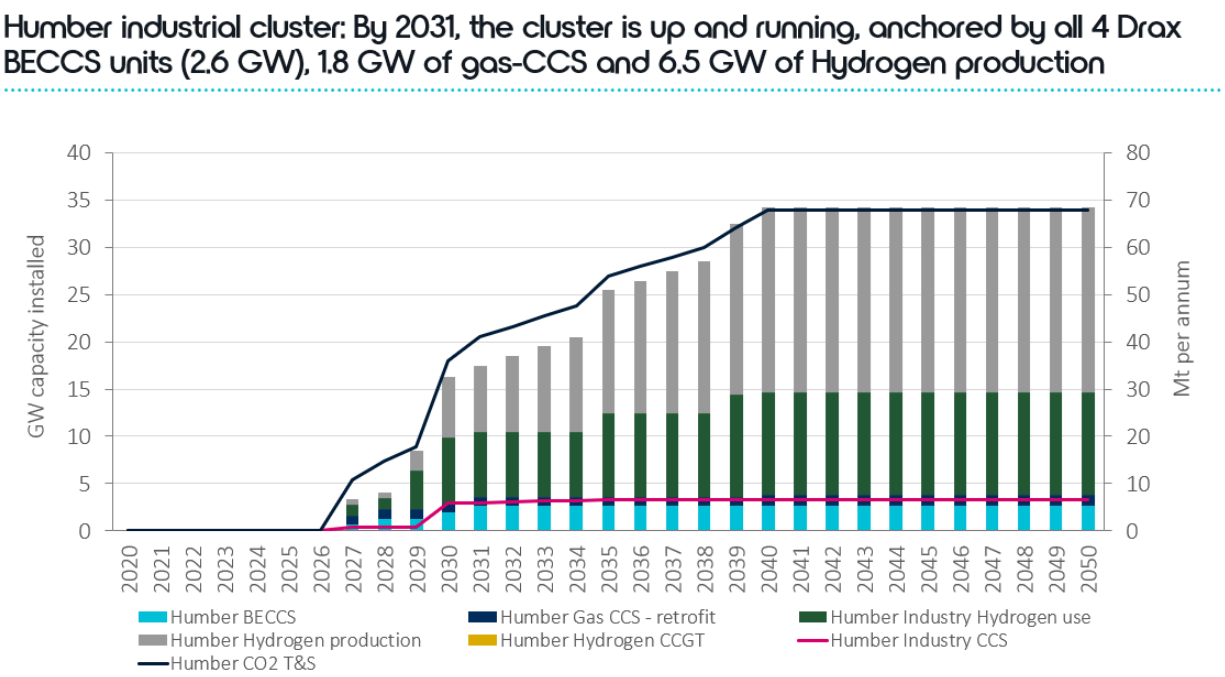
*For the remainder of the analysis in this report, we therefore use the 'two pairs' deployment scenario as the baseline (including at the Humber, wider regional and UK deployment levels).*

The Humber industrial cluster

To quantify the benefit of rolling out CCS and hydrogen technologies in the Humber industrial cluster, the following projects were assumed to be deployed:

- Four Drax BECCS units of 0.66 GW each, deployed in pairs in 2027-2028 and 2030-2031
- Hydrogen production including 0.6 GW Equinor Autothermal reformer in 2026, as well as additional production capacity to allow for Hydrogen demand from transport and buildings. In total, 6.5 GW of Hydrogen production is deployed by 2030
- Gas-CCS at Immingham VPI (post-combustion retrofit) of 1.0 GW, with total gas-CCS capacity of 1.8 GW in the cluster by 2030
- Hydrogen use in industrial processes from the Equinor ATR unit
- One 100% decarbonised gas turbine at Keadby 3, coming online by 2030
- 6 $MtCO_{2\text{-}e}$ per annum of industrial CCS in the Humber

Figure 2 Deployment pathway for Zero Carbon Humber




Source: Vivid Economics

Humber and Teesside industrial clusters

**The Humber and Teesside industrial clusters are well positioned to accelerate the deployment of CCS and hydrogen infrastructure**. The proximity of the two clusters provides opportunities to share CCS infrastructure and we therefore analyse a context where both clusters are deployed in parallel.

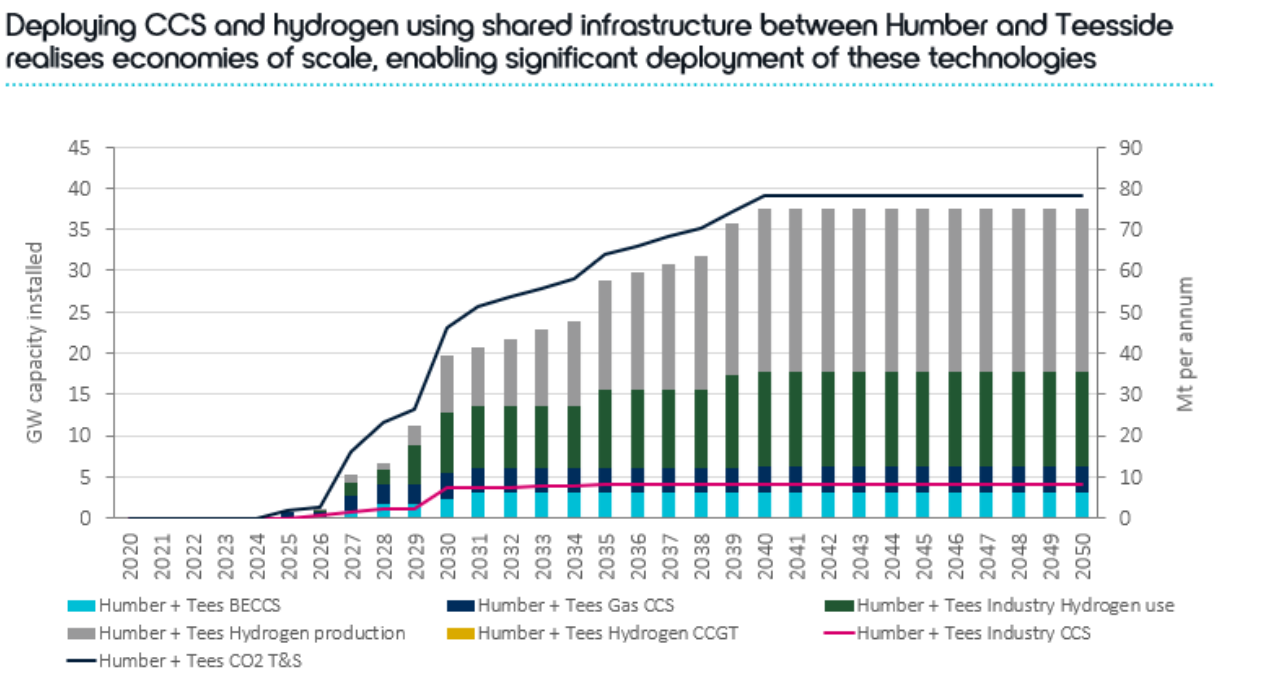
Figure 3 shows the deployment pathway for the combination of the Humber and Teesside industrial clusters combined. **The combination of Humber and Teesside enables significant deployment of CCS and hydrogen technologies, substantially accelerating the rollout of other CCS clusters.**

In addition to the Humber industrial cluster, the Teesside industrial cluster comprises[6]:

- 0.4 GW of BECCS in 2030
- 2.1 GW of gas-CCS in 2030
- 0.3 GW of Hydrogen production in 2030
- 0.5 GW of industrial Hydrogen consumption in 2030
- 1.4 $MtCO_{2\text{-}e}$ per annum of industrial CCS in 2030
- 10 $MtCO_{2\text{-}e}$ per annum of CCS transmission and distribution capacity in 2030

[6] The deployment levels are constant to 2050

Figure 3 Deployment pathway for Zero Carbon Humber and Net Zero Teesside



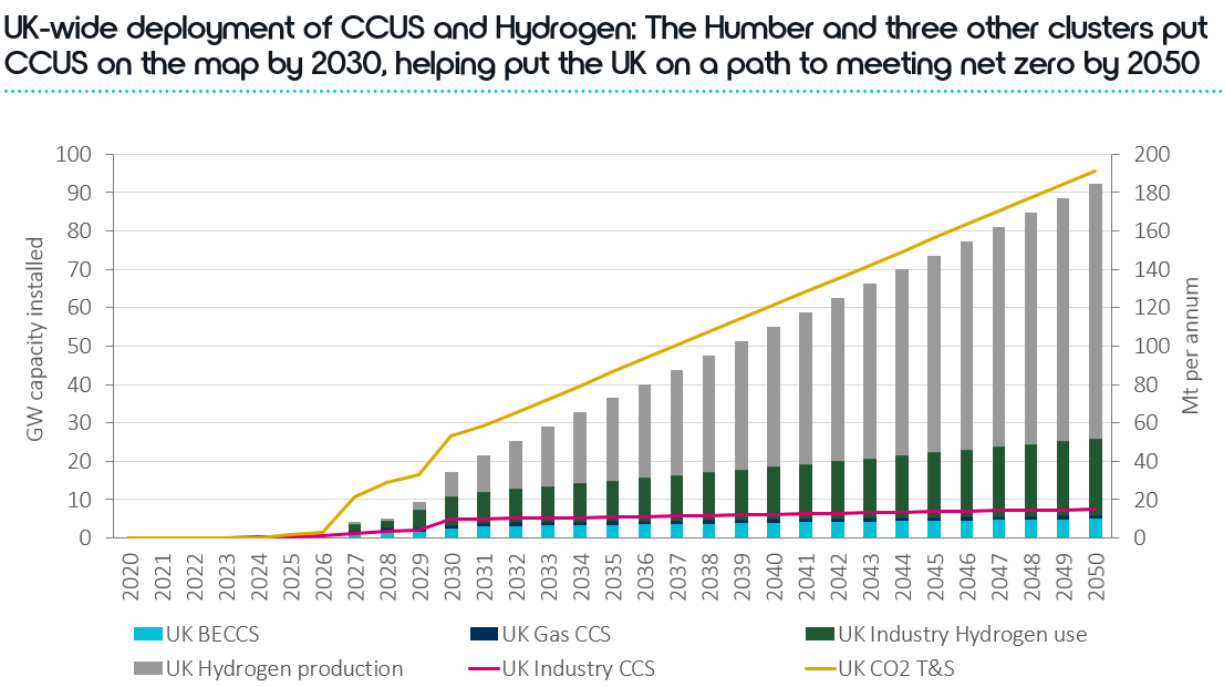

Source: Vivid Economics

**Taken together with two further clusters, the Scottish Acorn and North West HyNET clusters, 53.1 Mt $CO_2$ per annum can be captured and stored in the UK by 2031**[7]. Figure 4 shows the deployment pathway at the UK level, comprising:

- The sum of the four Drax BECCS units and the Teesside BECCS units, totalling 2.4 GW in 2030
- Gas-fired CCS deployment comprising retrofits at Humber and Teesside, totalling 3.1 GW in 2030
- 0.8 GW of new-build gas-fired CCS at Humber (Keadby 3)
- The sum of industrial Hydrogen consumption from Humber and Teesside, totalling 7.4 GW in 2030
- Hydrogen production totalling 6.8 GW in 2030
- Industrial CCS from the Humber industrial cluster and Net Zero Teesside totalling 7.3 Mt $CO_{2\text{-}e}$ per annum in 2030
- Industrial CCS from the Acorn and HyNET clusters totalling 2.3 Mt $CO_{2\text{-}e}$ per annum in 2030
- CCUS transmission and distribution from the Humber industrial cluster and Net Zero Teesside totalling 46.1 Mt $CO_{2\text{-}e}$ per annum in 2030
- CCS transmission and distribution from the Acorn and HyNET clusters totalling 7 Mt $CO_{2\text{-}e}$ per annum in 2030
- Additional gas-CCS retrofits, hydrogen production and industrial hydrogen consumption to achieve net zero between 2030 and 2050, consistent with the CCC'S net zero report. [8]

[7] Although we model the South Wales Industrial Cluster (SWIC), this does not come online until 2032, so it is not included in the discussion of UK CCUS cluster capacity to 2030.
[8] Beyond 2030, we extrapolate linearly to the CCC's Net Zero Further Ambition scenario

Figure 4 Deployment pathway at the UK level




Source: Vivid Economics

**Box 1 Acorn cluster**

- Acorn is a cluster located in Scotland, currently being championed by the Scottish Government, pale blue dot, Shell, Chrysaor and Total. It encompasses 9.5 $MtCO_2$-e per annum of process emissions across fossil and biomass thermal power, manufacturing and petroleum processing (NECCUS, 2019).
- Using a combination of UK Government (CCUS Innovation Programme), European Union and Industry match funding, Acorn CCS is currently progressing the detailed engineering for this first phase of the project in the hope of reaching a final investment decision in late 2021.
- For the purpose of this report, we have modelled the project as comprising 0.34$MtCO_2$-e per annum CCS at Shell's St Fergus gas plant, becoming operational in 2024 in Phase 1 and infrastructure capable[9]

**Box 2 HyNET North West cluster**

- HyNET is a cluster located in North West England, currently being championed by Cadent and the Northwest Business Leadership Team. It seeks to capture 2 $MtCO_2$-e per annum of process emissions across industrial processes and petroleum refining (Progressive Energy, 2019).
- A consortium comprising Progressive Energy, Essar, Johnson Matthey and SNC Lavalin has been awarded £7.5M of government funding to undertake a 'FEED' study in relation to a hydrogen production plant, whilst £5.3M of government funding has been awarded to another consortium to undertake detailed design and practical demonstration of conversion of three sites from natural gas to hydrogen.

[9] Taken directly from Acorn's base case investor presentation

- For the purpose of this report, we have modelled the project as comprising 2 $MtCO_2$-e per annum of industrial CCS and 2 $MtCO_2$-e per annum of CCS transmission and distribution, based on the HyNET base case.

Box 3 **Net Zero Teesside**

- Net Zero Teesside (NZT) is a cluster in the North East of England, currently being championed by the Tees Valley Combined Authority and five Oil and Gas Climate Initiative members. It seeks to capture 10 $MtCO_2$-e per annum of emissions from the power and industrial sectors in the Tees Valley (Vivid Economics, 2020).
- NZT has received funding from UK Research and Investments for the first phases of the Deployment and Roadmap programme for decarbonisation strategies.
- For the purpose of this report, we have modelled the project exactly as in the report 'Economic benefits of Net Zero Teesside'.

Box 4 **South Wales Industrial Cluster (SWIC)**

- The South Wales Industrial Cluster (SWIC) is focused on the potential to create collaborative projects in areas with a significant portion of the economic activity in South Wales, including RWE's Pembroke Power station in Milford Haven, the Valero Energy Refinery, Tata Steel's integrated steelworks at Port Talbot with and Tarmac's Cement Works in Aberthaw (RWE, 2020).
- The project has received a significant boost with the allocation of grant funding for South Wales from UK Research and Innovation. The funding will support the first phase of the South Wales Industrial Cluster (SWIC) Roadmap and Deployment projects which will seek to identify the best options for cost-effective decarbonisation of industry in South Wales.
- For the purpose of this report, we have modelled the project as comprising 2.3 Mt $CO_2$ from the Tata steel works in 2032, 0.3 Mt $CO_2$ from the Tarmac cement plant in 2033, 4.6 Mt $CO_2$ from the Valero refinery in 2034 and 4.9 Mt $CO_2$ from the Pembroke power plant in 2035.

## 3.2 UK content

**Deploying CCS and hydrogen technologies in the Humber will result in a high proportion of UK domestic content in the process plants and equipment which will be deployed**. We assume that UK companies capture the same level of local content as today, as shown in Table 1 below.[10] Obtaining the same market share as similar goods and services today relies on the UK moving first by deploying CCS clusters by 2030 and UK firms leveraging expertise in existing strengths such as oil and gas, chemicals and engineering.

[10] Content for CCUS comes from COMTRADE statistics, whilst content for SMR equipment, MMV and M&R equipment, EPCm and installation and O&M is based on a stakeholder workshop conducted for the BEIS EINA projects (Vivid Economics, 2019b)

Table 1 UK content by market

| Component | UK market share | Based on similar goods such as: | Source |
|---|---|---|---|
| $CO_2$ capture and pollution control | 58% | Machinery for filtering or purifying gases | COMTRADE |
| Conversion and generation | 0% | Assumption | EINA (2019) |
| $CO_2$ transport (pipe system) | 27% | Line pipe, of a kind used for oil or gas pipelines | COMTRADE |
| $CO_2$ storage | 21% | Pumps, compressors, drilling or production platforms | COMTRADE |
| SMR equipment | 33% | Chemical reactors, CCS | EINA (2019) |
| MMV and M&R | 44% | Same as domestic + surveying equipment | COMTRADE |
| EPCm | 77% | OFS | EY (2017), EINA (2019) |
| Installation and O&M | 95% | Tradability assumption | EINA (2019) |

Notes: UK market share represents how much of the market for that particular good or service (such as EPCm) can be captured by UK-based companies. The values are less than 100% for almost all categories of goods and services, because UK companies compete for market share in the UK market with foreign companies from the EU-27 and the rest of the world.

Source: Vivid Economics

# 4 Direct Impact

**The direct economic benefits of the project are large and sustained:**

- **At Drax Power Station, deployment of BECCS units in 2027-2028 and 2030-2031 could support 4,100 direct jobs and £370m in direct GVA annually on average during the construction phase between 2024 and 2031, with a peak of 7,700 direct jobs in 2028.**
- Deploying CCS and hydrogen technologies in the Humber could support 16,000 direct jobs and £1.2bn in direct GVA annually on average during the construction phase from 2024 to 2031, with a peak of 25,200 direct jobs and £1.8bn in direct GVA in 2027.
- The Humber and Teesside industrial clusters combined could support 19,000 direct jobs and £1.5bn in direct GVA annually on average during the construction phase between 2024 and 2031, with a peak of 30,200 direct jobs and £2.2bn in direct GVA in 2027.
- The Humber and wider UK deployment of BECCS, CCS and Hydrogen technologies could support 33,000 direct jobs and £2.5bn in direct GVA in 2030.

## 4.1 Direct economic impact

**The ability of UK providers of capital equipment and design, engineering, construction and project management services to capture a high proportion of the economic value of CCS and hydrogen deployment in the Humber, is key to realising the direct economic impacts of the project.** The UK is currently a leader in a number of products and services relevant to the CCS industry, including the manufacture of pollution control equipment, machinery for filtering and purifying gases, pipes, chemical reactors and engineering, procurement, construction and project management services. By multiplying the market share of these goods and services, which will be captured by UK firms, with the capex expenditure required to bring this project online (including capex and opex cost declines as Nth of a Kind units are installed and commissioned), we arrive at plausible values for direct jobs and gross value added.

**Direct employment benefits estimate the number of jobs supported by capital expenditure.** Jobs estimates are the number of full-time equivalents supported directly through expenditure on BECCS, gas-CCS, hydrogen and CCS infrastructure. These are direct jobs 'supported', not jobs 'created', since the workers directly supported by CCS expenditure may be attracted to or displaced from other sectors due to changes in energy consumption and investment.

**Ground truth:** How CCUS could help transition the region to net zero

Interview with Bill Adams, TUC Regional Secretary for Yorkshire and the Humber region, October 2020

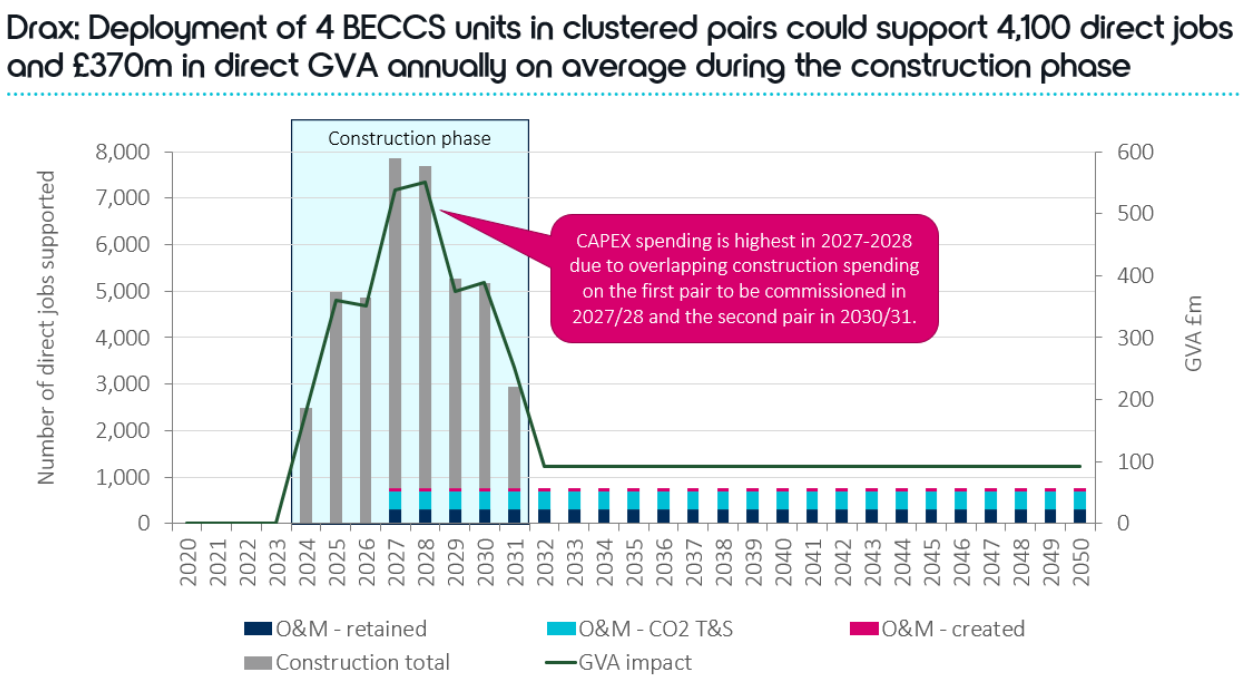
- Bill says that **CCUS is helpful not just for Drax, but in decarbonising cement and steel works on both sides of the river also**. He says that since up to 30 years might be needed to get to net zero, investors may be nervous to invest in a 10-year project without certainty for the next 30 years. The TUC is willing to work with local unions to support this transition, who themselves want to work with government. What local companies want, Bill suggests, is to negotiate a realistic transition such that instead of stranded assets, the region has 'future-ready' assets.

- **CCUS and the broader net zero transition can help play a wider role in achieving the goal of a quality retirement** for those who – like the previous generation of miners – now risk being left out of the transition because they're at a later stage of their career and may choose to not retrain. For apprentices – such as the 250/year who attend Sheffield Advanced Manufacturing Research Centre – training at companies like Drax and Equinor will be absolutely essential, Bill suggests. He points out that it is all about **establishing a social partnership between unions, businesses and government to hit net zero**, since there are for example, lots of 'bright young kids who just want to have good jobs and normal lives – companies should give them a chance'.
- On the role which government can play, Bill believes low-to-negative interest rates mean that now is the time to invest to minimise stranded asset risk. In particular, he believes that the export potential of the technology is large, and the UK could play a leading role in helping the likes of India and China decarbonise. **The UK Government's promises to invest in the North can be combined with the hunger for yield at pension funds to invest in CCUS now**.
- The TUC sees great potential when it looks at its friends in Germany. What's happening here with the transition away from coal? He paints a wonderful picture, providing the example of Eastern German coal mine (Kochbuss) – turning the coal pit into a man-made lake, creating high-tech industrial jobs in the region, changing the curriculum. He contrasts that with a potentially dystopian vision for the Humber unless CCUS and Hydrogen help to transition away from fossil fuels. He concludes the interview by powerfully making the case that **CCUS is about creating 'breathing space' so the region does not go through a decline.**

We now set out the impacts at 4 different levels: Drax (facility), Humber (cluster), East Coast (Humber and Tees) and UK.

**At the Drax level, 4,100 direct jobs could be supported and £370m in direct GVA created annually, on average, during the construction phase from 2024 to 2031.** Construction work such as laying foundations and preparing the site will create jobs from as early as 2024. Once the first two units receive FID, O&M jobs are assumed to be secured for all four biomass units since these jobs can be redeployed from within the existing Drax plant and also between the BECCS units. Beyond 2031, operations and maintenance (O&M) jobs provide a steady source of employment at the Drax facilities, enabling up to 800 staff to keep the BECCS units running smoothly in a combination of retained and new jobs. **At its peak in 2028 over 7,500 direct jobs could be supported and £550m in direct GVA created annually.**

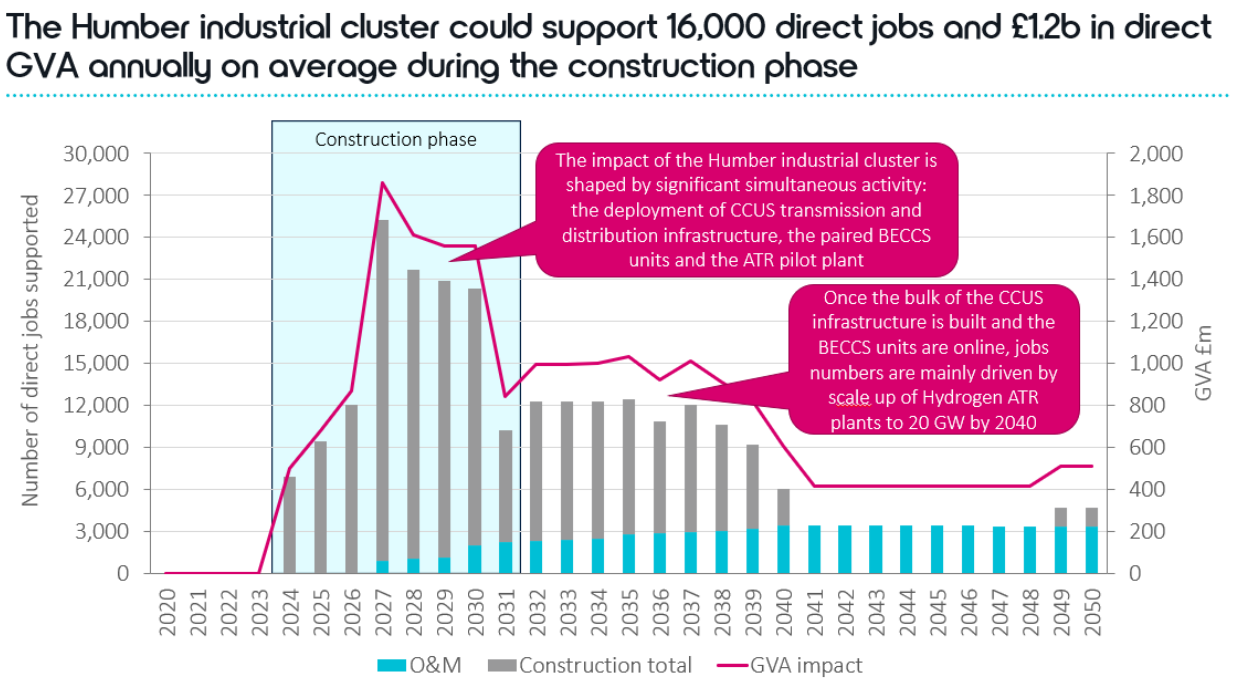
Figure 5 Direct economic benefits at the Drax level




Notes: The scope of this assessment includes 4 BECCS units and associated $CO_2$ T&S infrastructure
Source: Vivid Economics

**At the Humber level, CCS and hydrogen projects support around 16,000 direct jobs and £1.2bn in GVA annually, on average, during the construction phase from 2024 to 2031.** From 2024 to 2027, deployment of CCS transmission and distribution infrastructure to facilitate BECCS, the first in the clustered pair of Drax BECCS units – which come online in 2027 - and a 0.6 GW Hydrogen production pilot plant – which comes online in 2026 - causes **direct construction jobs to peak at 25,200 and direct GVA to peak at £1.8bn in 2027**. From 2027 to 2030, CCS infrastructure continues to be deployed, but activity is driven by the coming online of the remaining Drax BECCS units as well as scale up of hydrogen production to 6.5 GW in 2030. Once online, up to 3,100 direct jobs can be supported annually on average in the operations and maintenance of these plants between 2032 and 2050, including a few hundred from the late 2040s as repowering takes place.

Figure 6 Direct economic benefits of ZCH at the Humber level



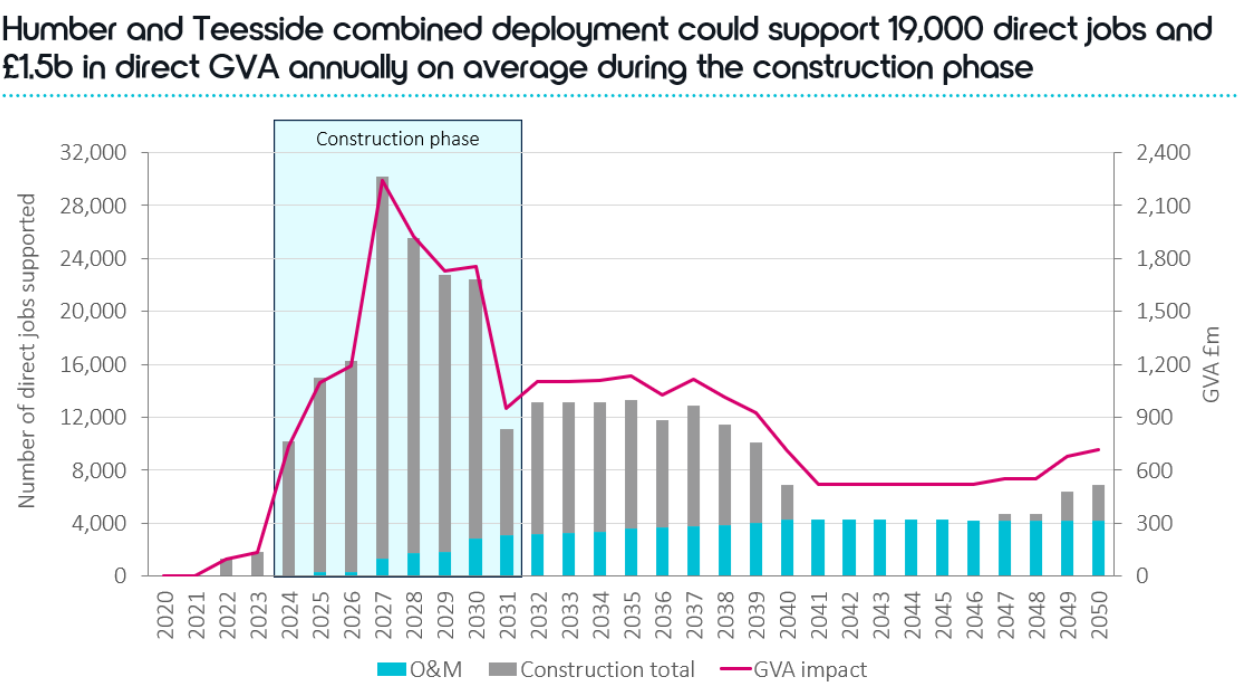

Notes: The scope of this assessment includes BECCS, gas CCGT with CCS, industrial CCS, industrial appliance conversion for hydrogen use, H2 CCGT, hydrogen production units, and required $CO_2$ T&S infrastructure.

Source: Vivid Economics

**At the 'East Coast Cluster' (Humber and Teesside) level, 19,000 direct jobs could be supported and £1.5 billion in direct GVA created annually, on average, during the construction phase from 2024 to 2031**. In particular, the combination of the first pair of Drax BECCS units and the Teesside BECCS unit, as well as CCS infrastructure and the Equinor ATR pilot plant, lead to a **peak in direct construction jobs of 30,000 and direct GVA of £2.2 billion in 2027**. Once both clusters are up and running, up to 4,000 operations and maintenance (O&M) jobs are supported annually between 2032 and 2050, along with almost £800 million in direct GVA during the same period.[11]

[11] Drax's BECCS units are assumed to not undergo repowering in the late 2040s, unlike facilities at Teesside.

Figure 7 Direct economic benefits of ZCH at the Humber and Teesside level




Notes: The scope of this assessment includes BECCS, gas CCGT with CCS, industrial CCS, industrial appliance conversion for hydrogen use, H2 CCGT, hydrogen production units, and required $CO_2$ T&S infrastructure

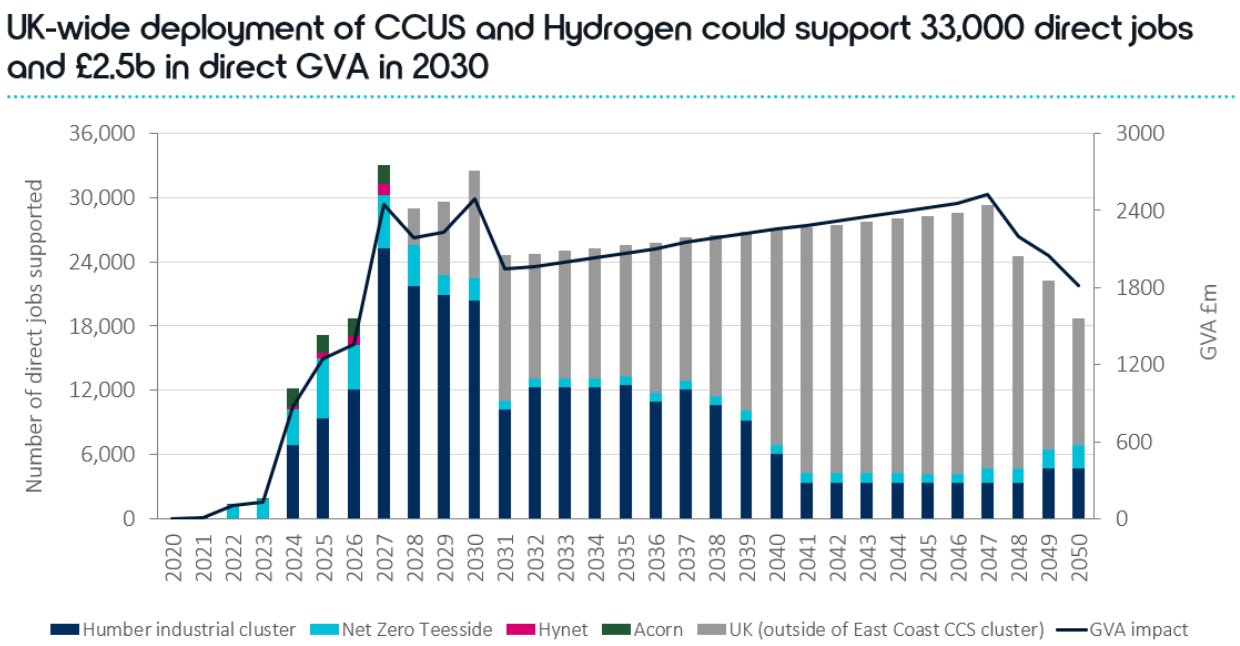
Source: Vivid Economics

**At the UK level, the combination of Humber, Teesside, Acorn and HyNET clusters support up to 33,000 direct jobs and £2.5 billion in direct GVA, annually in 2030.** We assume that additional CCS capacity is deployed elsewhere in the UK, to linearly hit the CCC's Net Zero Further Ambition scenario by 2050 via 5GW of BECCS, 3.9GW of gas-CCS (retrofit and new build), 66GW of Hydrogen production capacity and 15 Mt $CO_{2\text{-}e}$ per annum worth of industrial CCS, resulting in an overall 190 Mt $CO_{2\text{-}e}$ per annum of $CO_2$ captured and sequestered. We assume this additional capacity results from scaling up of the Humber, Teesside, Acorn, HyNET and South West Industrial Cluster (SWIC) clusters[12], as well as potential additional clusters.

As this additional capacity comes online, direct construction jobs peak at 33,000 annually in 2027, whilst direct GVA peaks at £2.5 billion in the late 2040s. Beyond 2047, the tailing off of additional construction as the capacity required for the UK to hit net zero is fully online, means that capex spending and therefore direct GVA and jobs, also start tailing off.

[12] The SWIC cluster comes online in 2032 and is represented in the UK total – see Box 4.

Figure 8 Direct economic benefits of UK-wide deployment of CCUS and Hydrogen




Notes: 1) The scope of this assessment includes BECCS, gas CCGT with CCS, industrial CCS, industrial appliance conversion for hydrogen use, hydrogen production and required $CO_2$ T&S infrastructure. Excludes capex and opex for power, transport and residential Hydrogen demand such as boiler retrofits in homes; 2) To 2030, CCUS deployment is at Net Zero Teesside, Zero Carbon Humber, Hynet and Acorn. The South Wales Industrial Cluster (SWIC) comes online in 2032 and is represented in the UK total. 3) Scenario assumes no new capacity after 2050, hence lower CAPEX in late 2040s.

Source: Vivid Economics

**Ground truth:** Export opportunities for CCUS and net zero

Interview with Pauline Wade, Director of international trade at the Hull and Humber Chamber of Commerce Hull Chamber of Commerce, October 2020.

- Pauline says **that the Port of Hull is a key driver of investment in the local economy**. Energy, chemicals, materials – everything is dependent on the port and as the UK accelerates deployment of renewables to meet net zero, the port will become more important than ever.
- She suggests – from her experience leading over 60 UKTI sponsored Trade Missions and exhibitions - that **investment in the region can be improved through better East-West connectivity** (primarily road and rail improvements) and better connectivity with Europe. Government has a role to play here.
- Hull has a proud history of being a place where a range of nationalities from Europe and beyond have settled because of the high quality of life, she says. The Siemens factory in Hull has been a really positive boon for the local economy and investment in a big R&D hub by Reckitt Benckiser has shown that **the region is able to bring in the best and brightest scientists and engineers.**
- The Hull Chamber of Commerce believes that knowledge and expertise in the region will grow with net zero. **Exporting the region's scientific and technical skills, machinery, equipment and services to Europe and the rest of the world presents an excellent opportunity to become a global leader in delivering net zero**.

# 5 Wider economic benefits

**Project spending on CCS and hydrogen deployment in the Humber will flow through the local and national economy, generating wider-economy benefits.** This includes indirect economic growth and employment from business-to-business spending and induced economic growth and employment from household-to-business spending.

- At the Drax level, BECCS could support 2,500 indirect and 3,900 induced jobs, as well as £170 million in indirect and £210 million in induced GVA, annually, on average, during the construction phase between 2024 and 2031.
- **At its peak, the Drax BECCS plants could support a total of 16,800 direct, indirect and induced jobs and £1.1 billion in direct, indirect and induced GVA.**
- At the Humber level, CCS and hydrogen deployment could support 7,100 indirect and 10,900 induced jobs, as well as £450 million in indirect and £580 million in induced GVA, annually, on average, during the construction phase between 2024 and 2031.
- **At its peak, the Humber industrial cluster could support a total of 49,700 direct, indirect and induced jobs, as well as £3.3 billion in direct, indirect and induced GVA.**
- The Humber and wider UK deployment of BECCS, CCUS and Hydrogen could support 54,000 indirect and 52,000 induced jobs, as well as £2.3 billion in indirect and £4.6 billion in induced GVA annually, on average during the construction phase from 2024 to 2031.
- **At its peak, the Humber and wider UK deployment could support over 205,000 direct, indirect and induced jobs and almost £15 billion in direct, indirect and induced GVA.**

**CCS and hydrogen deployment in the Humber offers wider economic benefits, including indirect spending in the supply chain and induced spending in the wider economy.** Once construction of the units is finished, wider economic benefits continue to flow through the economy. This includes spending in the wider supply chain, as equipment manufacturing causes suppliers to purchase goods and services from local manufacturers, as well as spending in the wider economy as workers purchase goods and services from local shops and businesses such as food and drink, leisure, healthcare and education. Indirect and induced economic benefits are estimating using Vivid's Investment Impact Model (IIM).

**Vivid's Impact Investment Model**

Vivid's input–output IIM is best-suited to assess the impact of the ZCH project on the regional and national economy. An input–output model captures interactions and feedback loops between all sectors in an economy and allows for the calculation of the indirect and induced impacts (in terms of GVA and jobs) alongside the direct impact.

The IIM is tried and tested in this task, having been successfully used to inform strategy for the Net Zero Teesside project (Vivid Economics, 2020). It has also been used successfully for Tees Valley Combined Authority (TVCA), informing its short- and long-term policy development strategies and selection of appropriate investments. It was essential that TVCA had a robust understanding of the scale of impact (and potential for displacement) of the proposed Freeport on the STDC site to ensure that the incentive

package offered was not overly generous, and thereby safeguarding a net return to the region. The model has been updated and fully calibrated to the UK and the North East.

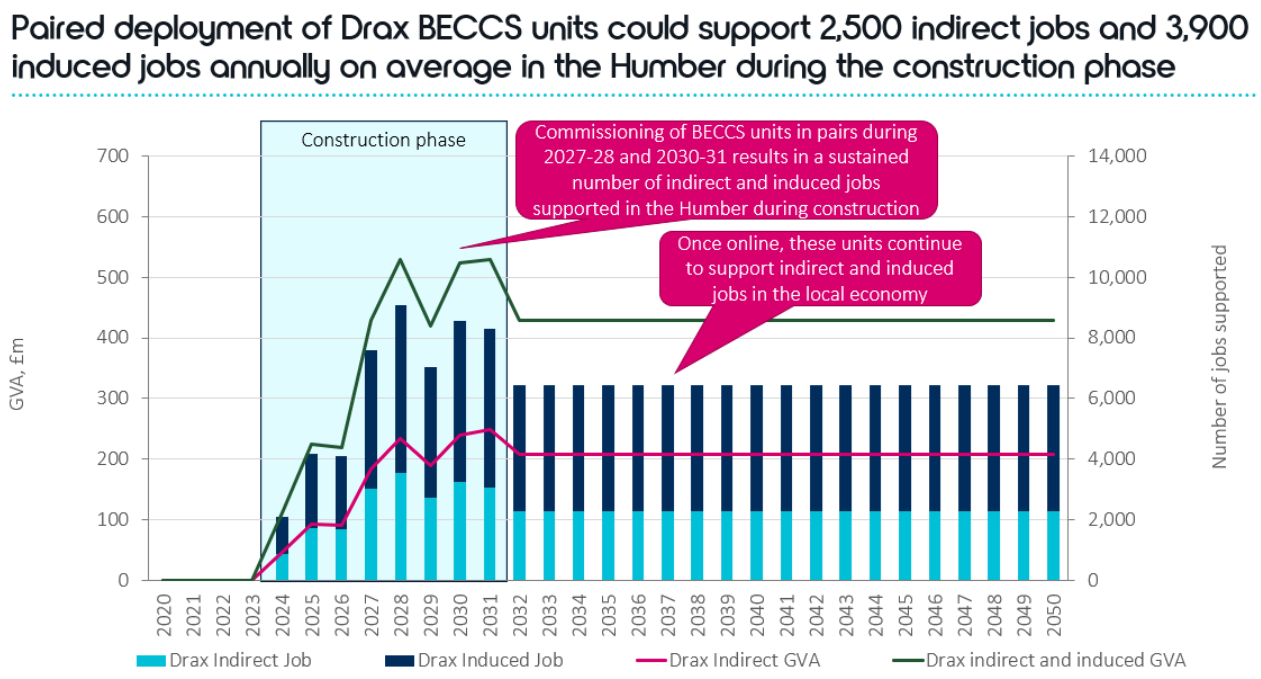
**At the Drax level, BECCS could support 2,500 indirect and 3,900 induced jobs, as well as £170 million in indirect and £210 million in induced GVA, annually, on average, during the construction phase between 2024 and 2031.** The coming online of the Drax BECCS units in pairs in 2027-2028 and 2030-2031 means that the wider spending in the supply chain and economy continues to circulate in the Humber throughout the construction period. These jobs are primarily driven by capital expenditure on BECCS and associated $CO_2$ transport and storage infrastructure. Indirect jobs are highest in the electricity, gas and air conditioning supply chain and manufacture of fabricated metal products (~1,200 jobs in 2030), whilst induced jobs concentrate in the retail and food and beverage sectors (~1,500 jobs in 2030 respectively).

**Once online, BECCS at Drax could support a further 2,300 indirect and 4,100 induced jobs, as well as £210 million in indirect and £220 million in induced GVA, annually, on average during the full operational phase from 2032 to 2050.** The ~800 direct O&M jobs at the Drax level between 2032-2050 mean that the Drax BECCS units provide indirect and induced economic benefits throughout the Humber as the units continue to support the decarbonisation of thermal power generation in the region. Indirect jobs are highest in the electricity, gas and air conditioning supply chain (~1,000 jobs in 2050), whilst the retail and food and beverage sectors continue to see the highest number of induced jobs (~1,200 jobs in 2050). Figure 9 shows the indirect and induced impact of Drax deployment in the Humber during both the construction phase and the operational phase.

**At its peak, the Drax BECCS plants could support a total of 16,800 direct, indirect and induced jobs and £1.1 billion in direct, indirect and induced GVA.** The jobs could comprise of 7,770 direct jobs (46% of total), 3,550 indirect jobs (21% of total) and 5,500 induced jobs (33% of total). The GVA could comprise of £550 million in direct GVA (51% of total), £234 million in indirect GVA (22% of total) and £295 million of induced GVA (27% of total).[13]

[13] Components may not sum exactly to total due to rounding.

Figure 9 Indirect and induced impact of Drax deployment in the Humber




Source: Vivid Economics

**At the Humber level, CCS and hydrogen deployment could support 7,100 indirect and 10,900 induced jobs, as well as £450 million in indirect and £580 million in induced GVA, annually, on average, during the construction phase between 2024 and 2031.** The coming online of all 2.6 GW of Drax BECCS units and the scale up of Hydrogen production in the Humber to 6.5 GW by 2030 means that the wider economic benefits continue to increase to 2030. A total of 24,400 indirect and induced jobs are supported in the year of peak direct jobs (2027). An average of £1.0 billion annually in indirect and induced GVA results between 2024 and 2031. Indirect jobs are highest in the electricity, gas and air conditioning supply chain and manufacture of fabricated metal products (~3,700 jobs in 2030), whilst induced jobs are concentrated on the High Street, in the retail and food and beverage sectors (~5,000 in 2030).

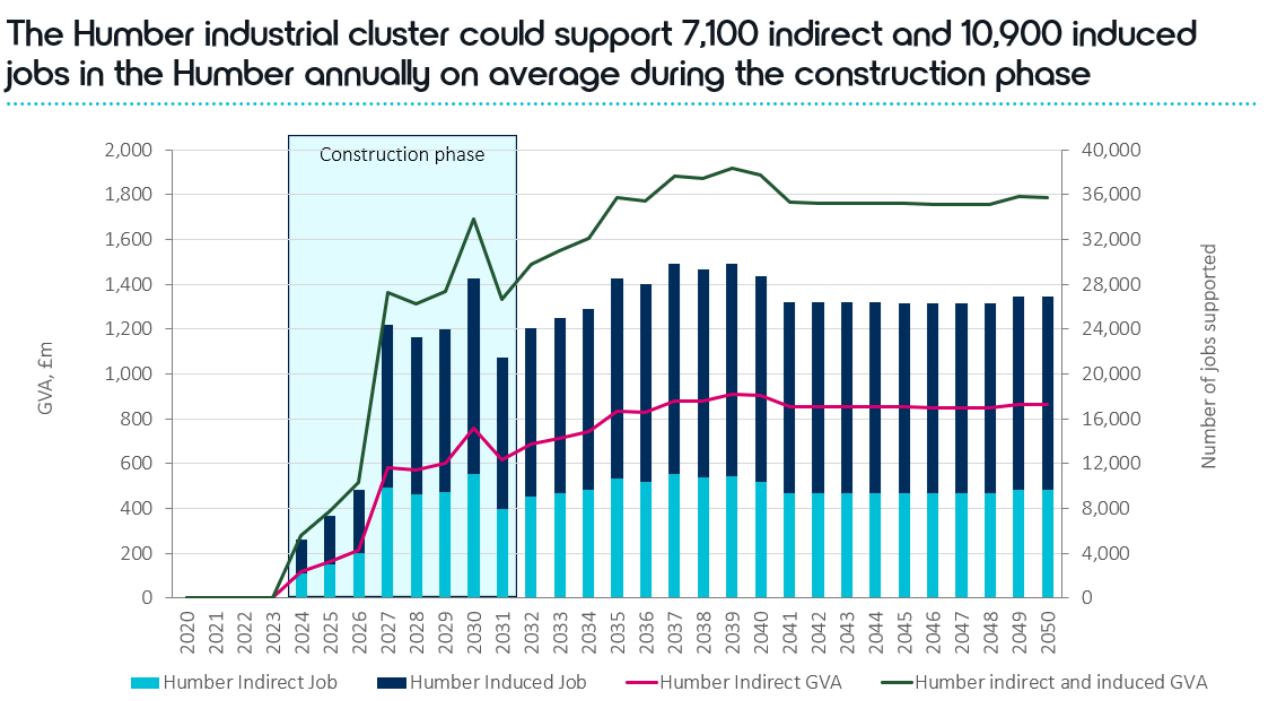
**Once online, CCS and hydrogen projects in the Humber could support a further 9,800 indirect and 17,200 induced jobs, as well as £840 million in indirect and £920 million in induced GVA, annually, on average, at the Humber level, during the full operational phase from 2032 to 2050.[14]** Operations and maintenance for the CCS and hydrogen plants means a substantial expenditure in the supply chain. Indirect jobs continue to be highest in the electricity, gas and air conditioning supply chain (4,200 jobs in 2050), whilst the High Street continues to see booming trade from induced spending (~5,000 jobs in retail and food and beverage in 2050). Education sees over 1,400 jobs annually by 2050, as O&M staff send their children to school and college, helping prepare the next generation of entrants to the net zero labour force in future years.

**At its peak, the Humber industrial cluster could support a total of 49,700 direct, indirect and induced jobs, as well as £3.3 billion in direct, indirect and induced GVA.** The jobs could comprise of 25,200 direct jobs (51% of total), 9,900 indirect jobs (20% of total) and 14,600 induced jobs (29% of total). GVA could comprise of £1.9

[14] Operations and maintenance (O&M) will begin almost as soon as the units are commissioned during the construction phase. Those jobs will be supported gradually as the units come online, with concomitant indirect and induced spending. Here we refer to O&M jobs which are essentially permanent. We therefore call this the 'full operational phase' in order to differentiate it from the more gradual O&M jobs supported during the construction phase.

billion in direct GVA (58% of total), £580million in indirect GVA (18% of total) and £780 million in induced GVA (24% of total).[15]

Figure 10 Indirect and induced impact of ZCH deployment in the Humber



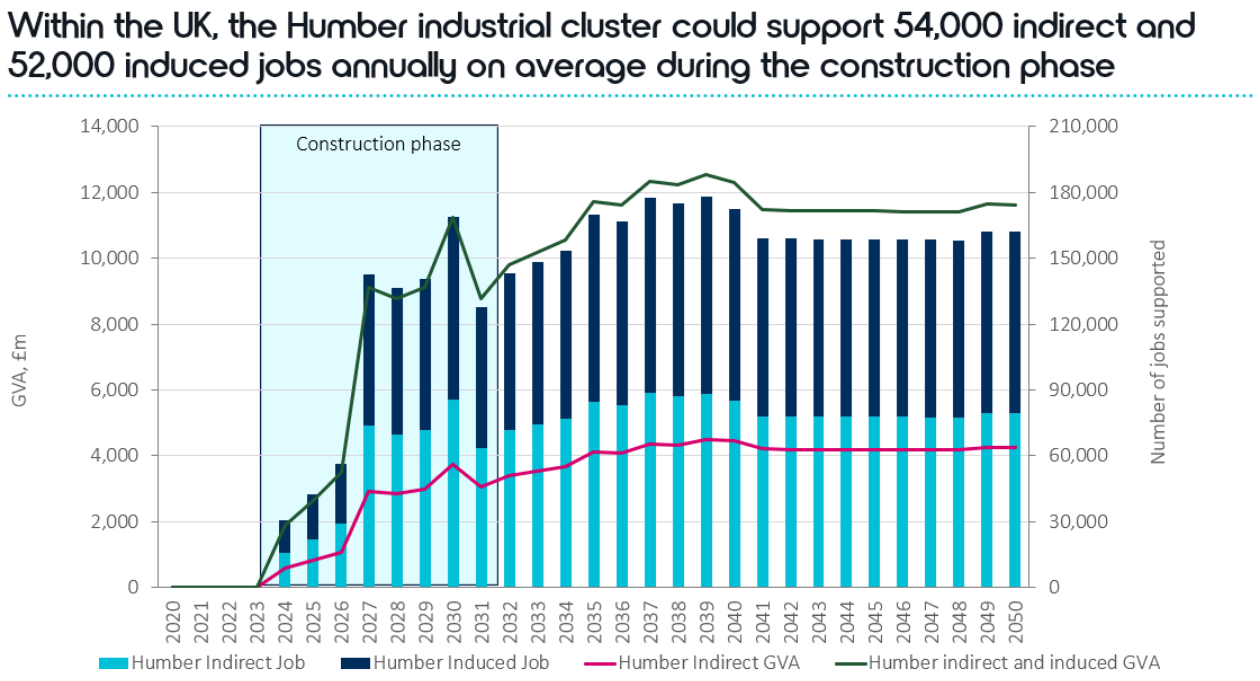

Source: Vivid Economics

**Within the UK, the deployment of CCS and hydrogen projects in the Humber could support 54,000 indirect and 52,000 induced jobs, as well as £2.3 billion in indirect and £4.6 billion in induced GVA annually, on average from 2024 to 2031.** Indirect supply chain spending is highest in the construction sector, supporting ~13,000 jobs in 2030. Induced spending is concentrated in food and beverage and retail (~ 59,000 in 2030). After CCS and hydrogen deployment reaches significant scale-up in 2031, its wider economic impact on the national economy would be driven by its operations and maintenance. This could support 80,000 indirect and 82,000 induced jobs within the UK, on average, from 2032 to 2050. Indirect jobs are concentrated in the electricity, gas and air conditioning supply chain (~25,000 indirect jobs in 2050), highlighting the wider role which CCS plays in ensuring a reliable energy network. Induced jobs are concentrated in food and beverage and retail sectors (~118,000 in 2050), as workers consume and shop on High Streets across the UK.

**At its peak, the Humber and wider UK deployment could support over 205,000 direct, indirect and induced jobs and almost £15 billion in direct, indirect and induced GVA.** Jobs could comprise of 26,800 direct jobs (13% of total), 88,300 indirect jobs (43% of total) and 89,900 induced jobs (44% of total). GVA could comprise of £2.2 billion in direct GVA (15% of total), £4.5 billion in indirect GVA (30% of total) and £8.1 billion in induced GVA (55% of total).[15]

[15] Components may not sum exactly to total due to rounding.

Figure 11 Indirect and induced impact of ZCH deployment




Source: Vivid Economics

# 6 Labour and skills availability

**Skills and investment gaps in the Humber manifest themselves in issues for younger and older workers – CCS and hydrogen deployment in the Humber could offer solutions.**

**Skills gap:**

- **The specialist skills gap in the Humber is accentuated by a lower proportion of school leavers achieving NVQ[16] stage 2 or beyond.** The skills gap is likely to get worse. According to the government's Working Futures model, by 2022, key manufacturing sectors – electricity and gas, engineering and construction - in Yorkshire and the Humber will require higher qualifications than currently available, potentially risking the decarbonisation of the region and the wider net zero target.
- **The COVID crisis has already led to a high proportion of furloughs in the region and there is the risk of longer-term economic scarring.** Although there are a number of proposed medium-to-long term solutions to ensuring the 'COVID generation' does not suffer long lasting damage to their economic prospects, enhanced apprenticeships offer a more immediate way to support the UK's economic recovery, inclusive growth and climate ambitions whilst also ensuring that the 'COVID generation' does not suffer long lasting damage.
- **To ensure a well skilled local labour force able to support the delivery of CCS and hydrogen projects in the Humber by the start of construction in 2024, interventions will need to be made now, including demonstrating the value of vocational work at school and offering enhanced apprenticeships.** The Humber industrial cluster is ideally placed to offer an enhanced model of apprenticeship. More broadly, the Humber offers the opportunity to create immediate, high quality jobs in the region, whilst contributing very meaningfully and immediately to the post-COVID recovery.
- **There are a number of ways in which Drax and other operators in the Humber can further support apprenticeships, in order to help alleviate the qualifications and skills gaps, whilst contributing to the post-COVID recovery:**
    - *Recruit and train the next generation of workers now*
    - *Introduce greater flexibility in the selection process for the Drax apprenticeship scheme*

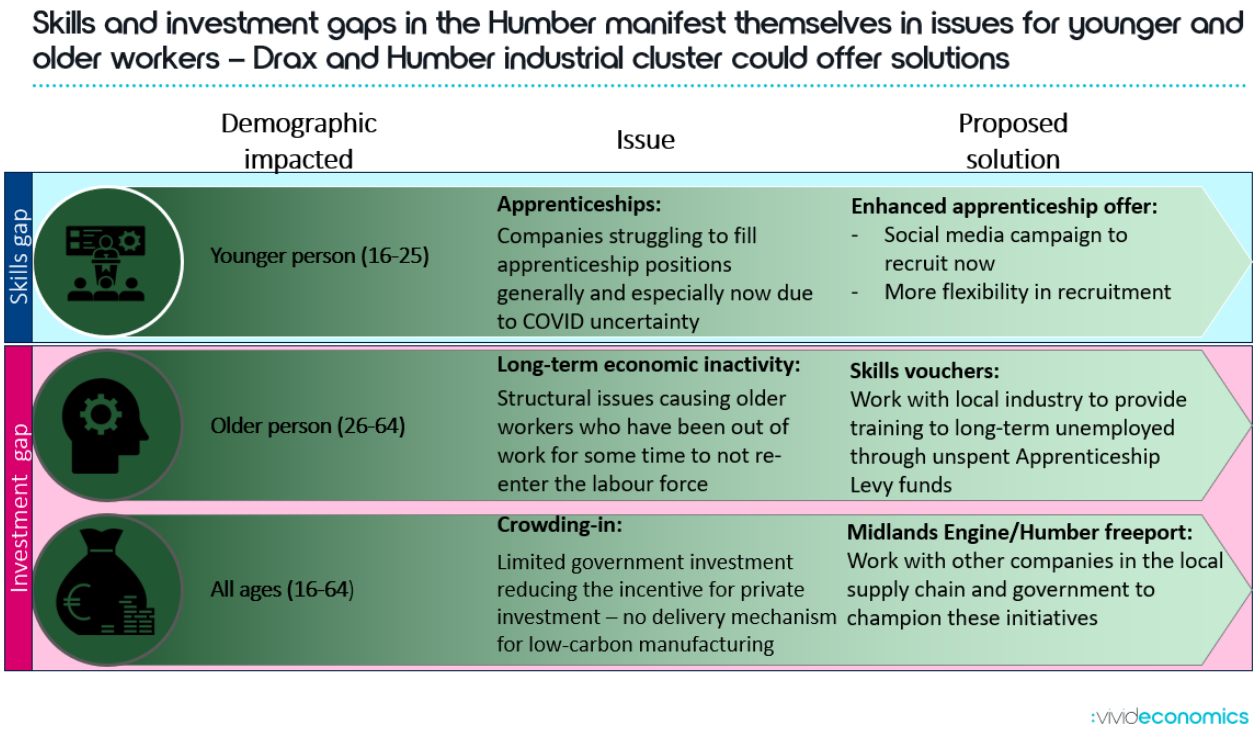
**Investment gap:**

- **The Humber receives amongst the lowest levels of government investment in R&D in the UK**, with business sector R&D investment of less than £1 billion in 2017 being almost five times lower than for the South East of England. **Lower government investment can lead to long-term economic inactivity and reduced potential for crowding-in investment from the private sector.**
- **'Skills vouchers' are a timely intervention to help address the long-term economic inactivity problem for older workers. To bring the skills voucher concept to life, Drax and other operators should consider teaming up with local industries to utilise unspent Apprenticeship Levy funding.**

[16] The National Vocational Qualification (NVQ) is a work-based qualification which recognises the skills and knowledge a person needs to do a job. The candidate needs to demonstrate and prove their competency in their chosen role or career path. Candidates need to demonstrate that they have the suitable skills, knowledge and understanding to carry out the tasks associated with their job role. NVQ's cover a wide range of subjects for almost every occupational area in every business sector.

**Skills and investment gaps in the Humber manifest themselves in issues for younger and older workers.** This chapter details these issues, discusses existing initiatives and makes recommendations for how Drax and Zero Carbon Humber could help address them. Figure 128 summarises the issues and proposed solutions detailed and discussed in this chapter.

Figure 12 Issues and proposed solutions detailed and discussed in this chapter




Source: Vivid Economics

## 6.1 Skills gap

**CCS and hydrogen projects offer the opportunity to create high quality jobs in the region.** The construction jobs created in the Humber are likely to be highly skilled including welders, pipe fitters, machine installers and technicians. Not only does this offer the chance to create *immediate jobs* given the shovel-ready nature of the project, but also jobs which are high quality, offering high wages and a chance to enhance the skills which workers will bring to the project. Furthermore, operational and maintenance jobs for the entire Drax BECCS plant will be supported as soon as a Final Investment Decision is made by Drax on the first of its four BECCS units. These jobs are likely to be permanent and offer high wages, as well as the chance to deploy skills more broadly within the Drax estate both in the UK and potentially at Drax's overseas operations.

**But there are specialist skills gaps in the Humber.** A report by the Humber Local Enterprise Partnership (LEP) indicated that 13% of businesses indicated a substantial skills gap in the workforce in 2019 (Humber LEP, 2019a). The highest number of vacancies are in specialist skills, particularly technical and practical skills. In the renewable energy and chemicals sectors, specific skills lacking include welding and electrical/instrumentation technicians.

**These specialist skills gaps are in the top one third of all English counties.** As shown in Figure 13 below, there were higher skilled trades occupations vacancies on average in the Humber than in England in 2017 (28% vs. 23%). A similar trend occurred in and in labour-intensive jobs (22% vs. 17% for England).

Figure 13 Skills shortage vacancies in the Humber compared to the Tees Valley and England

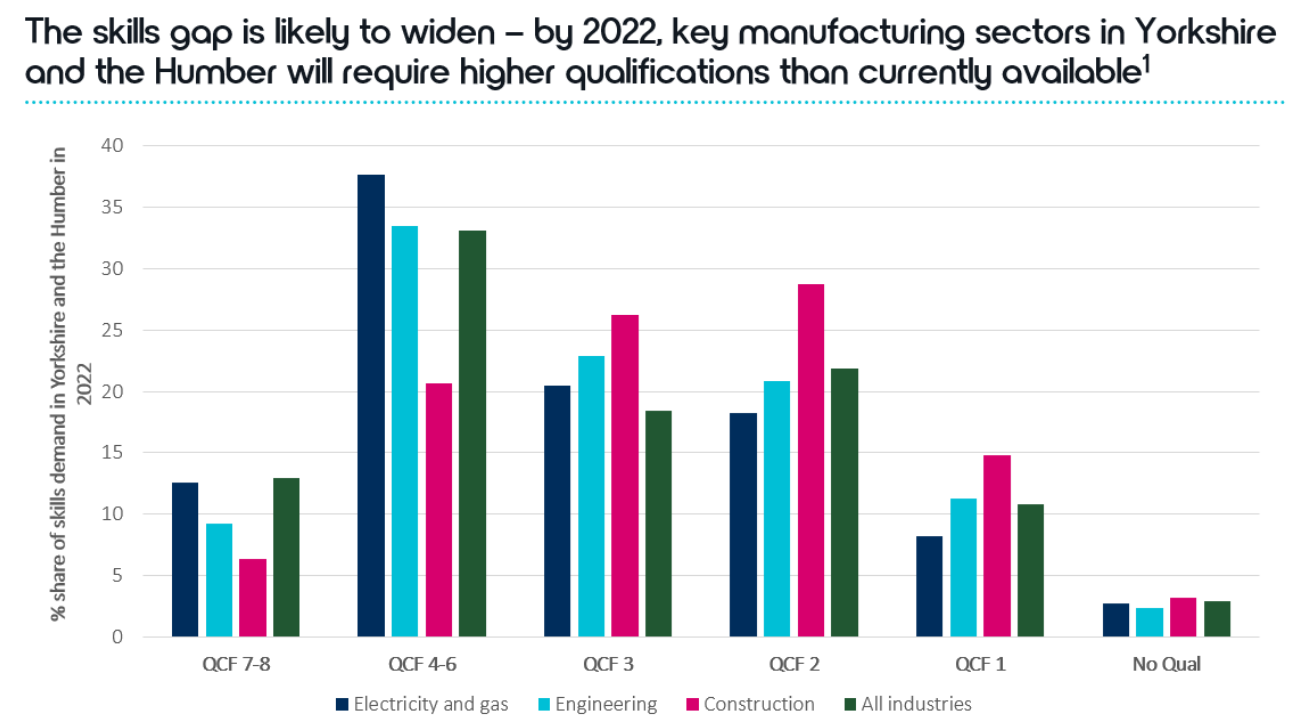
## Where are the skills shortages in the local economy?

| Type | England total | Humber | Tees Valley |
|---|---|---|---|
| Total number of skills-shortage vacancies in 2017 | 95,249 | 1,274 | 693 |
| MIDDLE-SKILL | 30% | 35% | 29% |
| HIGH-SKILL | 37% | 29% | 47% |
| LABOUR-INTENSIVE | 17% | 22% | 6% |
| SERVICE-INTENSIVE | 22% | 18% | 21% |
| Skilled trades occupations | 23% | 28% | 27% |
| Professionals | 17% | 15% | 32% |
| Associate professionals | 18% | 14% | 6% |
| Machine operatives | 7% | 14% | 6% |
| Caring, leisure and other services staff | 13% | 12% | 15% |
| Elementary staff | 10% | 8% | 1% |
| Administrative/clerical staff | 8% | 6% | 2% |
| Sales and customer services staff | 9% | 6% | 6% |
| Managers | 4% | 1% | 9% |

Source: Vivid Economics analysis based on Employer Skills Survey by DfE in 2017

**The skills gap is likely to get worse.** According to the government's Working Futures model, by 2022, key manufacturing sectors – electricity and gas, engineering and construction - in Yorkshire and the Humber will require higher qualifications than currently available (refer to Figure 20). This means that employers are likely to face even larger skills shortage vacancies in future years, particularly as the energy transition begins to accelerate by the mid-2020s. As the Humber is the largest industrial emissions cluster, such a widening skills gap could risk the potential to build CCS and hydrogen projects, risking the net zero target.

Figure 20 Percentage share of skills demand in the Yorkshire and Humber in 2022

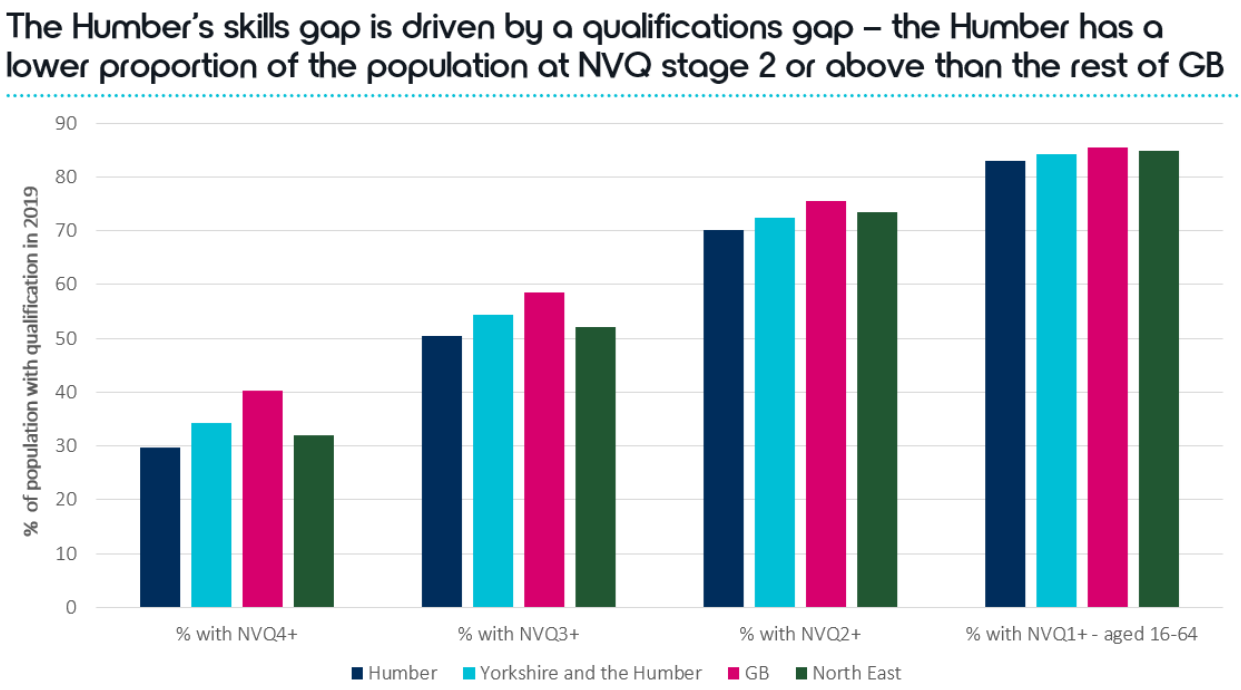



Notes: 1) The higher the QCF, the higher the qualification. QCF 3 translates to A-Levels, Level 6 translates to a Bachelors Degree and Level 8 to a PhD

Source: Vivid Economics based on Working Futures (2015)

**Part of the skills gap is driven by the Humber having a lower proportion of school leavers achieving NVQ stage 2 or beyond**. As shown in Figure 21 below, at almost all qualification levels beyond NVQ1, the Humber had a lower proportion of qualified people than in Great Britain as a whole. The gap is smallest at the NVQ1 stage, with the percentage of the population holding this qualification being at approximately the same level as North East England and the Great Britain more broadly. However, the gaps start to open up from there. At NVQ3, the gap is 3 percentage points with North East England and 5 percentage points with Great Britain as a whole, whilst by NVQ4, the gap has widened to a full 10 percentage points with GB. This indicates that interventions are potentially required to help alleviate the causes of the qualifications gap.

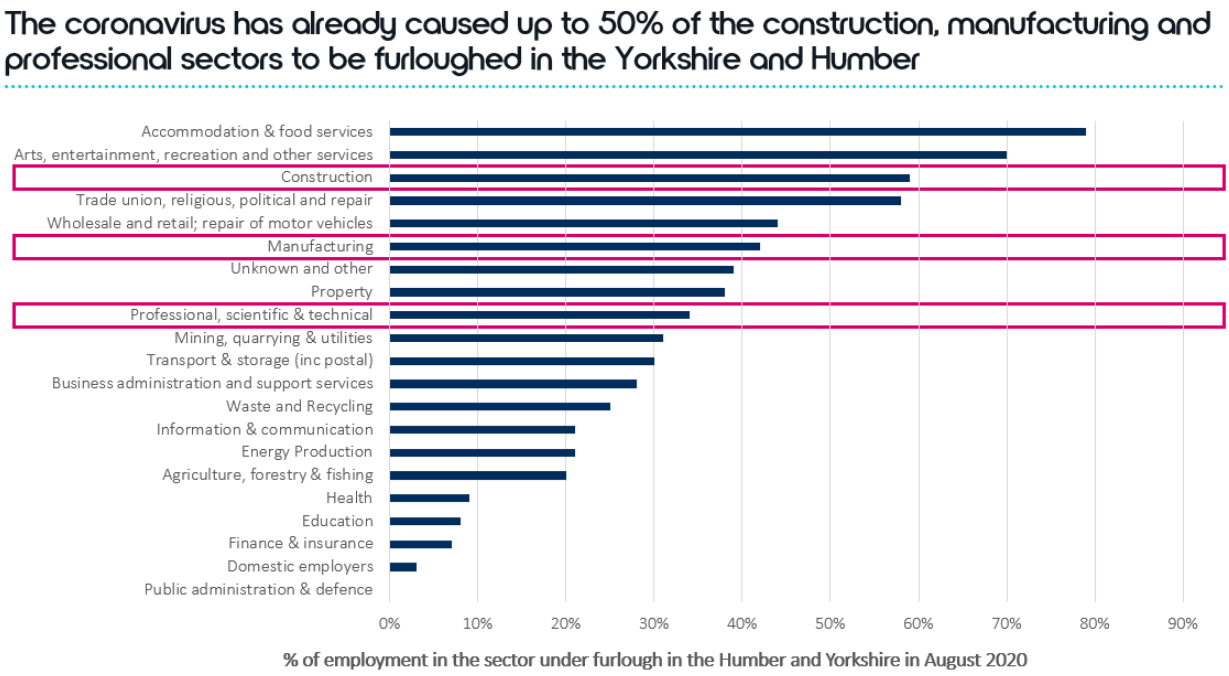
Figure 21 Distribution of qualifications in the Humber compared to the region and nationally




Source: Vivid Economics based on NOMIS, August 2020

**Additionally, the COVID crisis has impacted the Humber in a significant way.** It has already led to a high proportion of furloughs in the region. Data collected as part of the Official Statistics on the Coronavirus Job Retention Scheme shows that over 30% of firms had furloughed workers in the Yorkshire and Humber region in August 2020. Indeed, furloughs have been highest in the construction, manufacturing and professional services sectors, with up to 50% of staff being on the Coronavirus Job Retention Scheme, as shown in Figure 14 (HMRC, 2020).

Figure 14 Sectors hardest hit by the coronavirus in the Yorkshire and Humber region




Source: Vivid Economics based on HMRC CJRS statistics, August 2020

**Apprenticeships have been area of focus through which government has sought to help alleviate the skills gap.** With an acknowledged productivity puzzle (New Economics Foundation, 2019), the UK Government has sought to emulate the European approach of vocational qualifications. Since 2017, the UK Apprenticeship Levy has sought to raise funds to halt the long-term trend of employers underinvesting in training. Apprenticeships are particularly seen as a way to complement the University qualifications needed to build the high performing economy of the future.

**What is the UK Apprenticeship Levy?**

- The UK Government introduced the Apprenticeship Levy in 2017. It aims to fund 3 million apprenticeships in the UK by 2020 (CIPD, 2019)
- Since April 2017, all UK employers in the public and private sector with a pay bill of over £3 million have had to contribute to the apprenticeship levy (0.5% of their annual pay bill). These employers are then able to access a digital account from which they can access funding to pay for apprenticeship training and assessment. The government provides a 10% top up.
- Smaller employers, who do not pay the apprenticeship levy, share the cost of training and assessing their apprentices with the government (5%/95% split between the employer and the government).
- The current UK Apprenticeship Levy scheme has unresolved challenges. These include firstly **concerns regarding the quality of the apprenticeships** (the quality of training providers and the proliferation in apprenticeship provision standards, as well as the 'rebadging' of low-skilled jobs and professional development courses such as MBAs as 'apprenticeships'). Secondly, **concerns regarding the complexity of the levy** (increased bureaucracy, difficulty in accessing funds and challenges in identifying and selecting suitable training providers, as well as the inflexibility of the levy being used for other skills development) (Reform, 2018).

**But apprenticeships have been hit particularly hard by the COVID crisis.** Companies are furloughing or making staff redundant, off the job learning has been disrupted, and apprentices have faced ongoing financial strains (Sutton Trust, 2020). Given that apprenticeship starts were already decreasing before the pandemic, employers are now facing additional strains which will make recruiting apprentices in the future even more difficult. Additionally, apprenticeship training providers face challenges in their own business models as employers are discouraged from hiring new apprentices. A survey from the Association of Education and Learning Providers (AELP) warns that only 38 of 279 polled providers are confident of surviving the crisis without closing or downscaling. Additionally, reduced economic activity is discouraging firms from hiring new apprentices and so will uncertainty about the length of the crisis (Ventura, 2020).

**The potential longer-term impact of COVID includes economic scarring for the 'COVID generation'.** There is a real risk of redundancies and lay-offs in the Humber and Yorkshire region due to ongoing economic uncertainty associated with the COVID crisis. Whilst in the near term this means a potential surplus of labour, evidence from similar recessionary periods suggests that workers can tend to become discouraged and thus detached from the labour force, eventually leading to loss of skills and productivity through enforced long term unemployment, particularly amongst youth (Cribb et al., 2017). Therefore rather than providing a large pool of labour, the COVID crisis threatens to lead to a permanent decline in skilled labour and productivity in the region, exacerbating existing income and wealth inequalities with the rest of the country and threatening the Government's agenda to 'level up' the regions.

**There are a number of proposed medium-to-long term solutions to ensuring the 'COVID generation' does not suffer long lasting damage to their economic prospects.** These include a jobs guarantee for young people, providing a vocational training stream earlier in a child's school career and increased University places (Major & Machin, 2020).

**Whilst laudable, such proposals are likely to take time to design, consult and implement and may not help address the skills gap in the Humber**. With the pandemic continuing to wreak havoc across the economy, more immediate solutions must be found.

**To ensure a well skilled local labour force able to support the delivery of CCS and hydrogen projects in the Humber by the start of construction in 2024, interventions will need to be made now, including demonstrating the value of vocational work at school and offering enhanced apprenticeships.** As students tend to be graded into technical, academic and vocational qualifications tracks as early as Key Stage 2 (aged 10-11, in Year 6), students may not have a full understanding of the potential employment opportunities in the region, including in skilled technical work in the Humber industrial cluster. There is therefore an opportunity for Drax and other operators to begin demonstrating the value of training and working in the engineering, procurement, construction and management industries which will ultimately be required to build the project, at an earlier stage in the life of a student. This could be done through career talks delivered at local primary schools by local Drax workers as early as Key Stage 2. Beyond early intervention, there is also an opportunity to leverage the apprenticeship model to mobilise the workers needed to support CCS and hydrogen deployment across the region.

**The jobs supported by Drax and other developers of CCS and hydrogen projects can contribute in a meaningful and immediate way to the post-COVID recovery.** Analysis done by Vivid Economics for the Finance for Biodiversity Initiative, as part of the Green Stimulus Index, indicates three key criteria to ensure that jobs created as a means to fuel the recovery provide large and immediate employment opportunities, compatible with ongoing social distancing measures, and in line with medium to long run public spending priorities (Finance for Biodiversity, 2020). As shown in Figure 15 below, assessed against these criteria, it is clear that a number of CCS and hydrogen projects in the Humber are a very real shovel-ready means to help boost employment opportunities in the region, particularly through the offer of an enhanced apprenticeship model.

Figure 15 Zero Carbon Humber assessed against Green Stimulus Index job creation criteria

**The Humber industrial cluster is a shovel-ready means to create high-skilled, high-paying jobs and transform the regions emissions as the post-COVID recovery takes shape**

| Vivid Green Stimulus Index criteria for COVID stimulus job creation[1] | How does the Humber industrial cluster meet this criteria? |
|---|---|
| **Timely:** Recovery measures that put people back to work need to come into play as soon as lockdowns start to ease. Projects which do not require lengthy retraining and skill development should be prioritised. Shovel-ready investments can also leverage lower input costs from the economic slowdown | ✓ **The Humber industrial cluster is shovel-ready**. Drax already has a BECCS pilot plant and Equinor has conducted FEED for its Hydrogen plant. Construction workers could be deployed in short order to build the project. |
| **Targeted job creation:** Job quality, longevity, and skill is assessed should focus on workers in hardest-hit sectors or workers experiencing wage loss | ✓ **The Humber industrial cluster will create high-skilled, high-paying jobs.** Construction jobs will benefit from the opportunity to enhance existing skills in the labour force, whilst O&M jobs are likely to persist well into the future as the project comes online. |
| **Long-run transformation:** Given current disruptions to economic activity, the transition away from high-carbon sectors and to low carbon sectors can be advanced to achieve equitable and long-term sustainable growth in line with global climate goals. | ✓ **The Humber industrial cluster will help transform the region's emissions.** By combining the elements of BECCS, CCUS and Hydrogen, Zero Carbon Humber (ZCH) is the UK's leading and largest decarbonisation cluster and can truly transform the region, helping accelerate the path to net zero. |

Source: Vivid Economics and Finance for Biodiversity

:vivideconomics

Notes: Criteria selected from the Vivid Green Stimulus Index 'Green employment and growth' note, July 2020
Source: Vivid Economics

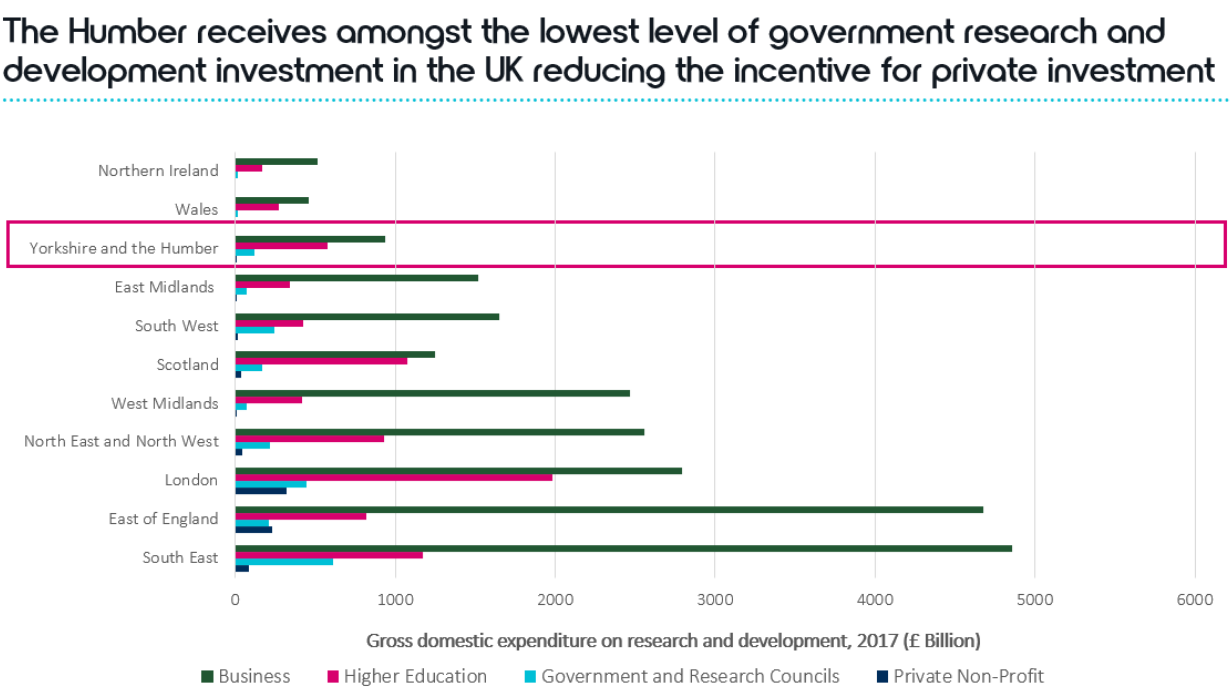
**There are a number of ways in which Drax and other operators can offer enhanced apprenticeships, in order to help alleviate the qualifications and skills gaps and assist in the post COVID recovery.** Two important, actionable and timely proposals include:

- **Recruit and train the next generation of workers now**: The coronavirus crisis creates a perfect opportunity to seek out high achieving school leavers who nevertheless have seen opportunities become restricted as cancelled exams and the Government's U-turn on exam grading creates uncertainty around University placements (The Guardian, 2020). *Drax and other Humber operators can seek to recruit these through an advertising campaign built on social media.*
- **Introduce greater flexibility in the selection process for the Drax apprenticeship scheme:** At present, Drax's Technical Apprenticeship Scheme requires GCSEs at grade C/5 or above in Maths, English Language and Science and have two additional GCSEs at grade C/5 or above (or equivalent) in any other subject (Drax, n.d.). But with COVID having impacted the ability of some school leavers to achieve such grades, *Drax should consider leveraging other credentials such as teacher references or the submission of evidence demonstrating mechanical or electrical engineering aptitude, such as completed Raspberry pi prototypes or pictures of work done on their own vehicles or homes*.

## 6.2 Investment gap

**In addition to a skills gap, there is also an investment gap in the region.** Data from the Office for National Statistics shows that government investment in R&D in the Yorkshire and Humber region was the lowest in England, with business sector R&D investment of less than £1 billion in 2017 being almost five times lower than for the South East of England. This lower investment leads to less funding being available for innovation in the advanced manufacturing needed to help the region remain competitive, with knock-on consequences for income distribution and wealth inequality.

Figure 16 R&D investment in Yorkshire and the Humber in 2017 compared to the rest of the UK




Source: Vivid Economics based on ONS Gross domestic expenditure on research and development, UK: 2017

**The investment gap results in two main problems, both of which could be addressed by Drax and other Humber operators.** These problems go beyond the skills gap for younger workers addressed earlier in Section 6.1. Indeed, these problems are more wide-ranging structural issues which require a level of active intervention by government, business and wider civil society because they impact a larger group of people than those impacted by the skills gap alone.

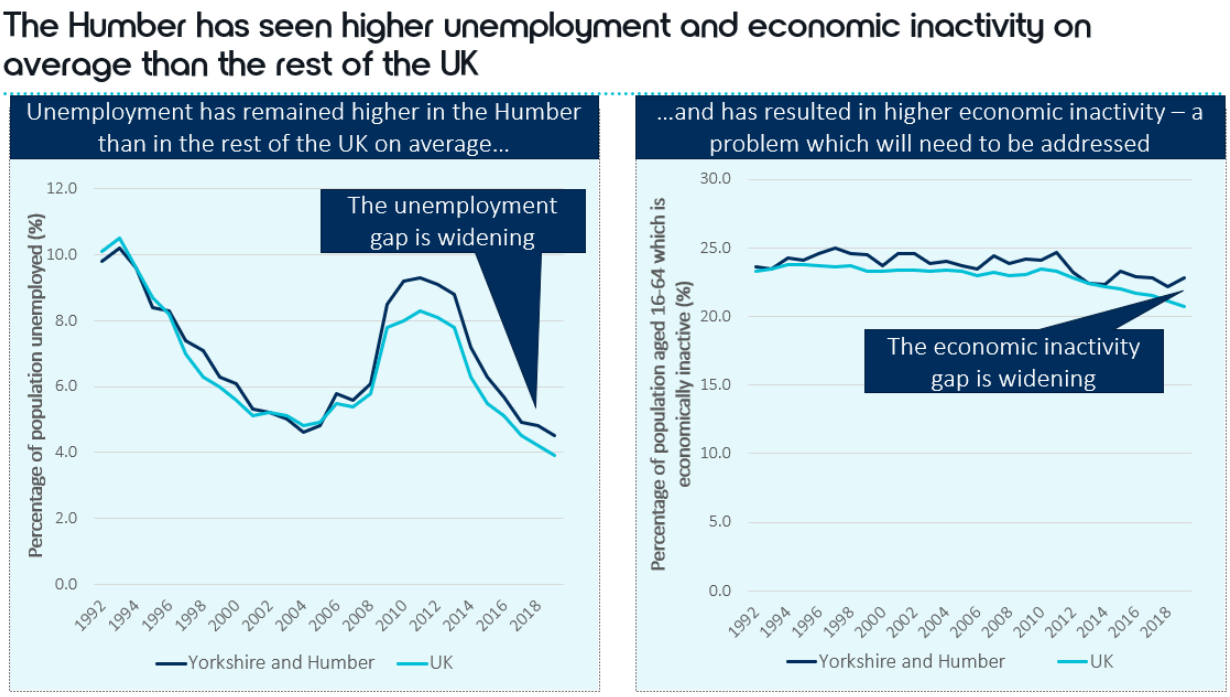
**The first problem associated with an investment gap is that of long-term economic inactivity.** Older workers who are already unemployed or economically inactive[17] (e.g. due to early retirement) in the region, may miss out on the high skilled jobs of the net zero economy. As shown in Figure 17 below, the rate of unemployment and economic inactivity in the region has trended higher than the UK average since the early 1990s. Although there are likely business cycle reasons for this, the gap between the Humber and the rest of the UK appears to be widening, suggesting an underlying trend of higher unemployment for reasons beyond the business cycle.

**There are likely structural reasons for the higher level of long-term economic inactivity in the Humber.** These may include limited opportunities for finding work in a speciality in which someone previously had experience or the prevalence of non-unionised jobs with lower benefits, in addition to long-term disability (Beatty, C., Fothergill, 2020).

**Irrespective of the reasons, evidence suggests that absent intervention to boost skills through retraining, workers who have been on the sidelines of the labour market, may continue to be discouraged from re-entering the workforce, threatening to widen income and wealth inequalities.**

[17] Economically inactive people are not in employment but do not meet the internationally accepted definition of unemployment. This is because they have not been seeking work within the last four weeks and/or they are unable to start work within the next two weeks (ONS, 2020).

Figure 17 Unemployment and economic inactivity in the Humber compared to the UK




Source: Vivid Economics based on ONS Labour Market Statistics time series

**The second problem associated with an investment gap is reduced potential for crowding-in investment from the private sector.** With no efficient mechanism for the delivery of research and development in zero carbon manufacturing in the Humber at present, businesses may have less incentive to invest in the technical capabilities needed to transform the region into the UK's first zero carbon cluster. Indeed, such 'crowding-in' of private sector investment is a well-understood mechanism to contribute to increased economic output (Afonso & Aubyn, 2008) and can be seen as one of the main drivers behind the Government's Industrial Strategy.

**Potential solutions to both the long-term economic inactivity and crowding-in problems require imagination and a desire to think creatively.** These problems are not limited to the Humber region or even the U.K. and have been prominent in other countries which have experienced structural changes and the need to update existing industrial strategies. There is no dearth of well-reasoned and well-evidenced solutions which have been proposed both for the region and the UK more broadly, but what is needed is to tailor these to the specificities of the transition to a zero carbon economy.

**Ground truth:** Opportunities for upskilling

Interview with Beckie Hart, Regional Director, Yorkshire and the Humber, CBI, October 2020.

- The CBI connects and supports businesses in the region. Beckie identifies a number of key strengths in different parts of the region, ranging from advanced manufacturing in South Yorkshire to technology, retail and finance in Leeds. **The region is not only economically diverse but also has a bigger GDP than the whole of Scotland.**
- Beckie also sees some of the challenges in the region: the prevalence of 'traditional' industries such as fossil-based manufacturing, Universities which are attended primarily by those born and bred nearby, high levels of youth unemployment, **educational outcomes lower than the regional and**

**national average,** 'lower aspirations' than elsewhere, a regional culture which causes people to stay in more than in other regions, causing businesses to reconsider investments.

- Beckie suggests that her experience on the ground with local businesses has found that the **skills gap operates at both ends of the spectrum**: labour-intensive industries struggling to find labour where automation is expensive, as well as big engineering and chemicals companies struggling to find and retain high quality managerial staff.
- At the same time, there are tremendous opportunities in the region: some quite big companies are already based there and the long-term vision of decarbonising the region is a 'really exciting proposition'. Beckie points out that the region has gone from decline after the end of the commercial fishing industry, to growth through industry. **Now is the time to go from being 'the dirty corner' to 'the clean corner'** to avoid decline as the push for net zero accelerates. A lot of regional businesses recognise that they have high emissions but 'want to be part of the solution'.
- She points out that the Chancellor's Kickstarter scheme won't be enough to fill the skills gap at the lower end of the skills gap spectrum, as some of these are quite young. What is needed is for the Government to urgently release its Energy White Paper and for **a strategy around how to get school-age children on paths to contributing to the net zero transition**. Could remote-working technology be used to get the likes of Drax and other businesses in the Humber into classrooms to do this she ponders?

**'Skills vouchers' are a timely intervention to help address the long-term economic inactivity problem for older workers.** By giving older workers grants to cover the cost of flexibly retraining in order to regain the skills which they may have lost from years of long term unemployment or economic inactivity, skills vouchers offer a means to ease back into the labour force and thereby participate in the zero carbon jobs of the future.

**What is a skills voucher scheme?**

- A skills voucher is grant funding provided by government for all eligible permanent residents and citizens, to be spent on education and training throughout their lives. A typical limit may be £10-15,000 per citizen – funded either by general taxation or hypothecated through payroll taxes.
- The funding can be made available in a tiered manner, with government topping up funds at various ages or stages of a person's life, such as £5000 at 25 when a young person has just entered the workforce, £3000 for mid-career retraining and another £3000 at 60, for retraining to extend someone's career beyond a typical retirement age. Skills vouchers are a means of ensuring that funds are available throughout someone's career and not just all used for example to study a post-graduate qualification at 22. Similar to pensions, individuals are able to make additional payments into their own vouchers.
- Such ideas have been debated in UK and European politics in the past, such as by the Liberal Democrats in their 2017 election manifesto, in the form of a skills wallet (Liberal Democrats, 2019). The current economic situation is causing a return to thinking along these lines.

**The UK Government has started to move in the direction of encouraging retraining.** The Chancellor's Winter Economy Plan to extend the UK's Coronavirus Job Retention Scheme (furlough) did not tie to a requirement for those on the scheme to commit to training, despite some initial reports suggesting that it might do so (The Independent, 2020).

A government-backed retraining programme was announced by the Prime Minister in September 2020, which provides a 'Lifetime Skills Guarantee' to give adults the chance to take free college courses valued by employers and introduces a new entitlement to flexible loans to allow courses to be 'taken in segments' (HM Government, 2020b). **Whilst these are encouraging moves by the Government, they do not explicitly meet the unique retraining and skills needs of the Humber as it prepares to decarbonise to hit net zero.** In particular, the Government's announcement does not indicate a concrete timeline for extending this scheme to the engineering and construction sector, committing instead to spend £8 million for digital skills boot camps, which 'from next year will be extended to sectors like construction and engineering'. Indeed, the region needs funding to fill the skills gap which goes beyond digital skills.

**To bring the skills voucher concept to life therefore, Drax and other operators should consider teaming up with local industries to utilise unspent Apprenticeship Levy funding.** This unspent Levy funding could be deposited into a digital account for each UK permanent resident or citizen registered for local council elections in Yorkshire and the Humber and then be made available through the form of payments directly to providers of technical and advanced engineering skills in the region. Such funding would then enable local residents who have been economically inactive, to be trained or retrained in areas such as welding, CNC machining, equipment installation and testing and monitoring, enabling them to ease into the net zero economy. Crucially, skills vouchers from unspent Levy funding would be available for those beyond the typical age for apprentices (16-25). The proposed skills wallet would therefore help address the economic inactivity problem.

**Beyond the long-term economic inactivity problem, there are a number of initiatives which are seeking to address the crowding-in problem.** Two such initiatives are most relevant to the investment gap in the Humber.

**The first initiative is the Midlands Engine, which aims to champion investment in the British Midlands**, including through partnerships and bringing investment in from the outside. Under the leadership of a titan of the engineering world – Sir John Peace – the Midlands Engine partnership brings together public sector partners and businesses to complement the activity of local and combined authorities, Local Enterprise Partnerships, universities, businesses and others (Midlands Engine, n.d.-b). To attract investment for innovation, the Midlands Engine Investment Fund delivered by the British Business Bank and supported by the European Regional Development Fund, brings over £250 million of investment to boost small and medium enterprise (SME) business growth in the Midlands, with access to small business loans and equity and debt finance ranging from £25,000 to £2m. Indeed, since 2018, over £50 million of UK equity investment has been secured by Midlands SMEs (Midlands Engine, n.d.-a).

**The second initiative is the freeport at the Port of Humber**. Freeports are part of a post-Brexit future which would benefit from trade tariff breaks and other incentives such as changes to planning rules and tax relief. The freeport at the Port of Humber is expected to attract new business, drive investment, create employment and ultimately, create global trading hubs (BusinessLive, 2020). As part of the criteria for successfully winning government funding, a freeport must demonstrate how it will 'create hotbeds for innovation' and 'promote regeneration and job creation' region (HM Government, 2020a) – criteria which the Port of Humber freeport is actively working to demonstrate in its bid and which if successful, will strengthen the case for inward investment in the Humber.

# 7 Conclusions

**In order to meet the UK's net zero target, BECCS will play a crucial role.** BECCS is crucial to the provision of firm low-carbon power and negative emissions, overcoming the site and emissions limitations of other low-carbon power technologies such as renewables, hydro and unabated gas and also ensuring that the CCC's forecast of 90 $MtCO_{2\text{-}e}$ per annum of negative emissions requirements can be met by 2050.

**By combining the elements of BECCS, CCUS and Hydrogen, the Humber industrial cluster will help accelerate the UK-wide buildout of the CCUS clusters needed to hit net zero.**

**A high proportion of UK domestic content could be captured in the process plants and equipment which will be deployed to realise the vision of the Humber**. The direct economic impact of CCS and hydrogen deployment across the Humber is a function of the expenditure in deploying capacity and the UK content of this expenditure. The ability of UK providers of capital equipment and design, engineering, construction and project management services to capture a high proportion of the economic value of developing CCS and hydrogen projects, is key to realising the direct economic impacts on the Humber.

**However, there are specialist skills gaps in the Humber.** Part of the skills gap is driven by the Humber having a lower proportion of school leavers achieving NVQ stage 2 or beyond. And the skills gap is likely to get worse. According to the government's Working Futures model, by 2022, key manufacturing sectors – electricity and gas, engineering and construction - in Yorkshire and the Humber will require higher qualifications than currently available. This means that employers are likely to face even larger skills shortage vacancies in future years, particularly as the energy transition begins to accelerate by the mid-2020s. As the Humber is the largest industrial emissions cluster, such a widening skills gap could impact the delivery of CCS and hydrogen projects in the region, risking the net zero target.

**The COVID crisis has made things worse.** It has already led to a high proportion of furloughs in the region. Apprenticeships have been hit particularly hard by the COVID crisis. The potential longer-term impact of COVID includes economic scarring for the 'COVID generation'. Enhanced apprenticeships can support the UK's economic recovery, inclusive growth and climate ambitions whilst also ensuring that the 'COVID generation' does not suffer long lasting damage. To ensure a well skilled local labour force able to participate in the Humber projects by the start of construction in 2024, interventions will need to be made now, including demonstrating the value of vocational work at school and offering enhanced apprenticeships.

**To ensure a well skilled local labour force able to participate in the Humber CCS and hydrogen projects by the start of construction in 2024, interventions will need to be made now, including demonstrating the value of vocational work at school and offering enhanced apprenticeships.**

**More broadly, CCS and hydrogen in the Humber offers the opportunity to create immediate, high quality jobs in the region, whilst contributing very meaningfully and immediately to the post-COVID recovery.**

# Summary of Findings

Table 2 Jobs Summary

| | Direct | Indirect | Induced | Total |
|---|---|---|---|---|
| Drax (annual average between 2024-2031) | 4,124 | 2,483 | 3,884 | **10,491** |
| Humber (annual average between 2024-2031) | 15,850 | 7,104 | 10,870 | **33,824** |
| Humber & Tees (annual average between 2024-2031) | 19,191 | Not calculated | Not calculated | n/a |
| UK (annual average between 2024-2031) | 24,623 | 54,002 | 51,719 | **130,344** |
| | | | | |
| Drax (peak) 2028 | 7,685 | 3,550 | 5,523 | **16,758** |
| Humber (peak) 2027 | 25,223 | 9,852 | 14,571 | **49,646** |
| Humber and Tees (peak) 2027 | 30,207 | Not calculated | Not calculated | n/a |
| UK (peak) 2039 | 26,832 | 88,324 | 89,920 | **205,076** |
| UK (peak) Direct jobs only 2027 | 33,071 | n/a | n/a | n/a |

Table 3 GVA Summary

| | Direct | Indirect | Induced | Total |
|---|---|---|---|---|
| Drax (annual average between 2024-2031) | £374m | £166m | £208m | **£748m** |
| Humber (annual average between 2024-2031) | £1186m | £452m | £581m | **£2219m** |
| Humber & Tees (annual average between 2024-2031) | £1453 | Not calculated | Not calculated | n/a |
| UK (annual average between 2024-2031) | £1845m | £2250m | £4636m | **£8731m** |
| | | | | |
| Drax (peak) 2028 | £550m | £234m | £295m | **£1079m** |
| Humber (peak) 2027 | £1859m | £582m | £778m | **£3219m** |
| Humber and Tees (peak) 2027 | £2240m | Not calculated | Not calculated | n/a |
| UK (peak) 2039 | £2221m | £4480m | £8059m | **£14,760m** |

# Appendix

## Direct benefits

### Deployment assumptions

| Context | Technology | Source | Description | Facility type |
|---|---|---|---|---|
| **Drax** | BECCS | Drax | - Clustered deployment of 4 units: 2027, 2028, 2030, 2031<br>- Results in 660MW x 4 at full capacity, capturing 16Mtpa | Retrofit on existing biomass plants |
| | $CO_2$ T&S | (Derived) | - In line with associated $CO_2$ capture scale at Drax<br>- Which implicitly assumes that T&S infrastructure grows at a pace to match CCUS deployment | New |
| **Drax II** | BECCS | Drax | - Sequential deployment of 4 units: 2027, 2029, 2031, 2033<br>- Results in 660MW x 4 at full capacity, capturing 16Mtpa | Retrofit on existing biomass plants |
| | $CO_2$ T&S | (Derived) | - In line with associated $CO_2$ capture scale at Drax<br>- Which implicitly assumes that T&S infrastructure grows at a pace to match CCUS deployment | New |
| **Humber** | BECCS | Drax | - Exactly equal to Drax BECCS of a full scale of 16Mtpa | Retrofit on existing biomass plants |
| | Gas CCS | Drax | - Represents VPI Immingham and Keadby 3<br>- Total capacity reaches 2GW in 2040 | VPI Immingham modelled as a retrofit; Keadby 3 as new build |
| | Industry: CCS | Drax | - Initially represents Philips 66, Total, British Steel<br>- Reaches full capacity at 6.6Mtpa in 2035 and stays flat | Retrofit |
| | Industry: H2 use | Derived from Equinor | - Assume industry in the Humber industrial cluster uses up the hydrogen from the initial 600MW ATR in 2027, then progressively reaches a level of hydrogen consumption equivalent to 5.5GW of ATR production capacity in 2040 | Conversion of industrial appliances |
| | H2 production | Derived from Equinor | - Assume initial ATR capacity of 600MW in 2027, reaching 6.5GW by 2030 and 19.5GW in 2040 | New ATR with CCS |
| | $CO_2$ T&S | (Derived) | - In line with associated $CO_2$ capture scale at the Humber<br>- Which implicitly assumes that T&S infrastructure grows at a pace to match CCUS deployment | New |
| **Teesside** | BECCS | Vivid Economics | - Scenario used in Net Zero Teesside report | Retrofit on existing biomass plants |
| | Gas CCS | Vivid Economics | - Scenario used in Net Zero Teesside report | New |
| | Industry: CCS | Vivid Economics | - Scenario used in Net Zero Teesside report | Retrofit |
| | Industry: H2 use | Vivid Economics | - Assume all hydrogen produced in NZT is used up by industrial facilities at the cluster | Conversion of industrial appliances |
| | H2 production | Vivid Economics | - Scenario used in Net Zero Teesside report | Retrofit SMR with CCS |
| | $CO_2$ T&S | Vivid Economics | - Scenario used in Net Zero Teesside report | New |
| **Hynet** | Industry: CCS | Hynet baseline | - 2Mtpa worth industry CCS at 2030 | Retrofit |

| Context | Technology | Source | Description | Facility type |
|---|---|---|---|---|
| | | | - Assume capacity grows linearly from zero in 2026 to full capacity in 2030 | |
| | $CO_2$ T&S | (Derived) | - Assume infrastructure scale grows at pace with the associated Mtpa's with industry CCS at Hynet | New |
| **Acorn** | Industry: CCS | Acorn phase 1 | - Represents a 0.34Mtpa CCS at Shell's St Fergus gas plant<br>- Operational in 2024 | Retrofit |
| | $CO_2$ T&S | Acorn phase 1 | - Infrastructure capable of handling 5Mtpa<br>- Operational in 2027 | New |
| **South Wales Industrial Cluster (SWIC)** | Industry and power CCS | SWIC base case | - 2.3 Mt $CO_2$ from the Tata steel works in 2032, 0.3 Mt $CO_2$ from the Tarmac cement plant in 2033, 4.6 Mt $CO_2$ from the Valero refinery in 2034 and 4.9 Mt $CO_2$ from the Pembroke power plant in 2035 | Retrofit |
| **UK** | BECCS | Scenario constructed by Vivid Economics based on CCC and Equinor scenarios | - Up to 2030: sum of Humber and Tees<br>- Beyond 2030: extrapolate linearly to 5GW in 2050, aligning with CCC's Net Zero Further Ambition scenario | Retrofit on existing biomass plants |
| | Gas CCS | | - Sum of Humber and Tees<br>- Reaches a total of 4GW at full capacity | A mix of new builds and retrofits |
| | Industry: CCS | | - Up to 2030: sum of Humber, Tees, Hynet and Acorn<br>- Beyond 2030: extrapolate linearly to a scale of capturing 15Mtpa in 2050 | Retrofit |
| | Industry: H2 use | | - Up to 2030: sum of Humber and Tees<br>- Beyond 2030: extrapolate linearly to consume an annual total of 80TWh hydrogen in 2050 | Conversion of industrial appliances |
| | H2 production | | - Up to 2030: sum of Humber and Tees<br>- Beyond 2030: extrapolate linearly to an annual production scale of 550TWh of hydrogen in 2050. Note that the underlying scenario for hydrogen demand consists of 125TWh used for electricity generation, 250TWh used for domestic and commercial heat, 95TWh used for transport, and 80TWh used for industry. | New ATR with CCS, except for hydrogen production in NZT, which is a retrofit on SMR |
| | $CO_2$ T&S | | - Up to 2030: sum of ZCH, NZT, Hynet and Acorn<br>- Beyond 2030: assume infrastructure grows at pace with total size of CCUS in the UK, which reaches a total of 191Mtpa in 2050 | New |

## Cost assumptions

| Technology | Cost estimate for | Stage | Cost estimate (CAPEX and fixed O&M) | Cost decline rate based on |
|---|---|---|---|---|
| BECCS | New build | NOAK | Wood (2018) | CAPEX: Poyry (2015) up to 2035, ESME till 2050<br><br>O&M: Poyry (2015) till 2035, flat from 2035 to 2050 |
| BECCS | Retrofit | FOAK | Drax | |
| Gas CCS | New build | NOAK | Wood (2018) | |

| | | | | |
|---|---|---|---|---|
| Gas CCS | Retrofit | NOAK | Wood (2018), adjusted for retrofit | |
| Industry CCS | Average of 8 types of industry CCS | FOAK | Element Energy (2014) | Leeson et al (2017) |
| Industry H2 use | Appliance conversion | 2020 | Element Energy (2019) | Assume no decline |
| H2 production | ATR with CCS | 2020 | CAPEX from IEA (2019), O&M from H21 NoE report | IEA (2019) |
| $CO_2$ T&S | T&S infrastructure | FOAK | CAPEX from Drax, O&M from Vivid's NZT report | Assume no decline |

## Indirect and induced benefits

**Indirect and induced benefits are estimated using the Vivid Investment Impact Model (IIM).** For the UK economy, the model is calibrated to account for the interactions between 127 sectors, in order to provide an accurate picture of the supply chain impacts from ZCH.

**The IIM estimates the impact on GDP of an increase in output from ZCH, based on the existing average technology observed in the I/O tables from the ONS.** The tables take the form of a square matrix, where outputs are calculated down the columns of the matrix, and inputs fed in via rows (that is, column X gives the output of sector X, while row X gives the sectors that use sector X as an input). The I/O table approach provides a complete high-level picture of the UK economy, including economic activity in 127 sectors and household consumption. GDP effects can be extracted using either the final demand approach or the factor payments approach.

**From the I/O tables, we built a schematic representation of all transactions happening in the UK economy, in the form of a Social Accounting Matrix (SAM).** The SAM is easier to interpret as all economic agents are represented in a single matrix: firms, households, government and foreign sector. Yet, the relationships are those provided by the I/O tables, so both terms can be used interchangeably. The column header is the buyer and the row header the seller. Hence, activities (firms) buy inputs from domestic output and imported goods, which taken together amount to the total intermediate demand. Similarly, activities need inputs from the factors of production to produce (labour and capital). The columns of activities provide payments to factors accounting for these transactions.

**The model implicitly makes three major assumptions:**

1. **Constant returns to scale as production is increased:** in other words, the empirical technology observed in the I/O tables is assumed to be the same at any level of production.

2. **Slack capacity:** there is enough underused capacity in the economy to scale up production without requiring additional investment.

3. **Fixed prices:** the model does not allow for price adjustments. This assumption is critical, as the model does not consider substitution effects between inputs, but rather assumes they will always be used in the same proportions. In the short run this is a reasonable assumption, yet in the longer run, prices will adjust to reflect the increase in demand. As a result, the estimated impact is likely to be slightly larger than the actual effect after prices adjust (upwards) and should be taken as an upper-bound estimate in the long run.

We calibrate a series of modules to assess the indirect and induced distributional effects of the investment shock from ZCH:

- Gross Value Added (GVA): we transform the total impact on domestic production into GVA. The model nets out all domestic and imported inputs required to produce the total domestic impact. This is equivalent to adding factor payments together, that is labour and capital, and adjusting for indirect taxes. For this work, we split the effect between indirect and induced impact to assess the relative magnitudes of each one. Estimating the indirect impact requires exhausting all the higher-order effects (i.e. remove the value of the inputs of the inputs of the inputs, etc). This exercise also allows for isolation of the total increase in domestic demand for intermediate inputs. From there we get induced effect by removing from the total domestic impact both the NZT investment shock and intermediate domestic inputs. Finally, to transform induced production into induced GVA, we proceed with a similar exercise of netting out the value of inputs until exhaustion.

- Employment: first we estimate the increase in total labour payments in each sector. We combine this output with the latest data on average salaries per sector from the ONS to estimate the employment impact. Using the indirect and induced effects describe above, we also produce the job estimates using that level of disaggregation.

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# Company profile

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