NEEDS AND BENEFITS STATEMENT

Drax Bioenergy with Carbon Capture and Storage

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations, 2009 - Regulation 5(2)(q)

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EXECUTIVE SUMMARY

Negative emissions are critical to deliver net zero (whereby the greenhouse gas emissions ('GHG') going into the atmosphere are balanced by the removal of such gases out of the atmosphere). Experts including the Committee on Climate Change agree (Committee on Climate Change, 2019) and this is clear in government strategies and action plans (HM Government, 2017, Amended 2018) (HM Government, 2020a). To tackle climate change and reach net zero, the world needs to remove carbon dioxide (CO_2) that's already in the atmosphere – not just reduce our CO_2 emissions today.

Climate change is happening now, so solutions are needed that are ready today and that are fit for the future, to deliver clean growth across industry and create green jobs, while helping to tackle climate change. We need negative emissions technologies that are ready to go now.

Since 2019, Drax Power Limited has tested cutting-edge carbon removal technology that takes carbon dioxide from the atmosphere and can lock it away forever. Combined with the sustainable forests from where we source our biomass, we are creating a system that captures and then removes CO_2 from the atmosphere both as the forests grow and as we generate electricity. This is called BECCS – Bioenergy with Carbon Capture and Storage.

Drax Power Station, near Selby, North Yorkshire, is the largest power station in the UK, and can be modified to create negative emissions and renewable energy using BECCS, as a first step towards the development of a global negative emissions industry.

Drax Power Limited is pioneering the only shovel-ready, industrial scale negative emissions technology in the world that is ready to deploy, to begin removing carbon emissions from the air and get the UK to net zero. BECCS at Drax will accelerate clean growth, protect British industries across the Humber, create thousands of new green jobs across the UK, and make Britain a global leader in developing climate-saving technologies (HM Government, 2020a) (HM Government, 2021a).

Drax Power Limited has been at the forefront of the shift to clean energy. The upgrading of its power plant from using coal to sustainable biomass was a world first, and Europe's largest decarbonisation project. Today the power station supplies clean, flexible renewable power to the grid, generating enough renewable electricity to power four million homes, whilst supporting the energy system and enabling more renewables like wind and solar to be brought online.

The Proposed Scheme goes further in embracing clean energy. The first phase of BECCS at Drax will permanently remove at least 8 million tonnes of CO_2 from the atmosphere each year, making Drax Power Station the world's largest single site carbon capture project.

The carbon removal technology BECCS is ready now, and can deliver the negative emissions the UK needs, at lower cost than many other carbon removal solutions.

Building BECCS will accelerate economic growth for the Yorkshire and Humber region: underpinning the world's first zero carbon industrial cluster, creating new high-skilled jobs, and putting the region at the heart of a global green economy.

Like wind and solar before, every new technology needs help to get it off the ground. Without Government policy support for BECCS in the short term, it will cost the UK over £75bn more to reach net zero and require a much greater lifestyle change. This increases the risk of the UK failing to meet this target altogether, undermining our position as a global leader. Without BECCS at Drax, major industries will lose out on the ability to negate their remaining hard-to-abate emissions, putting thousands of jobs across the Humber at risk in the transition to net zero. Drax Power Limited consider the BECCS project as the first step towards a global negative emissions industry. But without it, other countries will occupy the global leadership position in the race to develop and export carbon capture technology.

Drax Power Limited believe the challenge of climate change is an opportunity to improve the environment we live in, as well as the economy, by using innovation to create clean growth and new jobs. This is why Drax Group Plc has a world leading ambition to be carbon negative by 2030 and is the only UK company that has proven it can capture carbon from a 100% sustainable biomass feedstock.

Without BECCS at Drax in the 2020s, the cost for the UK to deliver net zero will soar. Now is the moment to act if the UK wants to capture this substantial and innovative opportunity. BECCS at Drax will deliver net zero, regenerate the Humber, and help the UK lead the world in fighting the climate crisis.

1. INTRODUCTION

1.1. OVERVIEW OF BECCS AT DRAX

1.1.1. The climate crisis is one of the biggest challenges of our time. The UK's net zero target that the UK must achieve net zero by 2050 (which was established in law in the Climate Change Act 2008 (2050 Target Amendment) Order 2019) demonstrates the country's commitment to tackling climate change. 'Net zero' means the greenhouse gas emissions (GHG) going into the atmosphere are balanced by the removal of such gases out of the atmosphere.

1.1.2. Bioenergy with Carbon Capture and Storage (BECCS) is an innovative technology that has been developed to permanently remove carbon dioxide (CO_2) from the atmosphere. The negative emissions and renewable power produced by BECCS are both vital to addressing the climate crisis. This is recognised in the Government's Ten Point Plan for a Green Industrial Revolution, published in November 2020 (HM Government, 2020b), which outlines the government's ambition to become a world-leader in technology to capture and store harmful emissions away from the atmosphere.

1.1.3. The Applicant proposes to install BECCS technology on up to two of its existing biomass power generating units at Drax Power Station, near Selby, North Yorkshire. This would capture CO_2 emitted as part of the electricity currently generated at the relevant units at Drax Power Station. This CO_2 would then be transported via a pipeline from Drax Power Station to a suitable geological storage site in the southern North Sea. Delivering BECCS will enable the Applicant to capture the carbon dioxide emitted during electricity generation, permanently removing more carbon dioxide from the atmosphere than is produced throughout the process – creating what is known as negative emissions. Biomass will continue to be sourced from sustainable sources, primarily sustainably managed forests in accordance with applicable national legislation and regulation, certification schemes and the Applicant's own Sustainable Sourcing Policy (Drax, 2019). The forests used to supply sustainable biomass absorb carbon dioxide as the trees grow. When that same sustainable biomass is combusted in electricity production, the carbon dioxide released is offset by the amount of carbon dioxide it absorbed from the atmosphere while it was growing. By capturing any carbon dioxide emitted as part of the combustion process, for storage in safe underground deposits, the process of biomass electricity generation becomes carbon negative, as more carbon dioxide has been removed from the atmosphere than has been added. The Proposed Scheme, known as

'BECCS at Drax', comprises the on-site infrastructure to capture the majority of the CO_2 from these existing operations to then be transported off-site.[1]

1.1.4. The Proposed Scheme, therefore, comprises an extension of an existing generating station for the purpose of section 14(1)(a) of the PA 2008, and therefore is a Nationally Significant Infrastructure Project ('NSIP'). Its construction and operation require planning permission to be secured through the Development Consent Order ('DCO') process. A DCO Application is therefore required for the Proposed Scheme as it falls within the definition and thresholds for a NSIP, under sections 14 and 15(2) of the PA 2008. The Proposed Scheme involves the use by the Applicant of land at the Drax Power Station for a purpose directly related to the generation of electricity by that station. The Applicant considers that, in this particular case, the installation of post-combustion carbon capture technology (Work No. 1 as set out in Schedule 1 to the draft DCO) constitutes the NSIP by virtue of it being an extension to the Existing Drax Power Station. The design is unique to carbon capture plants and arises as a result of Units 5 and 6 (the last two remaining coal-fired units at the Existing Drax Power Station) being decommissioned before the Proposed Scheme is operational. This presents an opportunity to the Applicant to design a carbon capture plant that makes use of spare capacity in terms of water treatment, water cooling and steam flows that arise as a result of the decommissioning of Units 5 and 6. The Proposed Scheme therefore involves the modification, upgrade and extension of existing apparatus which will result in the Proposed Scheme becoming an integral part of the process of generating electricity at the Existing Drax Power Station. The effect of the extension (the Proposed Scheme) will be that Units 1 and 2 of the Existing Drax Power Station will not only generate electricity but also produce negative emissions in generating that electricity. Further detail is provided in the Explanatory Memorandum (document reference 3.2)

1.1.5. This Needs and Benefits Statement supports the DCO Application, made pursuant to section 37 of the PA 2008, which is submitted to the Government through the Planning Inspectorate ('PINS'). PINS has six months to examine and then three months to prepare a report on the application to the relevant Secretary of State ('SoS'), including a recommendation. The SoS then has three months to make a decision on the planning application.

1.1.6. The Proposed Scheme, therefore, comprises an extension of an existing generating station for the purpose of section 14(1)(a) of the PA 2008, and therefore is a Nationally Significant Infrastructure Project. A DCO is therefore required for the Proposed Scheme as it falls within the definition and thresholds for a "Nationally Significant Infrastructure Project" (a "NSIP") under sections 14 and 15(2) of the PA

[1] Note, the transport and storage infrastructure for this will be consented through separate applications. The Endurance Partnership will be responsible for the marine pipeline and onward storage under the North Sea. National Grid Ventures will be responsible for the low carbon pipelines which would take CO_2 from Drax Power Station to the Humber Coast. Also note, the use of biomass as a fuel at Drax Power Station is an existing consented operation which also falls outside of the application proposals.

2008. Further detail is provided in the Explanatory Memorandum (document reference 3.2).

1.2. PURPOSE OF THIS REPORT

1.2.1. This Needs and Benefits Statement is part of the suite of documents which accompany the DCO Application. The purpose of this document is to clearly set out the need for BECCS at Drax and its benefits.

1.2.2. This report demonstrates why the BECCS at Drax project is required, building on the emerging Government policy support for CCS infrastructure. It explains why the Proposed Scheme is necessary from a national perspective and how it is also of international importance as it is a vital part of the response to the climate crisis. The report presents the overarching need for renewable power and negative emissions for the UK to reach net zero by 2050. The report then outlines the positive contribution that BECCS at Drax brings in terms of its economic, social and environmental impacts. There are also benefits which can be realised at the local, national and international level.

1.2.3. The DCO Application is also supported by a suite of plans and other supporting reports and assessments including the Planning Statement, which assesses the proposals against the relevant planning policies. An Environmental Impact Assessment ('EIA') has been undertaken, which is a process of evaluating the likely environmental impacts of the proposed project. This is documented in the Environmental Statement submitted in support of the Application.

1.3. STRUCTURE OF THIS REPORT

1.3.1. This report is structured as follows:

- **a.** An Executive Summary is provided at the beginning of the document;
- **b.** This chapter (Chapter 1) provides an introduction to the report;
- **c.** Chapter 2 provides a brief summary of the legal and policy context in which this report sits;
- **d.** Chapter 3 outlines the environmental and socio-economic context of relevance to the proposals, including an overview of the UK power sector, having particular regard to renewables, biomass and carbon capture technologies;
- **e.** Chapter 4 sets out the need for the Proposed Scheme, in the context of national and international targets, and also draws upon the relevant national and local planning policy framework;
- **f.** Chapter 5 considers the economic benefits of the proposals;
- **g.** Chapter 6 considers the social and community benefits of the proposals;
- **h.** Chapter 7 considers the environmental benefits of the proposals; and
- **i.** Chapter 8 provides the overall conclusion of the report.

1.3.2. The Needs and Benefits Statement should be read in conjunction with the other documents submitted with the Application, in particular:

a. The Glossary (document reference 1.7);

b. The Plans (document reference 2.1 – 2.5);

c. The Draft DCO and Explanatory Memorandum (document reference 3.1 and 3.2);

d. The Consultation Report (document reference 5.1);

e. The Planning Statement (document reference 5.2); and

f. The Environmental Statement (document reference 6.1 – 6.4).

2. LEGISLATIVE FRAMEWORK

2.1.1. Large-scale infrastructure developments such as the Proposed Scheme are underpinned by a complex set of UK and local policies. These include policies which directly support renewable technologies and carbon capture technology, and more general policies relating to the potential impacts of development proposals.

2.1.2. NPSs are designated under the Planning Act 2008 (PA 2008) to set out national energy policy and form the framework for decision-making on applications for development consent for major infrastructure, defined as NSIPs.

2.1.3. The current suite of energy NPSs were designated by the Department of Energy and Climate Change in 2011, and comprise:

a. The Overarching National Policy Statement for Energy (EN-1);

b. Fossil Fuel Electricity Generating Infrastructure (EN-2);

c. Renewable Energy Infrastructure (EN-3);

d. Gas Supply Infrastructure and Gas and Oil Pipelines (EN-4);

e. Electricity Networks Infrastructure (EN-5); and

f. Nuclear Power Generation (EN-6).

2.1.4. The two NPSs of relevance to this project are EN-1 and EN-3.

2.1.5. The government has undertaken a review of the existing energy NPSs to ensure they reflect current energy policy, and to ensure the planning policy framework can deliver investment in the infrastructure needed for the transition to net zero by 2050. A consultation ran from 6 September 2021 to 29 November 2021 on the revised energy NPSs. EN-6, which currently sets out the planning and consents regime for nuclear projects deployable before 2025, was not proposed to be amended as part of this review.

2.1.6. In a departure from the original suite of NPSs, draft EN-1 may have effect on its own in relation to certain types of infrastructure for which there is no technology specific NPS, such as CCS.

2.1.7. While the NPSs review is undertaken, the current suite of NPSs remain relevant government policy. For any application accepted for examination before designation of the amendments to the NPS, the original suite of NPSs should have effect. The amended NPS will therefore only have effect in relation to those applications for development consent accepted for examination after the designation of those amendments. As it is anticipated that this application will be accepted prior to the designation of the new NPSs, the application will be decided against the policies set out in the 2011 NPSs.

2.1.8. Whilst the DCO Application must be determined in accordance with the relevant NPSs, under section 104(2)(d) of the PA 2008, regard must also be had to any other matters of importance and relevance. The Applicant considers that this includes the following, which are considered in the subsequent sections of this report:

a. Draft policies in draft EN-1 (given that they were considered as such in recent NSIP decisions for Norfolk Vanguard Offshore Windfarm and Little Crow Solar Park);

b. Relevant policies in the National Planning Policy Framework ('NPPF');

c. Relevant local planning policy; and

d. Other national and international policies and agreements.

2.1.9. For this type of NSIP, PA 2008 requires the SoS, as the decision maker, to decide the application in accordance with the relevant NPSs, except to the extent it is satisfied that to do so would:

a. Lead to the UK being in breach of its international obligations;

b. Be in breach of any statutory duty that applies to the Secretary of State;

c. Be unlawful;

d. Result in adverse impacts from the development outweighing the benefits; or

e. Be contrary to regulations about how its decisions are to be taken (in this case the Infrastructure Planning (Decisions) Regulations 2010).

2.1.10. This assessment of the Proposed Scheme against the NPSs is undertaken in the Planning Statement. However, as per the above, the SoS could make an exception to this approach, where the adverse impact of the Proposed Scheme would outweigh its benefits (section 104(7)). The consideration of benefits is therefore a key consideration for the application. EN-1 states *"the IPC should take into account environmental, social and economic benefits and adverse impacts, at national, regional and local levels*[2]*"* (EN-1 paragraph 4.1.4). This report therefore outlines the need for and the benefits of the Proposed Scheme. This informs the balancing exercise of the benefits against the potential impacts of the Proposed Scheme, which is set out in the Planning Statement.

[2] Note, the IPC no longer exists and the SoS is now the decision maker.

3. ENVIRONMENTAL AND SOCIO-ECONOMIC CONTEXT

3.1. THE CLIMATE EMERGENCY CRISIS

3.1.1. In May 2019, the UK parliament declared a climate emergency. This has similarly been declared by international, national and local authorities such as the European Parliament. Whilst there is no fixed definition of a 'climate emergency', the focus is on the need for 'urgent action' to reduce or halt climate change, in order to prevent further environmental damage.

3.1.2. More recently, the IPCC have published the Sixth Assessment Report 'Climate Change 2022: Impacts, Adaptation and Vulnerability' (2022) which assesses the impacts of climate change at global and regional levels (IPCC, 2022). This reinforces the urgent need to respond to this global emergency finding that without immediate and deep emissions reductions across all sectors, limiting global warming to 1.5°C is beyond reach. However, there is increasing evidence of climate action, and there are significant opportunities to reduce emissions by 2030. BECCS is an example of such 'climate action' being taken. The report states that global temperatures are likely to breach the 1.5°C threshold during the 21st century, albeit this is more than likely to be a temporary overshoot. It therefore stresses the need to implement adaptation to climate change. This emphasises the urgency for using CCS whilst other projects and technologies progress.

3.1.3. In December 2020, the government published the Energy White Paper: Powering our Net Zero Future (HM Government, 2020a), in which they outlined the need to *"build back greener"* from the impact of Coronavirus, addressing the inter-generational challenge of climate change:

> "Unchecked, the impact of rising global temperatures represents an existential threat to the planet… Failing to act will result in natural catastrophes and changing weather patterns, as well as significant economic damage, supply chain disruption and displacement of populations. Tackling climate change will require decisive global action and significant investment and innovation by the public and private sectors, creating whole new industries, technologies, and professions".

3.1.4. Responding to this global challenge, whilst requiring investment and innovation, presents opportunities for growth and job creation.

3.1.5. One such area for innovation which is recognised as a direct response to climate change, and of relevance to this Proposed Scheme, is the investment in clean technologies such as wind, hydrogen and carbon capture. The global markets for low-carbon technologies and clean energy are fast growing, with exports of new technologies such as carbon capture, utilisation and storage (CCUS) having the potential to add £3.6 billion Gross Added Value (GVA) to the UK economy by 2030.

3.1.6. This is also addressed in the Government's Ten Point Plan for a Green Industrial Revolution, published in November 2020 (HM Government, 2020b), which outlines

the government's key targets relating to clean energy, transport, nature and innovative technologies. One of these points is:

> "Carbon capture: Becoming a world-leader in technology to capture and store harmful emissions away from the atmosphere, with a target to remove 10 MT of carbon dioxide by 2030, equivalent to all emissions of the industrial Humber today".

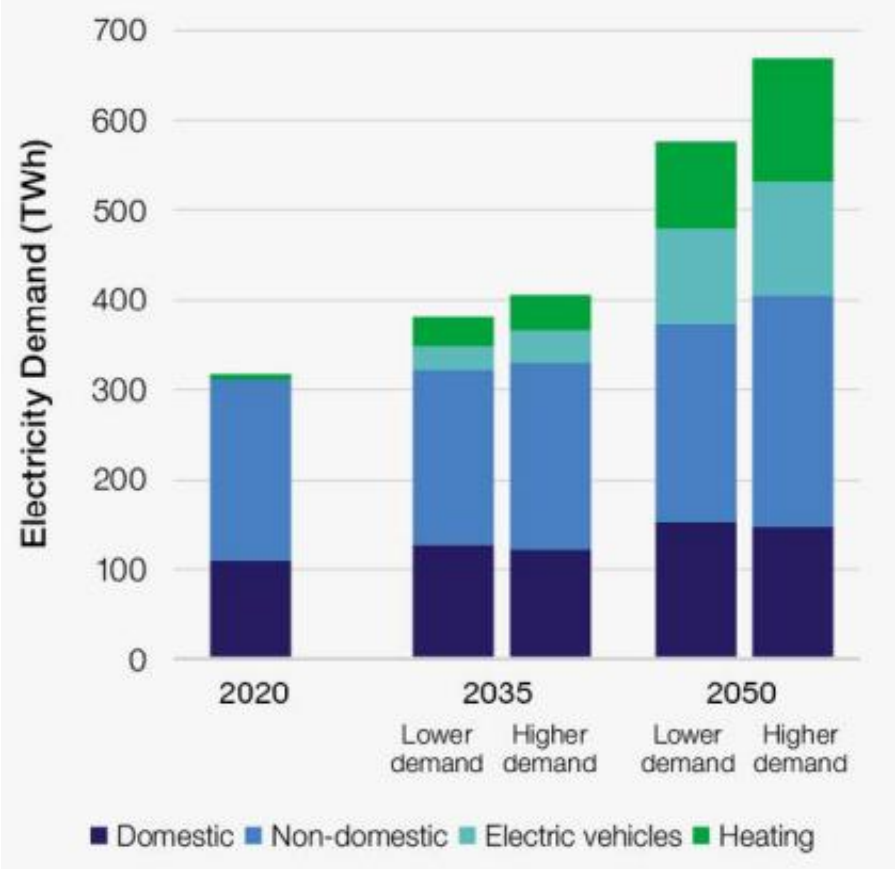
3.1.7. Further detail is provided in the Planning Statement (document reference 5.2).

3.1.8. The UK government sets out in its "Net Zero Strategy: Build Back Greener" (2021) that it aims to be a leader in the new 'Green Industrial Revolution', recognising that acting early will drive down the costs of the latest clean technology, enabling consumers to reap the benefits sooner. It's also stated that *"by accelerating the deployment of cheap renewable power, and rolling out further energy efficiency measures, government decarbonisation policies mean that the average consumer energy bill in 2024 will likely be cheaper than it would otherwise have been"* (HM Government, 2021b).

3.2. THE UK POWER SECTOR

3.2.1. The UK's use of electricity is expected to increase moving forwards. Analysis from the Department for Business, Energy & Industrial Strategy ('BEIS') shows that by 2050, electricity demand could be double the 2020 level of usage (see **Plate 3.1** below). This is due to a combination of factors, including: moving away from the use of fossil fuels in order to meet climate change objectives; displacing petrol and diesel in cars and, to some extent, gas for heating; demographic changes; and economic growth.

Plate 3.1 - Electricity Demand, Net Zero Scenarios



Source: (HM Government, 2020a)

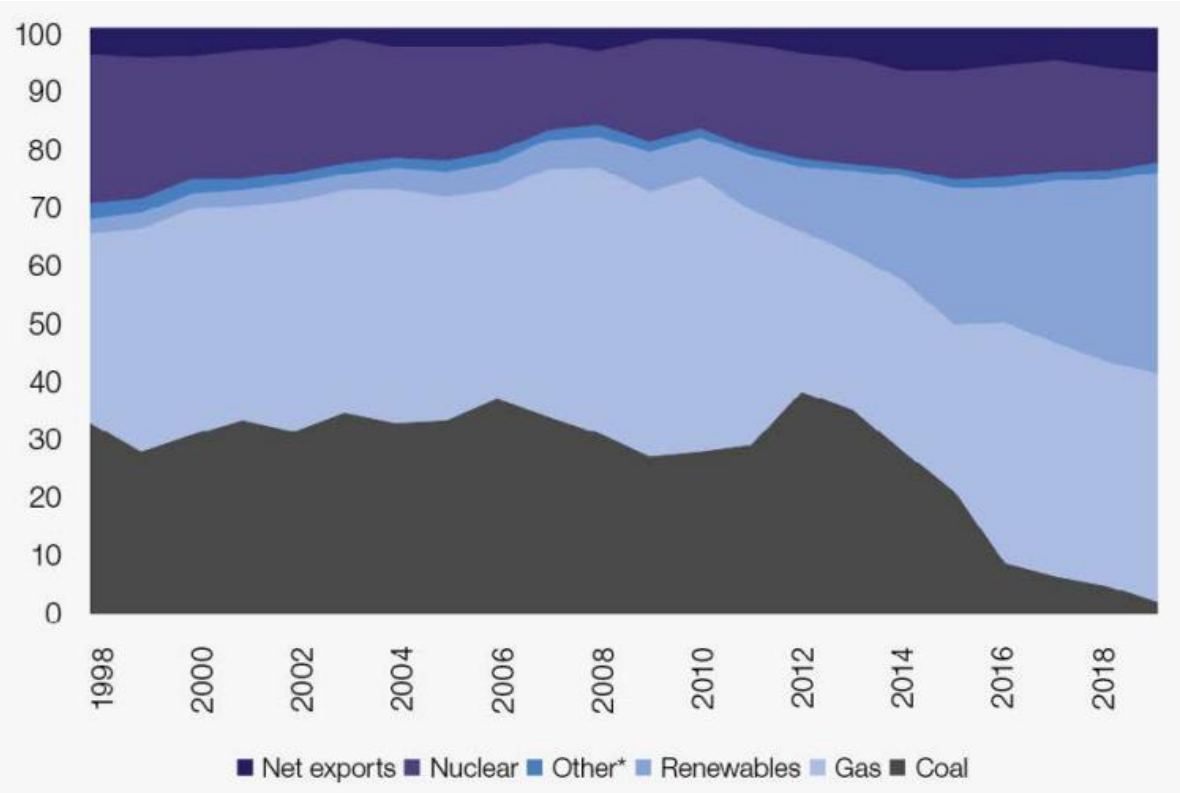
THE UK RENEWABLES SECTOR

3.2.2. The government has recently stated its intention to transform the energy system, in Draft EN-1 (published September 2021), which sets out the government's proposed future energy. This means tackling emissions whilst continuing to ensure secure and reliable supply, and affordable bills for households and businesses (paragraph 2.3.5 of Draft EN-1, 2021). Key to this is the decarbonisation of the UK's energy supply.

3.2.3. In 1990, fossil fuels provided nearly 80% of the UK's electricity supply, whereas by 2020, over half of its power came from low-carbon technologies (HM Government, 2020a). The rapid growth of renewables has a been a crucial feature of this transformation. Renewable capacity has grown fivefold since 2010, driven by the deployment of wind, solar and biomass.

3.2.4. Renewables now account for over one third of electricity generation, up from 7% in 2010. Yet, this green revolution has been delivered without disruption to the reliability of our electricity supply and the scale of deployment has contributed to a significant reduction in the cost of renewables.

Plate 3.2 - Change in UK Power Supply 1998 – 2019



*Other includes oil, pumped storage, and other thermal generation

Source: (HM Government, 2020a)

THE BIOMASS SECTOR

3.2.5. Biomass offers a significant source of renewable and low carbon energy. It involves the combustion of material of recent biological origin derived from plant or animal matter. The biomass used for heat and power usually falls into one or more of three categories (EN-3, 2011, paragraph 2.5.5):

a. Biomass sourced from conventional forestry management including sustainably managed forests, sawmill residues (often processed to produce wood pellets), and parts of trees unsuitable for the timber industry;

b. Biomass from agricultural crops and residues, including crops grown primarily for use in energy generation and agricultural residues such as straw, husks and kernels; and

c. Biomass from biodegradable waste and other similar materials including sewage sludge, animal manure, waste wood from construction, and food waste that would otherwise be disposed of in landfill.

3.2.6. Unlike coal, this is a renewable resource through replanting and regrowth as a continual cycle (EN-3, 2011, section 2.5). The government notes that whilst energy is required to grow, harvest and transport it, biomass is considered to be low carbon, providing that the biomass has been cultivated, processed and transported with due

consideration of sustainability (EN-1, 2011, paragraph 3.4.3). For this reason, the government support the use of biomass as a significant source of renewable and low carbon energy (EN-1, 2011, paragraph 3.4.3).

3.2.7. The government's support for biomass, both generally, and in the context of its relationship to carbon capture, is clearly set out in Draft EN-1, which states at paragraph 2.5.1:

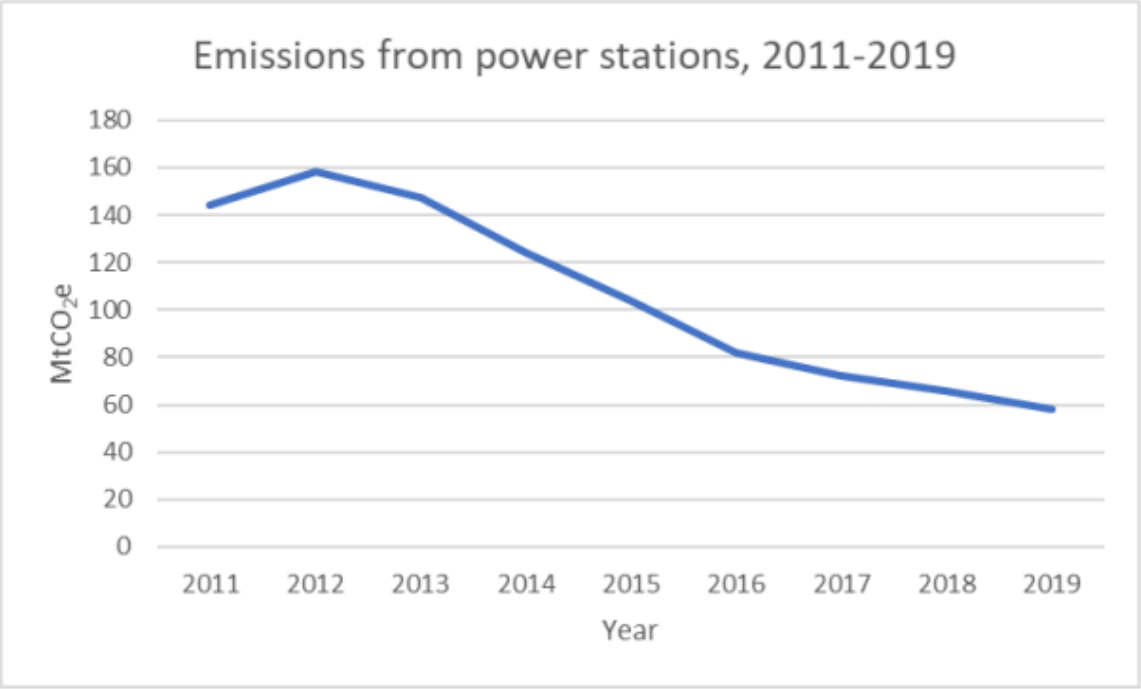
> "The combustion of biomass (fuels of recent biological origin as described in paragraph 2.6.1 below) for electricity generation plays an important role in meeting the UK's energy needs and supports the decarbonisation of the sector. It also has a potentially significant role in supporting delivery towards the UK's net zero target when combined with carbon capture and storage".

DECARBONISATION AND THE CARBON CAPTURE SECTOR

3.2.8. To meet net zero by 2050, the government recognises that a step change is required in terms of the decarbonisation of the energy system (Draft EN-1, 2021, paragraph 2.3.2).

3.2.9. Progress is being made. Since the designation of the original EN-1, overall GHG emissions from the power sector have more than halved, from circa 145 Metric tons of CO_2 equivalent ('$MtCO_2e$') in 2011 to circa 60 $MtCO_2e$ in 2019 (see **Plate 3.3**). This is mainly due to the proportion of renewable generation increasing from 9% to 37% between 2011 and 2019, whilst the proportion of electricity generation from coal reduced from 27% to 2% over the same period (Draft EN-1, 2021, paragraph 2.4.1).

Plate 3.3 - GHG Emissions from Power Stations 2011-2019



Source: (Draft EN-1, 2021)

3.2.10. To reduce carbon emissions from the combustion of fuel, Carbon Capture and Storage ('CCS') technologies can be used. Draft EN-1 (2021) states that CCS enables up to 90% of the CO_2, which otherwise would be released to the atmosphere, to be captured, compressed and transported to a storage point in deep geological formations, such as depleted oil and gas fields and saline aquifers. In the UK, the majority of locations thought to be best suited to storage of CO_2 are located offshore. Note, the technology which the Applicant proposes to install as part of the BECCS at Drax project is designed to remove approximately 95% of the CO_2 from the flue gas emitted from two of the four generating units, which may be able to exceed the expectations set out in Draft EN-1.

3.2.11. When the Overarching National Policy Statement for Energy ('EN-1') was originally published in 2011, CCS was an emerging technology which had not yet been demonstrated at commercial scale on a power station. EN-1 highlighted the importance the Government placed on demonstrating CCS, and the potential deployment of this technology beyond the demonstration stage (EN-1, 2011, paragraph 3.6.5).

3.2.12. In the recently updated Draft EN-1 (2021), the government states that new CCS infrastructure will be needed to ensure the transition to a net zero economy. This is because it will be difficult to completely decarbonise all sectors of the economy, with aviation and agriculture viewed as particularly challenging. Where sectors are not completely decarbonised, negative emissions will be needed to offset the residual emissions in those sectors. As such, the government consider negative emissions using CCS infrastructure to be essential to meet the net zero target (Draft EN-1, 2021, paragraph 3.5.7).

3.2.13. There is a broad international consensus that CCUS has a vital future role in reducing emissions (HM Government, 2017, Amended 2018). The government recognise that the exact technology and energy mix in 2050 cannot be known now, so the path to net zero will need to respond to the innovation and adoption of new technologies over time (HM Government, 2021b). However, the government expects that CCUS will need to be relied upon to meet demand across sectors and to remain low carbon.

3.2.14. In October 2021, the East Coast Cluster ('ECC') was named as one of the UK's first CCUS clusters following a successful bid to BEIS. Once operational, the cluster has the potential to transport and securely store nearly 50% of all UK industrial cluster CO_2 emissions – up to 27 million tonnes of CO_2 emissions a year by 2030. ECC would be led by the Northern Endurance Partnership, supporting both the Net Zero Teesside and Zero Carbon Humber (of which BECCS forms part) industrial decarbonisation proposals.

3.3. LOCAL AREA CONTEXT

3.3.1. The Proposed Scheme is located in the local authority area of Selby District Council ('SDC'), within the North Yorkshire County Council ('NYCC') area, in the Yorkshire and the Humber region. North Yorkshire Council, a single new council for everyone in North Yorkshire, will be formed in April 2023, replacing the current county council and seven district and borough councils. The administrative boundary of East Riding of Yorkshire ('ERoY') is approximately 1.7 km to the east of the existing Drax Power Station. The nearest settlements are the villages of Drax (approximately 700 m south east of the Order Limits (document reference 2.1)); Long Drax (approximately 900 m north east of the Order Limits); Hemingbrough (approximately 2 km north of the Order Limits); and Camblesforth (approximately 1 km south west of the Order Limits).

3.3.2. There are a variety of land uses surrounding the site including private properties, community facilities, businesses, and agricultural land.

DRAX POWER STATION

3.3.3. Drax Power Station was originally built, owned and operated by the Central Electricity Generating Board. It had a capacity of just under 2,000 megawatts ('MW') when Phase 1 was completed in 1975, increasing to 4,000 MW from six coal-fired units after the construction of Phase 2 in 1986. It is now owned and operated by Drax Power Limited (the Applicant).

3.3.4. Drax Power Limited has already made a material contribution to the decarbonisation of the UK's energy system, converting four of its coal power units to biomass since 2013. The two remaining coal units (units 5 and 6) stopped generating electricity commercially in March 2021 and will cease operations entirely prior to works to construct the Proposed Scheme commencing. The use of biomass pellets reduces Drax Power Station's carbon emissions by 80% compared to coal, and the biomass sourcing policy used by Drax Power Limited goes beyond the stringent requirements outlined by both Ofgem and the EU. This is evident when comparing the average biomass supply chain GHG emissions at Drax Power Station which were 100 $kgCO_2e$ / MWh in 2021 and 109 $kgCO_2e$ / MWh in 2020 (reference to the Drax ESG Data Supplement 2021 document, enclosed) to the GHG emissions from electricity generated from coal in the UK which is circa 1018 $kgCO_2e$ / MWh as set out in the Department of Energy & Climate Change (DECC) report Life Cycle Impacts of Biomass Electricity in 2020 (reference to the DECC 2014 document, enclosed). The DECC report notes that the government has set limits for biomass emissions of 285 $kgCO_2e$/MWh from 2020, 200 $kgCO_2e$/MWh from 2025 and 180 $kgCO_2e$/MWh from 2030. On this measure, Drax is clearly meeting the limits and also benefitting the climate by increasingly burning biomass instead of coal. This is verified by an independent assessment by Bureau Veritas UK Limited (**Appendix A**), which confirmed that nothing indicated that the GHG emissions data (of 109 $kgCO_2e$/MWh in 2020) was not fairly stated in all material respects. The conversion from coal to biomass was a world first which created a robust and resilient global supply chain for sustainable biomass.

3.3.5. Drax Power Station plays a central role in producing the UK's electricity, providing the most renewable power of any single location in the UK, some 14 terawatt-hours (TWh) or enough electricity to power the equivalent of four million homes. Drax Power Station provides 6% of the country's electricity needs and generated 12% of the UK's renewable power in 2021 (Drax, 2022).

3.3.6. Since January 2019, Drax Power Limited has been trialling bioenergy with carbon capture technology. In 2019, it became the first power generator in the world to capture CO_2 from a 100% biomass feedstock using BECCS. Drax Power Limited is now ready to employ the negative emissions technology at scale and Drax Group Plc want the company to become carbon negative by 2030. Drax Power Limited propose to install carbon capture technology on up to two of the four generating units which use biomass to produce renewable electricity, which is designed to remove approximately 95% of the CO_2 from the flue gas emitted from those units. This would mean it becomes the UK's first negative emissions power station from 2027.[3]

3.4. POPULATION AND LABOUR FORCE

3.4.1. Nomis data has been sourced for Selby (Nomis, 2020a) and North Yorkshire (Nomis, 2020b). The resident population of Selby District was 91,700 residents in 2020, making it the fourth most populous of the seven local authority areas in North Yorkshire.

3.4.2. The working age population estimate is similar to the North Yorkshire and Great Britain averages, with 61.1% of Selby District residents aged between 16-64, compared to 62.1% in North Yorkshire and 62.4% in Great Britain. Of the working age population in Selby District, 78% were economically active; in line with both North Yorkshire (77.1%) and Great Britain (78.5%) levels.

3.4.3. The proportion of people aged between 16-64 in Selby District holding NVQ1 and above is 83.3%; broadly in line with the North Yorkshire (86.4%) and the Great Britain (87.7%) averages. It is notable however, that those people achieving degree level qualifications (NVQ4 and above) in Selby District (29.3%) is somewhat lower than both the North Yorkshire (37.0%) and Great Britain (43.1%) averages. Overall, this suggests a slightly lower skilled workforce within Selby District compared to the region and wider national levels.

3.5. EMPLOYMENT

3.5.1. The NOMIS Job Densities Report (Nomis, 2020a), is available on a Local Authority-wide and sub-regional level and indicates the availability of employment and labour demand. As of 2020, the job density level (i.e., the ratio of total jobs to the population aged 16-64) in Selby District was 0.75. This is slightly lower than the averages

[3] Further detail on the Proposed Scheme is set out in the Planning Statement.

across North Yorkshire (0.79) and Great Britain (0.84) and indicates slightly fewer employment opportunities within Selby District when compared with the region.

3.5.2. The service sector (Industry Sectors G-S) accounts for 64.7% of jobs, with the second largest proportion of jobs in the Manufacturing sector (23.5%); notably higher than the proportion within the Yorkshire and the Humber Region (11.4%) and in England as a whole (7.9%).

3.5.3. In 2020, the number of jobs identified in the Business Register and Employment Survey (BRES) before Selby District were 34,000, 73.5% of which were full-time and 26.5% part-time. Drax Power Station is a key employer within the region, directly employing over 700 employees on-site, and supporting over 4,200 indirect jobs in the Yorkshire and the Humber region (Drax, 2022).

4. NEED FOR THE PROPOSED SCHEME

4.1.1. The Government considers that, without significant amounts of new large-scale energy infrastructure, the objectives of its energy and climate change policy cannot be fulfilled. EN-1 (2011) therefore states that substantial weight should be given to the consideration of need in the decision-making process (paragraph 3.2.3). It adds that the weight which is attributed to considerations of need in any given case should be proportionate to the anticipated extent of a project's actual contribution to satisfying the need for a particular type of infrastructure.

4.1.2. As set out below, national, international and local policy establishes a clear identified need for CCUS. There is a clear need for BECCS technology and this project, BECCS at Drax, in order to contribute to satisfying the overall need for CCUS, which is detailed in this section.

4.1.3. Also, of particular relevance and to be afforded substantial weight is the urgency of the need with the aim for CCUS in place by 2030 being central to government policy (HM Government, 2021b).

4.2. LEGISLATION, POLICY AND GUIDANCE

CLIMATE CHANGE TARGETS

4.2.1. Climate change is a global emergency that goes beyond national borders. It is an issue that requires international cooperation and coordinated solutions at all levels.

4.2.2. To tackle the potential impacts of climate change, world leaders met at the UN Climate Change Conference ('COP21') in Paris and, on 12 December 2015, signed the Paris Agreement. The legally binding international treaty on climate change was adopted by 196 Parties and entered into force on 4 November 2016. Its goal is to substantially reduce global greenhouse gas emissions to limit the global temperature increase in this century to 2°C, compared to pre-industrial levels, while pursuing efforts to limit the increase even further to 1.5°C.

4.2.3. To achieve this long-term temperature goal, countries aim to reach global peaking of greenhouse gas emissions as soon as possible to achieve a climate neutral world by mid-century.

4.2.4. The Agreement sets long-term goals to guide all nations, which includes the need to review countries' commitments every five years.

4.2.5. In November 2021, COP26 concluded in Glasgow, with every Party (representing almost 200 countries) agreeing the Glasgow Climate Pact. This global agreement will accelerate action on climate and seeks to keep alive the hope of limiting the rise in global temperature to 1.5°C. This includes commitments to move away from coal power, halt and reverse deforestation, reduce methane emissions and speed up the switch to electric vehicles.

4.2.6. In the UK, it was established in law in the Climate Change Act 2008 (2050 Target Amendment) Order 2019 that the UK must achieve net zero by 2050, i.e. where the greenhouse gases going into the atmosphere are balanced by the removal of such gases out of the atmosphere.

4.2.7. The Climate Change Act requires the UK government to set carbon budgets to act as 'stepping stones' towards the 2050 emissions target. In the Sixth Carbon Budget, the government set a target for emissions to be cut by 78% by 2035 (Committee on Climate Change, 2020), which was enacted in April 2021.

UK GOVERNMENT POLICY

National Policy Statements

4.2.8. NPS EN-1 states that energy is vital to economic prosperity and social well-being and, as such, it is important to ensure that the UK has secure and affordable energy (EN-1, 2011, paragraph 2.1.2). Government policy recognises that this requires a significant amount of infrastructure and in order to cut GHG emissions this requires major investment in new technologies.

4.2.9. The government is committed to reduce GHG emissions in order to mitigate the worst impacts of climate change – more frequent extreme weather events like floods and droughts, increased global instability, conflict, public health-related deaths and migration of people to levels beyond any recent experience (EN-1, 2011, paragraph 2.2.7).

4.2.10. The UK is choosing to largely decarbonise its power sector by adopting low carbon sources quickly. The government relies upon the private sector to deliver this necessary new infrastructure and the policy framework seeks to facilitate such proposals which constitute sustainable development. The government would like industry to bring forward many new low carbon developments (EN-1, 2011, paragraph 3.3.5), and recognise it is for industry to propose the specific types of developments that they assess to be viable (EN-1, 2011, paragraph 3.3.6). This is the nature of a market-based energy system.

4.2.11. The government supports the use of biomass as a significant source of renewable and low carbon energy (EN-1, 2011, paragraph 3.4.3). The government also supports CCS which it states has the potential to reduce carbon emissions by up to 90% (EN-1, 2011, paragraph 3.6.4). At the time of its publication in 2011, EN-1 outlined the government's position on CCS as follows:

> "The Government is leading international efforts to develop CCS. This includes supporting the cost of four commercial scale demonstration projects at UK power stations. The intention is that each of the projects will demonstrate the full chain of CCS involving the capture, transport and storage of carbon dioxide in the UK. These demonstration projects are therefore a priority for UK energy policy. The demonstration programme will also require the construction of essential infrastructure (such as pipelines and storage sites) that are sized and located both for the purpose of the demonstration programme and to take

account of future demand beyond the demonstration phase. The IPC should take account of the importance the Government places on demonstrating CCS, and the potential deployment of this technology beyond the demonstration stage, in considering applications for consent of CCS projects and associated infrastructure" (EN-1, 2011, paragraph 3.6.5).

4.2.12. Further detail on nationally significant renewable energy infrastructure was set out in EN-3. This highlighted that the combustion of biomass for electricity generation is likely to play an increasingly important role in meeting the UK's renewable energy targets (EN-3, 2011, paragraph 2.5.1). It identified that biomass generating stations can have CCS technology applied and highlighted the need for proposed biomass plants at (or over) 300 MW of generating capacity to have Carbon Capture Readiness ('CCR') (EN-3, 2011, paragraph 2.5.28).

4.2.13. The BECCS at Drax project utilises technology which is designed to remove approximately 95% of the CO_2 from the flue gas emitted from Units 1 and 2, which may be able to exceed the expectations set out in EN-1.

Emerging National Policy Statements

4.2.14. The Energy White Paper: Powering our Net Zero Future (December 2020) sets out how the Government can make the transition to clean energy by 2050. This centres upon a shift away from fossil fuels to clean energy technologies, in line with the government's objectives to ensure the UK's supply of energy remains secure, reliable, affordable and consistent with our net zero target. Whilst the need for the energy infrastructure set out in the energy NPSs remains (except in the case of coal-fired generation which is actively being phased-out), the white paper commits to a review of the existing energy NPSs to ensure they reflect current energy policy, and to ensure the planning policy framework can deliver investment in the infrastructure needed for the transition to net zero.

4.2.15. As referred to above, this commitment was delivery upon by the consultation that ran from 6 September 2021 to 29 November 2021 on the revised energy NPSs that support decisions on major energy infrastructure.

4.2.16. The emerging NPS cannot be accorded significant weight as it has not yet been adopted. However, as it has been prepared more recently, it indicates the Government's intended direction of travel for future energy policy, and therefore is an important and relevant consideration which the Secretary of State may take into account, and place the appropriate amount of weight on, pursuant to section 104(2)(d) of the Planning Act 2008.

4.2.17. Draft EN-1 (2021) provides an update from EN-1 (2011) with the key shift being from the target for a reduction of at least 80% of Greenhouse Gas ('GHG') emissions by 2050, to net zero by 2050, and 78% by 2035, compared to 1990 levels (Draft EN-1, 2021, paragraph 2.2.4).

4.2.18. It states that in order to meet this more ambitious target:

> "We need to transform the energy system, tackling emissions while continuing to ensure secure and reliable supply, and affordable bills for households and businesses. This includes increasing our supply of clean energy from renewables, nuclear and hydrogen manufactured using low carbon processes (low carbon hydrogen) and, where we still emit carbon, developing the industry and infrastructure to capture, transport and store it" (Draft EN-1, 2021, paragraph 2.3.5).

4.2.19. Draft EN-1 also reinforces the government's commitment to boost growth and productivity across the whole of the UK, creating new high-quality jobs in the UK's clean energy industry (Draft EN-1, 2021, paragraphs 2.1.2, 2.3.3).

4.2.20. It confirms that our future energy system will come from a range of sources (including renewables, nuclear, low carbon hydrogen) and will use a range of new technologies and innovative infrastructure projects including CCS.

4.2.21. In Draft EN-1, the need for biomass with or without CCS is established as urgent. The government also states that new CCS infrastructure will be needed to ensure the transition to a net zero economy (Draft EN-1, 2021, paragraph 3.5.1). It has clarified that CCS infrastructure will be needed to capture and store CO_2 from the use of bioenergy (i.e., BECCS) and that this could be new or re-purposed infrastructure.

4.2.22. The UK is well-placed to use BECCS infrastructure, with an estimated 78 billion tonnes of CO_2 storage capacity under the seabed of the UKCS, which is one of the largest potential CO_2 storage capacities in Europe (Draft EN-1, 2021, paragraph 3.5.2).

4.2.23. In Draft EN-1, the government states that new CCS infrastructure will be needed to ensure the transition to a net zero economy. This is because it will be difficult to completely decarbonise all sectors of the economy, with aviation and agriculture viewed as particularly challenging. Where sectors are not completely decarbonised, negative emissions will be needed to offset the residual emissions in those sectors. As such, the government consider negative emissions using CCS infrastructure to be essential to meet the net zero target (Draft EN-1, 2021, paragraph 3.5.7).

4.2.24. Draft EN-1 clarifies why new CCS infrastructure will be needed to ensure the transition to a net zero economy:

> "It will be difficult to completely decarbonise all sectors of the economy, with aviation and agriculture viewed as particularly challenging. Where sectors are not completely decarbonised, we will need negative emissions to offset the residual emissions in those sectors. Capturing and storing emissions from bioenergy or directly from the air using CCS infrastructure provides a source of negative emissions. There are other sources of negative emissions, such as afforestation, but all of these are limited in some way and negative emissions using CCS infrastructure are viewed as essential for delivering our net zero target" (Draft EN-1, 2021, paragraph 3.5.7).

4.2.25. Finally, Draft EN-1 also recognises that meeting the government's energy objectives necessitates a significant amount of energy infrastructure, including the infrastructure needed to capture, transport and store CO_2 (Draft EN-1, 2021, paragraph 2.3.3).

National Planning Policy Framework

4.2.26. Whilst the DCO Application must be determined in accordance with the relevant NPSs, under section 104(2)(d) of the PA 2008, regard must also be had to any other matters of importance and relevance, which includes relevant policies in the National Planning Policy Framework ('NPPF').

4.2.27. The NPPF was originally adopted in March 2012 and most recently updated in July 2021. It sets out the Government's planning policies for England and forms the basis for applications to be considered under the Town and Country Planning Act (1990). Paragraph 5 of the NPPF makes it clear that the document does not contain specific policies for NSIPs and that such applications are to be determined in accordance with the decision-making framework set out in the PA2008 and relevant NPSs, as well as any other matters that are considered *"both important and relevant"*. However, paragraph 5 goes on to confirm that matters that can be considered to be both important and relevant to NSIPs may include the NPPF and the policies within it.

4.2.28. One of the guiding principles of the NPPF is that the purpose of the planning system is to contribute to the achievement of sustainable development (paragraph 7). This means pursuing three interdependent objectives: economic, social and environmental. The environmental objective focuses on protecting and enhancing our natural, built and historic environment, which includes moving to a low carbon economy (paragraph 8). This is reiterated in chapter 14, which offers support for renewable and low carbon energy and associated infrastructure (paragraph 152).

4.2.29. The policies contained within the NPPF are expanded upon and supported by the online Planning Practice Guidance ('PPG'), which was originally published in March 2014 and is updated regularly with changes to government guidance. This states the importance of increasing the amount of energy from renewable and low carbon technologies, reiterating the policies in the NPPF and NPSs. It aims to ensure the UK has a secure energy supply, reduce greenhouse gas emissions to slow down climate change, and stimulate investment in new jobs and businesses (PPG Paragraph: 001 Reference ID: 5-001-20140306, Revision date: 06 03 2014).

OTHER UK GOVERNMENT SUPPORT FOR CARBON CAPTURE

4.2.30. The government's commitment to net zero and decarbonisation of the energy sector through carbon capture technologies is reinforced through a number of statements and publications.

4.2.31. The government have been exploring ways to deploy CCUS at scale in the UK since 2007 and committed to further investment to bring forward technology through the public and private sectors working together, as set out in its Clean Growth Strategy (HM Government, 2017, Amended 2018). It recognised that such investment can demonstrate international leadership in carbon capture usage and storage (CCUS)

and help to make such technologies a viable future option (p.70). The Strategy set out the ambition to support CCUS clusters.

4.2.32. The government subsequently published Clean Growth: The UK Carbon Capture Usage and Storage deployment pathway: An Action Plan in 2018 (HM Government, 2018) which was designed to enable the development of the first CCUS facility in the UK, commissioning from the mid-2020s. This would help the UK to meet its ambition of having the option to deploy CCUS at scale during the 2030s, subject to costs coming down sufficiently.

4.2.33. The Action Plan states that:

> "Carbon dioxide transport and storage infrastructure in the UK, incorporating pipelines and / or shipping, is likely to be essential to support the decarbonisation of our industrial centres and deployment of CCUS at scale" (p.38).

4.2.34. The government are advised by The Committee on Climate Change ('CCC') (an independent, statutory body established under the Climate Change Act 2008) on setting and meeting carbon budgets and preparing for climate change. In May 2019, CCC published a report Net Zero: The UK's contribution to stopping global warming (Committee on Climate Change, 2019). It states that to achieve UK net-zero by 2050, CCS is a necessity not an option. The report notes that global progress with regards to CCS has also been slow, and whilst 43 large-scale projects are operating or under development around the world, none are in the UK. On an international level, the UK has been sharing knowledge on CCS with the EU and other countries including China and Mexico, including support on practical aspects of delivering large-scale commercial CCS projects and leading an international working group to accelerate deployment of CCS. The report recommended the government taking the lead on infrastructure development, with long-term contracts and investment encouraged.

4.2.35. The CCC report does raise a challenge presented by land-based greenhouse gas ('GHG') removal, such as risks relating to the very large-scale use of BECCS, which may create conflicts with other uses of land such as food production. The report suggests that this can be reduced by using a range of technologies to remove GHGs from the atmosphere and supporting global development patterns that reduce the need for GHG removal. This potential challenge is also raised in the IPCC's recent report (IPCC, 2022), which notes that, whilst BECCS is an integral part of all widely accepted pathways to holding global temperature rise to 1.5°C, it requires large areas of land which can conflict with the need to produce food and protect biodiversity. This stems from the change of land use for the supply of biomass to feed BECCS technologies as planting trees in places where they do not naturally grow can have serious environmental impacts. As a project, BECCS at Drax does not create conflicts with other uses of land. The proposed BECCS technology makes use of the existing power station site and associated biomass supply ie is a retrofitting project rather than the construction of a new power station and establishment of a completely new biomass supply chain. Drax Power Station uses sustainably-sourced

biomass, primarily sustainable wood pellets from working forests, primarily in the US South but also in Europe, Canada and South America, to generate low-carbon, renewable electricity. These are established sustainably managed working forests and the Applicant monitors trends in forest cover and land use within its catchment areas for sustainable biomass to ensure that biomass demand is not causing a negative climate impact as a result of land use change.

4.2.36. The government subsequently prepared the aforementioned Energy White Paper: Powering our Net Zero Future (HM Government, 2020a). The action plan seeks to *"stimulate the continued deployment of key low-carbon technologies in the near term, while encouraging innovation in the technologies of the future which offer the greatest potential to reduce costs"* (p.45). This highlights the government's support for carbon capture, stating the UK is in a strong position to become a global technology leader in CCUS. It outlines the government's ambition to capture 10 Mt of CO_2 a year by 2030 (the equivalent of four million cars' worth of annual emissions) and that the industry could support up to 50,000 jobs in the UK by 2030. The government is therefore investing up to £1 billion to support the establishment of CCUS in four industrial clusters in the UK, one of which is the ECC. The document sets out the government's clear support for this form of development:

> "We will support the deployment of at least one power CCUS project, to be operational by 2030, and put in place the commercial framework required to help stimulate the market to deliver a future pipeline of power CCUS projects" (p.47).

4.2.37. It should be recognised that, without planning for any specific technology solution or mix of energy sources, the government state in the Energy White Paper (HM Government, 2020a) that a low-cost, net zero consistent system is likely to be composed predominantly of wind and solar energy. However, they recognise that ensuring the system is also reliable means intermittent renewables need to be complemented by technologies which provide power, or reduce demand, when weather conditions mean that wind or solar power is not being generated. This includes CCS.

4.2.38. This is considered further in the government's Department for Business, Energy and Industrial Strategy's (BEIS) Modelling 2050: Electricity System Analysis, published in 2020. This comprises an analysis of the electricity system in 2050 to understand the potential impact of decarbonisation on system costs (BEIS, 2020). Electricity will be increasingly important in supporting delivery of net zero and understanding the ways in which the system can deliver more electricity whilst producing fewer carbon emissions, and the relative cost of doing so, is central to developing an energy strategy to support delivery of net zero. This affirms the view that all low-cost solutions will likely also require other forms of low-carbon generation to provide resilience during extended periods of low wind and solar irradiation. The modelling does not specifically consider certain renewable generation technologies such as BECCS, hydro, wave and tidal albeit all may have a role to play in reaching net zero.

4.2.39. This is reflected in the Special Report of the Intergovernmental Panel on Climate Change (IPCC) on the impacts of Global Warming of 1.5°C which anticipates that 85% of power will come from renewables, like wind and solar, by 2050 (IPCC, 2019). The other 15% will therefore need to come from reliable technologies like sustainable biomass. The use of BECCS therefore ensures renewable energy with negative emissions and a reliable supply.

4.2.40. More recently, in March 2021 the government published the Industrial Decarbonisation Strategy (HM Government, 2021a) which considers how the full range of the UK's industry sectors can reflect the net zero target. The indicative roadmap to net zero UK industry includes a goal to deliver four low carbon capture clusters in the next decade and at least one, which may be the world's first, net zero industrial cluster by 2040. The government will support the deployment of CCUS on industrial sites in clusters to capture and store around 3 $MtCO_2$ per year by 2030, with the strategy seeking to deliver. It prioritises the delivery of clusters first, which would minimise the cost of the transition, allowing multiple industrial sites to use such infrastructure. The clustering approach allows for locations to access dedicated pipe networks for CO_2 and hydrogen transport and storage, and can decarbonise with CCUS, hydrogen or BECCS. BECCS position as part of the East Coast cluster therefore accords with this strategy.

4.2.41. The government plans to publish a Bioenergy Strategy in 2022, which will establish the role which BECCS can play in reducing carbon emissions across the economy. It notes that current evidence strongly suggests that, given limited sustainable biomass supply, the government may need to prioritise the use of biomass where it can be combined with CCS (i.e., BECCS), resulting in negative emissions.

4.2.42. The government subsequently published the "Net Zero Strategy: Build Back Greener" (2021) which reinforces the need to fully decarbonise the power system by 2035, subject to security of supply (HM Government, 2021b). The power sector generated 11% of UK emissions in 2019, and it is considered that its decarbonisation may rely on the use of BECCS. The urgent need for such projects is established, which notes:

> "By 2030 we envisage significant deployment of mature BECCS technologies and commercial scale deployment of DACCS. BECCS technologies will include retrofit applications in the power and industry sectors. BECCS applications in the power sector could be deployed by the late 2020s".

4.2.43. This Strategy details the government's aim to accelerate decarbonisation in 'clusters', It outlines that the East Coast Cluster (of which BECCS forms part) will act as an economic hub for green jobs in line with the government's ambition to capture 20-30 Mt CO_2 per year by 2030. The government's investment in CCUS is supported by its commitment for two industrial clusters by mid 2020s (of which the Humber is one), and for four sites by 2030, capturing up to 10 Mt CO_2 emissions per year.

4.2.44. In April 2022, the UK Government published the British Energy Security Strategy ('BESS'), in response to the rising global energy costs, pushed higher by the conflict in Ukraine, and the UK's dependence on imported oil and natural gas, which has

ultimately resulted in an increase in the cost of living in the UK (HM Government, 2022a). The policy paper sets out how the UK Government are *"going to bring clean, affordable, secure power to the people for generations to come"* and *"build a British energy system that is much more self-sufficient"*. As part of the '10 Point Plan', the government outlines it will invest in CCUS, which to date has included:

a. Committed £1 billion in public investment to decarbonise our industrial clusters

b. Announced the first 2 clusters in the north-east (Teesside and the Humber) and the north-west (Merseyside).

c. Launched phase 2 of the Industrial Energy Transformation Fund, allocating £60 million to decarbonisation technologies, with a further £100 million delivered in May and October this year.

4.2.45. Regarding oil and gas, the BESS states that the UK must utilise its North Sea reserves in order to reduce reliance on imported fossil fuels and use the empty caverns for carbon dioxide storage. It also highlighted the objective to deliver CCUS clusters to futureproof the North Sea. The BESS anticipates that 95% of British electricity generation could be low carbon by 2030, and that the target to fully decarbonise Britain's electricity supply by 2035 is still achievable, subject to the security of the supply. The British Energy Security Strategy seeks to achieve *"20 to 30 MT CCUS target"* by 2030, assisted through a £1 billion commitment to delivering four CCUS clusters by 2030. The Proposed Scheme will significantly assist in meeting this objective, permanently removing at least 8 Mt CO_2 from the atmosphere each year ie at least 40% of the 20 Mt lower-threshold government target for 2030.

4.2.46. Alongside this, the government published the CCUS Investor Roadmap which outlines the joint government and industry commitments to the deployment of CCUS in the UK and sets out the approach to delivering four CCUS low carbon industrial clusters, capturing 20-30 Mt CO_2 per year across the economy by 2030 to help meet the UK's 2050 net zero target (HM Government, 2022b). It highlights how the UK is well-placed to act as a leader for CCUS, including world leading research institutions (the highest density of world class universities), 5.6m people employed in engineering, and an estimated 78 Gt CO_2 storage capacity (one of the largest in Europe and enough to support the UK's demands for hundreds of years).

4.2.47. The government is also developing business models for industrial and power CCUS, low-carbon hydrogen production and CO_2 Transport and Storage in order to support CCUS projects and stimulate private sector investment, with the aim to finalise business models in 2022.

4.2.48. There is evidently a clear direction of travel for the UK government's support for CCUS and BECCS as part of achieving net zero. The above statements and publications provide a supportive context for BECCS at Drax.

LOCAL PLANNING POLICY

4.2.49. The Proposed Scheme is solely within Selby District and North Yorkshire County. Whilst the relevant NPSs comprise the primary planning framework against which to

assesses the application, local planning policies are also of importance and relevance.

4.2.50. The statutory development plan for the area of relevance to the Proposed Scheme currently comprises the following documents:

a. The Selby District Core Strategy Local Plan (adopted October 2013);

b. The saved policies of the Selby District Local Plan (adopted February 2005);

c. The saved policies of the North Yorkshire Waste Local Plan (adopted 2006); and

d. The saved policies of the North Yorkshire Minerals Local Plan (adopted 1997).

4.2.51. The Core Strategy is the long-term strategic vision for how the District will be shaped by setting out a number of broad policies to guide development.

4.2.52. Whilst the Core Strategy and other local planning policies are over eight years old, thereby pre-dating international agreements and the latest government papers and strategies, they provide useful context as to the long-established need for reducing carbon emissions.

4.2.53. The Core Strategy sets out the aim to reduce carbon emissions in the District (paragraph 1.17) and to ensure that new development contributes to mitigating and adapting to the future impacts of climate change (paragraph 3.4). One of the objectives is to make best use of natural resources by promoting low-carbon and / or renewable energy operations (paragraph 3.5, Objective 15).

4.2.54. The Core Strategy also recognises the importance of the energy sector to the economy of the District, highlighting Drax Power Station as a major employer, which contributes to national energy infrastructure as well as the local economy. It explicitly states that Drax Power Station has the potential for future development of renewable and low carbon energy, recognising the importance of its geographical location in terms of a direct connection to the National Grid. The Core Strategy notes *"It is recognised that there is a need for further investment in energy infrastructure in line with national policy as a prominent contributor to economic prosperity. Supporting the energy sector will assist in reinvigorating, expanding, and modernising the District's economy"* (paragraph 6.32). The use of biomass as a renewable, low carbon energy source is supported (Policy SP16).

4.2.55. In recognising the support for the technology at a national level, the Core Strategy states that CCS will be generally supported in line with national policy, where appropriate alongside other lower carbon schemes and environmental improvement schemes at the District's power stations (paragraph 7.23, Policy SP17). SDC recognises that the District is particularly well-placed to exploit opportunities for carbon capture (paragraph 7.42) and appreciates that such proposals for CCS may be of such a scale as to be determined at national level rather than the District Council as planning authority (paragraph 7.43).

4.2.56. The national goal of reducing CO_2 emissions is a long-standing policy target, forming a primary objective to the promotion of sustainable development in the Selby District Local Plan (2005, paragraph 2.10). This has translated as long-standing support for

renewable energy technologies such as biomass (previously supported by Policy ENV6, which has now been superseded by the Core Strategy) and additional industrial development at Drax Power Station (Policy EMP10).

4.2.57. SDC is preparing a new Local Plan to establish a vision and framework for future growth of the district. The Preferred Options consultation was held from January to March 2021 and a further consultation on additional sites proposed for allocation was undertaken from August to September 2021. The Publication version of the new Local Plan is currently under preparation.

4.2.58. The Preferred Options consultation document identifies the need for CCS as a vital technology in tackling climate change (paragraph 4.49) and recognises that the area's existing energy infrastructure provides a key opportunity to enable the District to be at the forefront of developing and utilising such technologies (paragraph 3.49). It highlights Drax Power Station's carbon capture pilot scheme and offers support to projects which bring forward the ambitions of creating a zero carbon sub-region.

4.2.59. Indeed, as part of the vision for 2040, the Preferred Options document states:

> "There will have been a significant shift in employment sectors as a result of the District's role as a key driver in the reduction of carbon emissions through carbon capture technologies and the skills in the local workforce from mining and energy production will be built upon to support the success and expansion of clean industries and jobs in low carbon and renewable energy… Significant progress will have been made towards meeting objectives for net zero carbon emissions".

4.2.60. Whilst this early iteration of the new Local Plan is subject to change, these ambitions align with the Government's policies towards supporting net zero carbon emissions.

4.3. CONTRIBUTION OF BECCS TO CCS NEED

4.3.1. The government's Clean Growth: The UK Carbon Capture Usage and Storage deployment pathway: An Action Plan in 2018 (HM Government, 2018) notes BECCS and direct air capture are considered the most scalable Greenhouse Gas Removal (GGR) technologies. Drax Power Station's collaboration on Europe's first BECCS Pilot is identified as a key opportunity for the industrial strategy in the Action Plan.

4.3.2. The Action Plan draws upon a report by The Royal Society and Royal Academy of Engineering (The Royal Society and Royal , 2018) which advised the Government:

> "…that even with very stringent emissions reductions across all sectors of the economy, around 130 Mt CO_2 / year would need to be accounted for by negative emissions technologies if the UK were to reach net zero emissions in 2050. To achieve this, they concluded that BECCS and Direct Air Capture at a significant scale – over 50% of the total amount of negative emissions – would be required."

4.3.3. BECCS at Drax will permanently remove at least 8 Mt CO_2 from the atmosphere each year ie over 6% of the 130 Mt CO_2 government target.

4.4. SITE SPECIFIC CONSIDERATIONS AND CONTRIBUTION TO LOCAL TARGETS

4.4.1. BECCS at Drax is a direct response to the identified need for negative emissions technologies in order to combat climate change.

4.4.2. The Proposed Scheme would involve the installation of post-combustion carbon capture technology to capture CO_2 from up to two existing 660-megawatt electrical ('MWe') biomass power generating units at the Drax Power Station (Unit 1 and Unit 2). The Proposed Scheme is designed to remove approximately 95% of the CO_2 from the flue gas from these two Units. The CO_2 captured will undergo processing and compression before being transported via a proposed new pipeline for storage under the southern North Sea. Transport and storage infrastructure will be consented through separate applications submitted by other parties (not the Applicant) (see further details on the transport and storage infrastructure below).

4.4.3. This need is established and urgent at the national and international level. Should BECCS at Drax be approved, this would be operational, and Drax Power Station would become the UK's first negative emissions power station by 2027. This will assist the government to meet the upcoming target from the Sixth Carbon Budget to cut emissions by 78% by 2035, and ultimately is an important contribution towards net zero and limited global warming.

4.4.4. In 2019, Drax Group Plc became the first company in the world to announce an ambition to become carbon negative. The target for this to be achieved by 2030 is dependent on BECCS. Converting the existing biomass units to BECCS would also secure the long-term future of the site.

4.4.5. There is currently a window of opportunity to deliver a crucial element of the UK's decarbonisation infrastructure. Baringa has modelled the case for deploying BECCS at Drax from 2027 (Baringa, 2021), with the summary presentation of their findings provided at **Appendix B**, which has concluded that:

a. Achieving the net-zero target without BECCS-Power would cost the UK an additional £26bn, or £30 a year for every household.

b. Not deploying BECCS at Drax in 2027 would cost the UK an additional £13bn and make achieving the 5th and 6th carbon budgets significantly harder.

4.4.6. The Baringa report confirms that without technologies like BECCS, it is not likely to be possible to hit the necessary targets of net-zero by 2050. The report states that early deployment of negative emissions technologies is deemed to be critical to achieving the UK's intermediate carbon targets. It is also deemed to be cost-effective if deployed before 2030 and such early deployment could enable BECCS-Power to scale up ahead of 2050.

4.4.7. The cost of retrofitting carbon capture technologies at Drax Power Station is significantly lower than developing a new-build BECCS facility.

4.4.8. Currently there are very few biomass-fired generating units and indeed Drax Power Station is the largest in the UK. A number of organisations and agencies have generated future models and scenarios which would hit the Government's net-zero target by 2050; the most credible scenario and those developed by the likes of the CCC all point to a need for BECCS and indeed upwards of 14 Mt of carbon captured through BECCS technology (Committee on Climate Change, 2019).

4.4.9. The Proposed Scheme would also assist in realising the ambitions of public-private partnerships in the region.

4.4.10. It will assist the York & North Yorkshire Local Enterprise Partnership (LEP) in realising its ambition to become carbon negative by 2040 (York & North Yorkshire LEP, 2021). The LEP is a public-private partnership charged with driving economic growth and prosperity across York and North Yorkshire.

4.4.11. It will also respond to The Yorkshire and Humber Climate Commission's (YHCC) call for meaningful climate leadership and the public and private sectors to deliver "significant, tangible contributions", as set out in The Climate Change Action Plan (Yorkshire & Humber Climate Commission, 2021). YHCC is an independent advisory body set up to bring senior leaders from the public, private and third sectors across the region. The Action Plan outlines a regional target to reach net zero by 2038, which includes supporting the "greatly accelerated decarbonisation of energy supply". It outlines support for CCUS, noting:

> "Carbon capture, utilisation and storage (CCUS) could make a significant contribution to the decarbonisation of some key industrial sectors where they cannot decarbonise through electrification or switching to green hydrogen".

Humber Industrial Cluster and East Coast Cluster

4.4.12. Drax Power Ltd is one of eight industry partners in the Humber Industrial Cluster project team; a group working together to develop the Humber Industrial Cluster Plan that will facilitate CO_2 emitting industries in Yorkshire and the Humber to achieve net zero by 2040 (Humber Industrial Cluster Plan, 2022). The Humber Industrial Cluster is the largest CO_2 emitting cluster in the UK, with 50% more emissions than the next largest of the six major industrial clusters nationally.

4.4.13. The Humber Industrial Cluster plan was set up in January 2021 and presents a key opportunity to achieving net zero emissions over the next 20 – 30-year period. Drax Power Ltd is a key participant and contributor in achieving this target which has local, regional, and national significance. Drax Power Station would act as an anchor project for Zero Carbon Humber, protecting and creating tens of thousands of jobs, kickstarting a new green industry for the region.

4.4.14. The East Coast Cluster is made up of both Zero Carbon Humber and Net Zero Teesside, supported by the Northern Endurance Partnership. The Humber and Teesside industrial clusters make up 50% of the UK's industrial emissions, so decarbonising these regions will have the biggest impact on the UK reaching net zero.

5. ECONOMIC BENEFITS OF THE PROPOSED SCHEME

5.1. NATIONAL ECONOMY

5.1.1. The Drax at BECCs project will be leading the way in the use of CCS technology in the UK. This type of technology is scalable and can be implemented elsewhere across the UK and worldwide. Whilst the UK have been collaborating with other nations in the development of CCS, other nations have been developing or operating large-scale projects. The UK risks being left behind as the EU, Norway, Canada, Australia, Japan, China and the US pursue carbon capture technologies and attract global investment in the industries of the future.

5.1.2. The installation of BECCS to an existing power plant is deliverable and value for money, particularly in comparison to a new CCS power plant project and other negative emissions technologies, as explained below.

5.1.3. CCC estimates the average cost of BECCS power generation at £120 / tonne of CO_2 in 2020, compared to £430 / tonne of CO_2 for direct air capture (Committee on Climate Change, 2020). Whilst these costs are forecast to fall over the next 30 years, BECCS currently offers the best value for money.

5.1.4. The use of BECCS technology on a biomass power plant is also beneficial, not least due to the renewable nature of the resource compared to fossil fuels, but also as the provision of a form of energy which is reliable and not dependent upon the weather. The IPCC anticipate that 85% of power will come from renewables, like wind and solar, by 2050 (IPCC, 2019). The other 15% will therefore need to come from reliable technologies like sustainable biomass. The use of BECCS therefore ensures renewable energy with negative emissions and a reliable supply.

5.1.5. The delivery of BECCS at an existing power plant is therefore a national first, which helps reinforce the UK as a key player in the development and delivery of carbon capture technology. This will ensure continued economic growth and investment in the UK power and renewables sector, whilst responding to the key global challenge of zero emissions.

5.1.6. Drax Power Limited is part of the Coalition for Negative Emissions, a multinational collection of organisations from a diverse range of industries with a shared ambition: to create a sustainable economy while helping protect the environment. A report published in 2021 (Coalition for Negative Emissions, 2021) recognises that the UK is uniquely positioned to lead a global scale-up of negative emissions solutions, given its advantages of the availability and ambition of its supply capacity, its leading role as a financial intermediation services provider, and examples of emerging ambitious demand from companies based in the UK. The report identifies the potential benefits of doing so, estimating that between 50,000 and 100,000 total new jobs could be created in the UK by 2050 by scaling up negative emissions projects to achieve the 1.5°C pathway need, based on the CCC's Sixth Carbon Budget. The report recognises that carbon removal presents a viable path for job protection, as 70 to 90 per cent of the skills required by a STEM oil and gas professional are highly relevant

to those required in engineered removal. It also notes that engineered removal is likely to occur in clusters that have historically experienced lower economic growth and where current jobs have higher transition risks, such as in the Humber. In doing so, the UK can develop engineering and construction capabilities around CCS delivery, which would create additional jobs and add economic value.

5.2. LOCAL AND REGIONAL ECONOMY

5.2.1. Investment associated with the Proposed Scheme will generate considerable economic benefits during both the construction and operational phases through the provision of BECCS technology. This will help deliver net zero emissions within the UK, and the provision of new infrastructure at Drax Power Station and the associated employment from constructing and operating the BECCS facility.

5.2.2. Employment growth will also arise locally through manufacturing services and suppliers to the construction process (indirect or supply linkage multipliers). Part of the income of the construction workers and suppliers will also be spent in the SDC and wider Yorkshire and the Humber region, generating further employment (induced or income multipliers) within the wider area.

5.2.3. The economic impacts of the Proposed Scheme can be expressed in terms of both employment generation and GVA – that is, the economic contribution (in terms of output) to the economy.

5.2.4. At the local level (focused on the Drax Power Station facility and its immediate surroundings) it is understood that the BECCS at Drax project could generate an annual average GVA during the construction phase (Vivid Economics Limited, 2021) of:

a. £300 million direct GVA;

b. £100 million in indirect GVA; and

c. £130 million in induced GVA (see **Appendix C**).

5.2.5. At the regional level (the Humber Industrial Cluster), BECCS at Drax is one of a number of CCS and hydrogen technologies being deployed. In partnership with other Humber Industrial Cluster projects could support an annual average of £1.1 billion GVA in the period to 2031 (Vivid Economics Limited, 2021).

SUPPORTING LOCAL JOBS

5.2.6. Temporary employment created by the construction phase will provide a significant short-term boost to the local and regional economy. The Applicant aims to source 80% of the construction materials and services needed to deliver BECCS at Drax from the UK supply chain. It is the intention of the Applicant that where possible, further opportunities for lower skilled jobs and potential engagement with local employment brokers or colleges, dependent on the contractor hired and in-work training and apprenticeship schemes which may be offered by them. At this stage of the Proposed Scheme, a contractor is yet to be determined. However, this commitment will be set out in a S106 Agreement should the DCO be made, as set

out in the Development Consent Obligation (section 106) Heads of Terms (document reference 7.1).

5.2.7. At the local level, it is estimated that the BECCS at Drax project could generate annual average construction employment (Vivid Economics Limited, 2021) of:

a. 4000 direct;

b. 1,600 indirect; and

c. 2,500 induced jobs.

5.2.8. Once the BECCS units are operational, up to 375 Full Time Equivalent ('FTE') employees will be employed at the site (a combination of retained and new jobs), and a total of 960 indirect and 1,800 induced FTE jobs will be created.

5.2.9. At the regional level (the Humber Industrial Cluster), BECCS at Drax could create an estimated 47,800 operational direct, indirect and induced FTE jobs (Vivid Economics Limited, 2021). With BECCS being an emerging and scalable technology within a growing renewables and CCS section, this is a skills transition offering long-term viability of jobs supported by the government (HM Government, 2021a).

5.3. REGENERATION OF THE AREA

5.3.1. The region, like much of the industrial North, has suffered from the decline of heavy industries such as steel, oil and chemicals and experienced associated economic decline. The long-term vision of decarbonising the region and growing its low carbon industry provides significant economic and employment opportunities (Vivid Economics Limited, 2021). As noted above, the Coalition for Negative Emissions report recognises that the UK workforce is well-placed to adapt to the emerging carbon removal job market and the Humber cluster has historically experienced lower economic growth (Coalition for Negative Emissions, 2021). Construction of the Proposed Scheme has the potential to increase confidence in the renewables and CSS markets, particularly investment and help raise the confidence of other investors within such markets, particularly given the rapidly growing CCS and hydrogen market and demand for associated industries such as the manufacture of component parts for facilities. BECCS at Drax will support the Humber Industrial Region as a focus for future development towards achieving net zero, and intensification of related employment activity.

5.3.2. Drax Power Ltd is expected to 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 (Vivid Economics Limited, 2021). There is the potential to raise the skills and qualifications of the local population. The construction of BECCS at Drax has the potential to develop local skills and increase

[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).

qualifications through specialised vocational training for construction employees at the site.

6. SOCIAL AND COMMUNITY BENEFITS OF THE PROPOSED SCHEME

6.1. PROVIDING OPPORTUNITIES FOR LOCAL PEOPLE

6.1.1. The Proposed Scheme will deliver new employment space by an existing major local employer, which (dependent on the future development of Drax Power Station and BECCS capacity) may offer further flexibility to increase employee capacity in the future.

6.1.2. A range of initiatives are being promoted by the Applicant, which will provide opportunities for local people to access employment and training opportunities. The use of local suppliers and contractors will also be encouraged, to ensure that benefits for local people are maximised. This will significantly help the local and regional economy through a post-COVID economic recovery.

6.1.3. By promoting the use of local suppliers and contractors, the Applicant will ensure that local people and businesses have the ability to benefit from the Proposed Scheme during the construction phase. Dependent on the contractor appointed, there may be opportunities for local people to access training opportunities through working in partnership with key local stakeholders (such as Jobcentre Plus, local colleges, business alliances and skills improvement programmes), providing opportunities for training in the construction industry and equipping them with a skilled trade. This is set out in the Heads of Terms and will be developed through the S106 Agreement. The Heads of Terms for the S106 Agreement seeks to capture the below:

- **a.** Ecological off-site improvement works (new and enhanced woodland and scrub) at Arthurs Wood and Fallow Field, providing ecological mitigation and supporting the delivery of biodiversity net gain (BNG) for the Proposed Scheme.
- **b.** Local Employment Scheme – to be submitted for approval prior to commencement (including the use of local suppliers and contractors, and developing opportunities for local people to access training opportunities)
- **c.** Contribution to the enhancement of off-site River Habitat, if relevant mitigation and enhancement cannot be provided (or fully provided) within the Order Limits.

6.1.4. Drax Power Limited would also look to other community initiatives, to raise awareness of CCS and BECCS with local schools and colleges. Drax Power Limited have already been involved in the STEM elements with schools and colleges and can look at opportunities to do so as this project moves forward.

6.1.5. Representatives of Drax Power Station attend a quarterly meeting with the Parish Council at the power station and would incorporate an agenda item relating to BECCS construction and development, which could also be open to invitation to NYCC and SDC, in order to maintain a continued line of communication with the community.

6.2. SUSTAINABLE DEVELOPMENT

6.2.1. The BECCS at Drax project is designed to remove approximately 95% of the CO_2 from the flue gas emitted from two of the four generating units, resulting in overall negative emissions of greenhouse gases (Drax, 2021). The biomass used in the generating units will continue to be sourced from sustainably managed forests. Therefore, it will contribute to the carbon negative production of electricity.

6.2.2. The IPCC says 85% of power will come from renewable sources by 2050, with the remaining 15% required through reliable technical solutions such as sustainable biomass. The BECCS at Drax project complements both nature-based and technical solutions and will be key for continuing sustainable development and achieving net zero emissions at the local, regional and national scale.

6.2.3. Further detail is provided in Chapter 7 of this Report.

7. ENVIRONMENTAL BENEFITS OF THE PROPOSED SCHEME

7.1. MEETING ENERGY TARGETS

7.1.1. As set out in Chapter 4 of this report, experts, including the CCC, agree that negative emissions technologies, including BECCS, are essential to fight the climate crisis and meet net zero targets by 2050. Early action is also necessary in order to meet the government target in the Sixth Carbon Budget, for emissions to be cut by 78% by 2035 (Committee on Climate Change, 2020).

7.1.2. BECCS at Drax's technology could ensure the generation of renewable power to millions of UK homes and businesses, whilst capturing 8 million tonnes of carbon from the atmosphere each year at Selby alone. Drax Power Station could deliver over 15% of the negative emissions the Climate Change Committee says the UK requires from BECCS to achieve net zero. The 8 Mt CO_2 / year would provide 6% of the 130 Mt CO_2 / year required by the government to reach net zero (the detailed analysis of this is provided in Chapter (Greenhouse Gases) 15 of the ES (document reference 6.1.15). This would equate to at least 40% of the 20 Mt lower-threshold government target for 2030 set in the British Energy Security Strategy.

7.1.3. This is a technology which can be applied elsewhere with BECCS at Drax demonstrating UK leadership and kick-starting a CCS revolution, which will be needed globally to meet climate targets.

7.1.4. There is enough sustainable biomass globally for BECCS to provide up to 4GT of negative emissions a year. This is the equivalent of four times the annual CO_2 emissions from the global commercial aviation sector.

7.1.5. Drax Power Limited is at the forefront of tackling climate change and has already transformed the UK's biggest power station to become Europe's largest decarbonisation project. Drax Power Station has been at the heart of the UK's energy system for decades and has a proven track record in innovation and decarbonisation, operating as a world leader in sustainable biomass.

7.1.6. Nature-based solutions alone will not meet the UK's net zero target. Intermittent wind and solar alone cannot meet fluctuating demand and keep the electricity network stable. As such, we need multiple solutions and technologies. BECCS complements both nature-based solutions and technical solutions, such as Direct Air Capture. The IPCC says 85% of power will come from renewables, like wind and solar, by 2050. The other 15% will therefore need to come from reliable technologies like sustainable biomass.

7.2. OTHER BENEFITS

7.2.1. Conversion of Drax Power Station's existing biomass units can pave the way to a substantial programme of new build BECCS and other negative emissions

technologies. Additionally, Drax Power Station's consistent demand for biomass can aid in the development of sustainable biomass supply chains (Baringa, 2021).

7.2.2. The Proposed Scheme also constitutes the reuse of previously developed land, rather than undeveloped land of greater ecological and wider environmental value. All of the proposed infrastructure will be within the curtilage of Drax Power Station. The land is currently partially occupied by the Flue Gas Desulphurisation ('FGD') plant and buildings, including Absorber buildings 1-6, which are no longer in operation and redundant. The demolition of these buildings was granted planning permission in January 2021 (LPA Ref: 2020/0994/FULM).

7.2.3. The Applicant is also targeting the delivery of 10% BNG as part of the Proposed Scheme and are exploring how this may best be delivered. Habitat creation and enhancement will be delivered in the Habitat Provision Area (within Order Limits) and Off-site Habitat Provision Area (outside Order Limits), with proposals contained in the Outline Landscape and Biodiversity Strategy (document reference 6.6). In addition, The Applicant is continuing to explore how permanent and temporary habitat loss required for delivery of the Proposed Scheme may be limited. Opportunities for delivering BNG in relation to watercourse habitats are also being explored.

8. CONCLUSIONS

8.1.1. There is clear national planning policy support for major energy infrastructure, CCS and reliable renewable energy supplies which can help us to reach net zero. This culminates in an overarching need for the use of BECCS technology and the Proposed Scheme. The Overarching National Policy Statement (EN-1) recognises the contribution CCS can make to meeting emissions targets.

8.1.2. This is a game-changing negative emissions technology that permanently removes CO_2 from the atmosphere and will be needed globally to meet climate targets. This is an opportunity for the UK to become a global leader in developing climate-saving technologies, led by Drax Power Limited who have been trialling this technology and are ready to deploy it at an industrial scale. Drax Power Station is the largest power station in the UK and can be modified to create negative emissions and renewable energy using BECCS, as a first step towards the development of a global negative emissions industry.

8.1.3. The first phase of BECCS at Drax will permanently remove at least 8 million tonnes of CO_2 from the atmosphere each year, making Drax Power Station the world's largest single site carbon capture project.

8.1.4. BECCS at Drax will accelerate clean growth, protect British industries across the Humber, create thousands of new green jobs.

8.1.5. We must act now. Without BECCS at Drax in the 2020s, the cost for the UK to deliver net zero will soar. There is an urgent need for this type of project and this Statement demonstrates the significant benefits which would arise should the application be approved.

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APPENDICES

APPENDIX A - INDEPENDENT LIMITED ASSURANCE STATEMENT, BUREAU VERITAS

INDEPENDENT LIMITED ASSURANCE STATEMENT

To: The Stakeholders of Drax Group plc

Introduction and objectives of work

Bureau Veritas UK Limited ('Bureau Veritas') has been engaged by Drax Group plc ("Drax") to provide limited assurance over its average biomass supply chain greenhouse gas (GHG) emissions data as reported in its Annual report and accounts 2020 ('the Report'). This Assurance Statement applies to the related information included within the scope of work described below. The aim of this process is to provide assurance to Drax's stakeholders over the accuracy, reliability and objectivity of the reported information.

Scope of work

The scope of our work was limited to assurance over Drax's 'average biomass supply chain GHG emissions' data included within the Report for the period 1st January to 31st December 2020 (the 'Selected Information').

Reporting Criteria

The Selected Information are reported according to Drax's internal reporting guidelines on GHG emissions data reporting. Biomass supply chain emissions for individual pellet plants are calculated using the Drax biomass carbon calculator, available at https://www.drax.com/sustainability/the-biomass-carbon-calculator/

Limitations and Exclusions

Our assurance process was subject to the following limitations as we have not been engaged to:

- Activities outside the defined reporting period;
- Positional statements (expressions of opinion, belief, aim or future intention by Drax) and statements of future commitment;
- Other information included in the Report other than the scope defined above.

This limited assurance engagement relies on a risk based selected sample of sustainability data and the associated limitations that this entails. The reliability of the reported data is dependent on the accuracy of metering and other production measurement arrangements employed at site level, not addressed as part of this assurance. This independent statement should not be relied upon to detect all errors, omissions or misstatements that may exist.

Responsibilities

The preparation and presentation of the Selected Information in the Report is the sole responsibility of the management of Drax.

Bureau Veritas was not involved in the drafting of the Report. Our responsibilities were to:

- Obtain limited assurance about whether the Selected Information has been appropriately and accurately prepared;
- Form an independent conclusion based on the assurance procedures performed and evidence obtained; and
- Report our conclusions to the Directors of Drax.

Assessment Standard

We performed our work to a limited level of assurance in accordance with International Standard on Assurance Engagements (ISAE) 3000 Revised, Assurance Engagements Other than Audits or Reviews of Historical Financial Information (effective for assurance reports dated on or after December 15, 2015), issued by the International Auditing and Assurance Standards Board.

Summary of work performed

As part of its independent verification, Bureau Veritas undertook the following activities:

1. Assessed the appropriateness and accuracy of the Selected Information;
2. Conducted interviews with relevant personnel of Drax;
3. Reviewed the data collection and consolidation processes used to compile the Selected Information, including assessing assumptions made, the data scope and reporting boundaries;
4. Reviewed a sample of the Selected Information against the corresponding source documentation provided by Drax; and
5. Performed a selection of aggregation calculations of the Selected Information.

The scope of a limited assurance engagement is substantially less than for reasonable assurance both in terms of the risk assessment procedures and in performing the procedures to address the identified risks.

Conclusion

On the basis of our methodology and the activities described above for the agreed scope, nothing has come to our attention to indicate that the GHG emissions data as stated below and in the Report are not fairly stated in all material respects.

Average biomass supply chain GHG emissions: 109 kgCO_{2e}/MWh of electricity

Statement of Independence, Integrity and Competence

Bureau Veritas is an independent professional services company that specialises in quality, environmental, health, safety and social accountability with over 190 years' history. Its assurance team has extensive experience in conducting verification over environmental, social, ethical and health and safety information, systems and processes.

Bureau Veritas operates a certified[1] Quality Management System which complies with the requirements of ISO 9001:2015, and accordingly maintains a comprehensive system of quality control including documented policies and procedures regarding compliance with ethical requirements, professional standards and applicable legal and regulatory requirements.

Bureau Veritas has implemented and applies a Code of Ethics, which meets the requirements of the International Federation of Inspections Agencies (IFIA)[2] across the business to ensure that its employees maintain integrity, objectivity, professional competence and due care, confidentiality, professional behaviour and high ethical standards in their day-to-day business activities. The assurance team for this work does not have any involvement in any other Bureau Veritas projects with Drax.

Bureau Veritas UK Limited

London

23rd February 2021

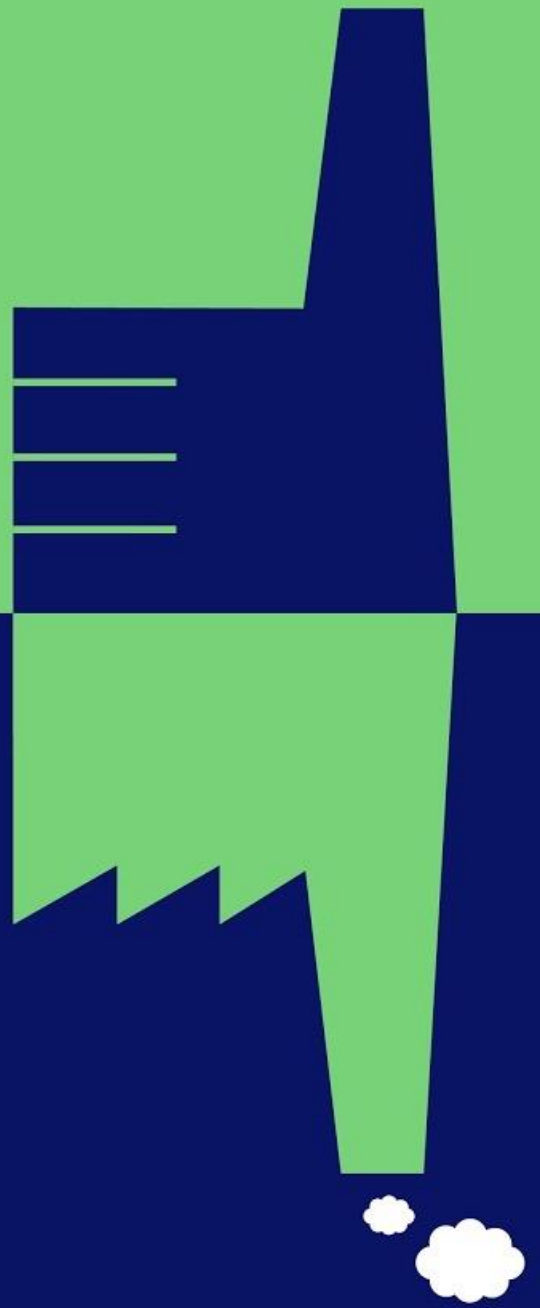
[1] Certificate of Registration available on request

[2] International Federation of Inspection Agencies – Compliance Code – Third Edition

APPENDIX B - VALUE OF BIOENERGY WITH CARBON CAPTURE AND STORAGE (BECCS) TO THE UK DECARBONISATION PATHWAY, BARINGA

Carbon Capture | by drax

Value of Bioenergy with Carbon Capture and Storage (BECCS) to the UK Decarbonisation Pathway



A vital contribution to UK decarbonisation

Drax is the largest decarbonisation project in Europe. Now we want to go further.

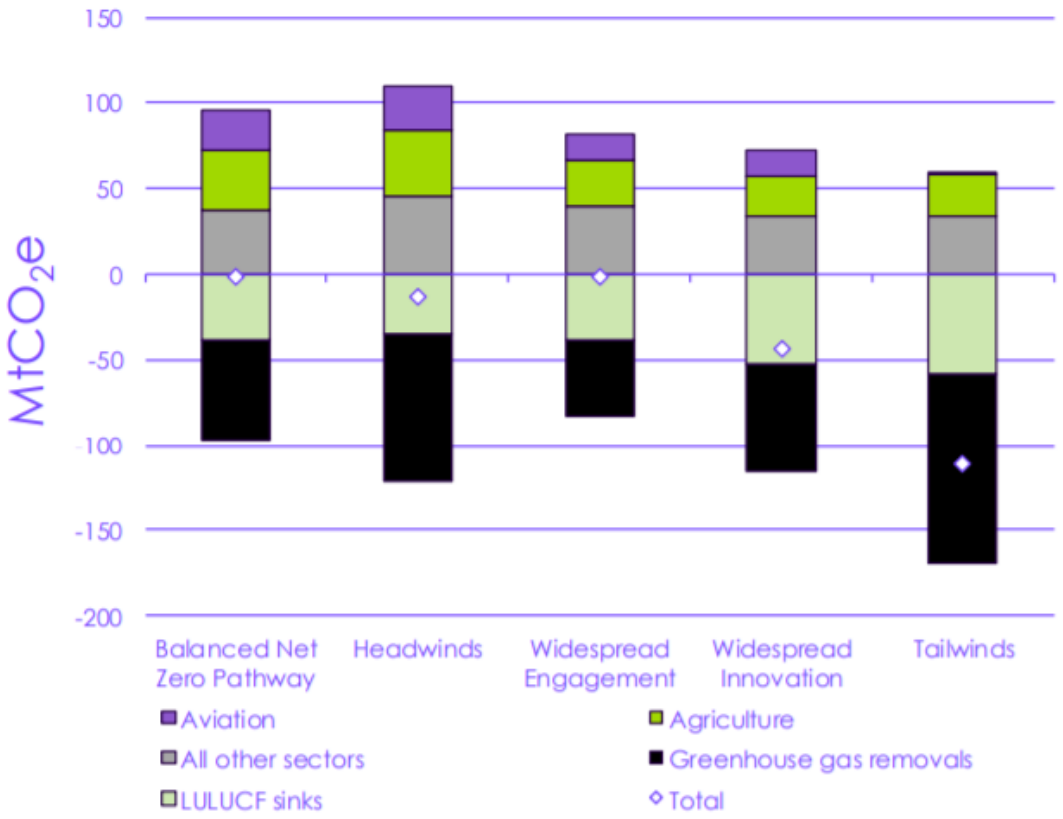
- Drax has already transformed its power station near Selby, North Yorkshire to become the largest decarbonisation project in Europe, having converted it to use sustainable biomass instead of coal.
- Now we have ambitions to go further by using bioenergy with carbon capture and storage (BECCS) to permanently remove millions of tonnes of CO_2 each year from the atmosphere.
- Drax has kickstarted the planning process to build this vital negative emissions technology, which will make a significant contribution to efforts to address climate change whilst creating thousands of new jobs and supporting a post-covid economic recovery.
- We have a unique window of opportunity to deliver a crucial element of the UK's decarbonisation infrastructure.

The need for negative emissions

To prevent harmful climate change, reducing emissions won't be enough.

- To reach net zero we need to reduce emissions across each sector of the global economy.
- But by 2050 a significant volume of emissions will still be emitted by hard-to-decarbonise sectors such as agriculture, aviation and certain heavy industries.
- To tackle climate change and reach net zero, we need to **remove carbon dioxide from the atmosphere** in order to compensate for any residual emissions.
- According to the Climate Change Committee's (CCC) 6th Carbon Budget, BECCS in power will need to remove 16-39 million tonnes of CO_2 a year by 2050 to meet net zero targets. The first phase of BECCS at Drax could deliver 8 million tonnes of CO_2 by 2030.

CCC emissions scenarios for 2050



Source: CCC 6th Carbon Budget Report

The need for BECCS

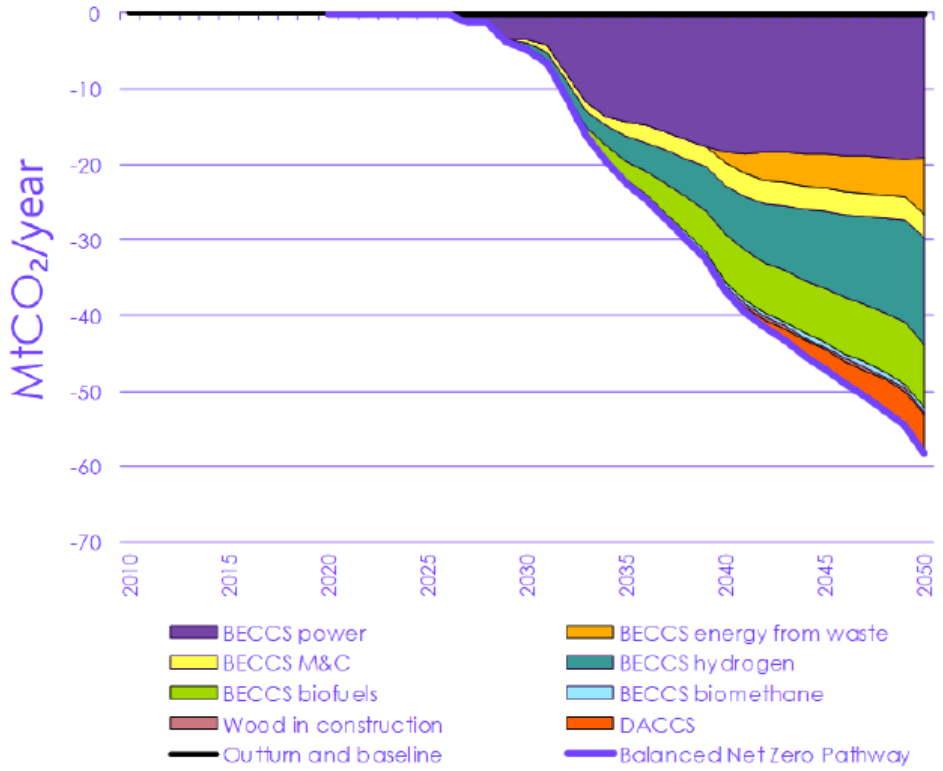
- In its “Balanced Pathway” scenario, the CCC estimates 58 million tonnes per year (mtpa) of negative emissions will be needed from greenhouse gas removals by 2050, of which 19mtpa will come from BECCS in power.
- BECCS in power is deployed from 2027 in all CCC scenarios.
- CCC scenarios have up to 39mtpa of greenhouse gas removals from BECCS power by 2050.

Table M12.1
Engineered GHG removals scenarios for the UK ($MtCO_2$/year in 2050)

	BECCS power	BECCS energy-from-waste	BECCS in industry	BECCS hydrogen	BECCS biofuels	BECCS bio-methane	DACCS	Wood in construction
Headwinds	39	10	4	23	10	0.6	0	0.4 (+1.0 in LULUCF)
Widespread Engagement	30	1	3	0	9	0.5	0	0.4 (+1.0 in LULUCF)
Widespread Innovation	16	5	3	12	11	0.5	15	0.4 (+1.0 in LULUCF)
Balanced Net Zero Pathway	19	7	3	14	8	0.6	5	0.4 (+1.0 in LULUCF)
Tailwinds	39	7	3	36	11	0.5	15	0.4 (+1.0 in LULUCF)
Baseline	0	0	0	0	0	0	0	NA

Source: CCC 6th Carbon Budget Report

Sources of abatement in the Balanced Net Zero Pathway for the GHG removals sector



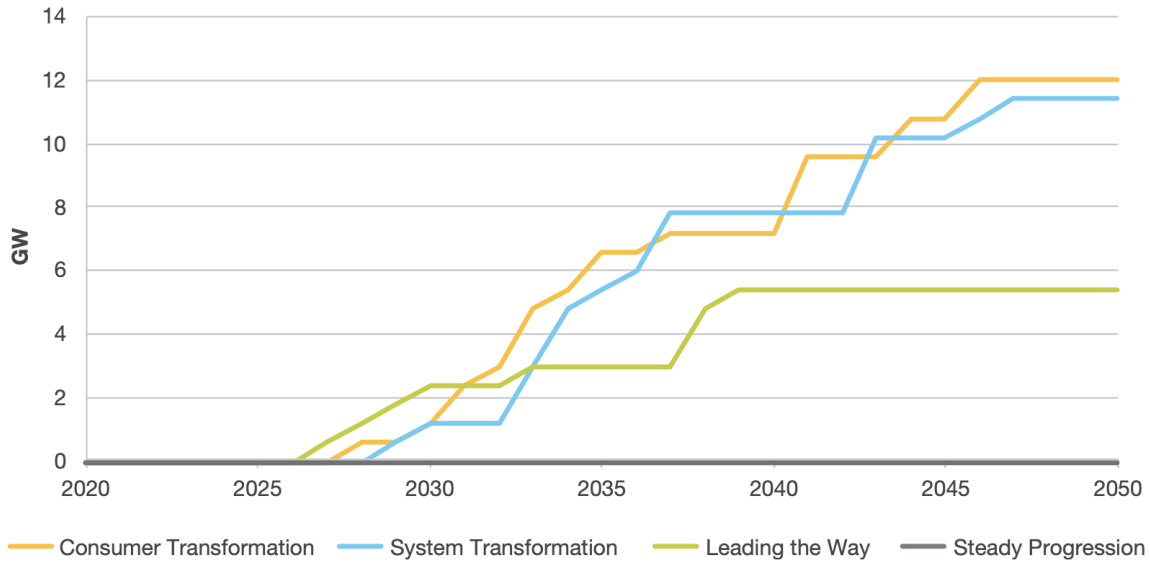
Source: CCC 6th Carbon Budget Report

BECCS-Power is needed to operate a decarbonised power grid

All National Grid's Net Zero Future Energy Scenarios deploy BECCS by 2028 and see a rapid increase in capacity in the 2030s

- This enables the power sector to be net zero by the early-mid 2030s.
- National Grid has committed to being able to run a zero carbon grid by 2025. To achieve this, it needs reliable sources of low carbon power.
- BECCS provides valuable power system services, such as inertia and voltage control, which are increasingly important as National Grid manages a power system with more intermittent renewables.

NGESO FES 2021: BECCS electricity generation capacity



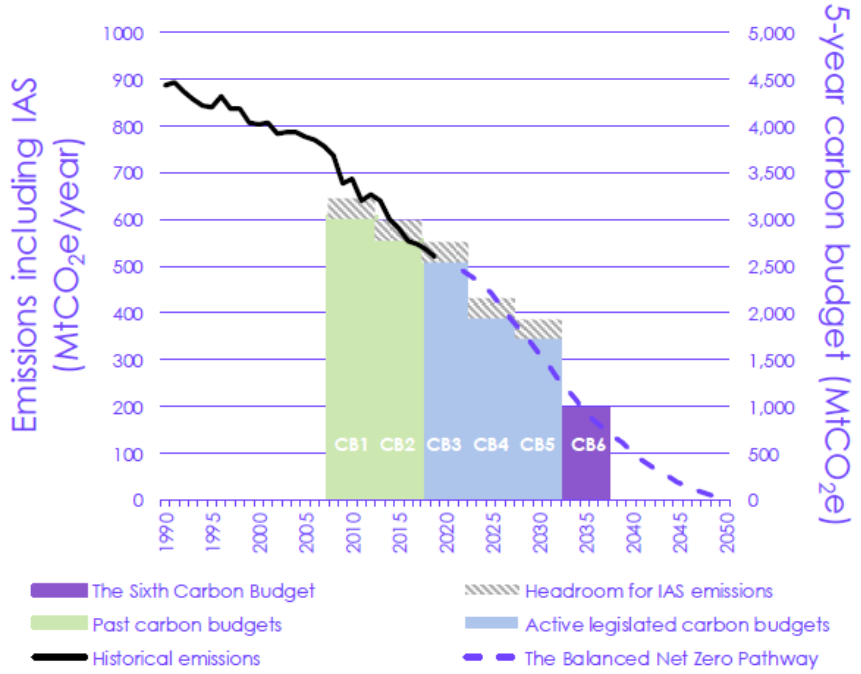
Putting the UK on track for net zero

drax

Without early deployment of BECCS, the UK's path to Net Zero is much more challenging

- Emissions have fallen by 40% in the last 3 decades – mostly from easy to achieve reductions in the power sector.
- Emissions will have to fall more quickly than the 4th and 5th carbon budgets to achieve the 6th carbon budget and net zero. This will require more action and engagement from individuals in society. Today…
  - Less than 5% of the energy used for heating homes and buildings is low carbon
  - 99% of all miles driven on UK roads are in vehicles with petrol and diesel engines
- **Deploying BECCS in 2027 would enable the Government to achieve the step change in emissions required to get from the 4th to the 5th and 6th carbon budgets,** providing headroom if other sectors of the economy prove harder and slower to decarbonise.

The recommended Sixth Carbon Budget



Source: BEIS (2020) *Provisional UK greenhouse gas emissions national statistics 2019*; CCC analysis
Notes: Emissions shown include emissions from international aviation and shipping (IAS) and on an AR5 basis, including peatlands. Adjustments for IAS emissions to carbon budgets 1-3 based on historical IAS emissions data; adjustments to carbon budgets 4-5 based on IAS emissions under the Balanced Net Zero Pathway.

Drax's 8 million tonnes of CO_2 will provide **13%** of the emission reductions required to achieve the 5th Carbon Budget

Executive Summary | Baringa Analysis

- Baringa were engaged by Drax to analyse the system value of Bioenergy with CCS (BECCS) both within the power sector and for whole system decarbonisation, as part of meeting the UK's Net Zero targets.
- They explored the role of BECCS-Power in driving cost-optimal pathways to meet net zero using three scenarios: **Central**, **Downside** and **Upside**, to test the role of BECCS-Power under different conditions.
- Key assumptions were aligned with published UK Government and Climate Change Committee (CCC) sources, in particular benchmarking results with analysis seen in the recent CCC 6th Carbon Budget publication.
- The analysis aimed to answer the following key questions:

The case for negative emissions

- To meet net zero is there significant demand for negative emissions in the energy system?
- How early do we need negative emissions?

Optimal build-out and the role of BECCS-Power

- What is the optimal build-out and role of BECCS-Power given competing abatement options?
- How do system costs change in the absence of building BECCS-Power?

The role and value of the Drax-BECCS project

- What is the role and value of the Drax-project as part of a broader need for BECCS-Power?
- How robust is the role for Drax given uncertainty around key BECCS and wider system factors?

Executive Summary | Baringa Findings

The case for negative emissions is clear

- Negative emissions are required to offset residual emissions from hard to abate sectors such as agriculture, aviation and certain heavy industries.
- Engineered solutions such as BECCS-Power can make a major contribution.
- The Government's 68% NDC commitment, alongside the findings of the CCC 6th carbon budget and the National Grid Future Energy Scenarios Report, all reinforce that **net zero is only achievable through negative emissions and BECCS-Power** in the UK.

Achieving the 5th carbon budget and net zero is significantly more expensive without Drax BECCS

- Without Drax BECCS in 2027, **it will cost the UK £13bn more to achieve the 5th carbon budget, and over £26bn more to achieve net zero. This is the equivalent of approximately £30 per year for each household in the UK, to reach net zero.**
- **If you don't deploy Drax in 2027 you have to spend more money sooner**, because of the lead times for deployment to build more wind, solar and storage 2021-27.
- **If you don't deploy Drax in 2027, the UK will be more reliant on measures that require consumer action in heat and transport** – both of which are much more challenging to achieve than a single large negative emissions project.

Drax-BECCS deployment in the late 2020s is 'no regrets'

- Drax is progressing plans to deploy carbon capture and storage on two of its biomass units, which would capture 8 million tonnes of CO_2 per year by 2030. This means **Drax could deliver 40% of the CCC's Balanced Pathway 2050 BECCS power target by 2030.**
- With an effective negative emissions policy and investment framework, the first BECCS unit could be operational by 2027.
- In all scenarios, **the decarbonisation pathway is lower cost if Drax-BECCS is deployed in 2027**.
- There are **additional innovation and learning benefits** from the early deployment of Drax-BECCS.

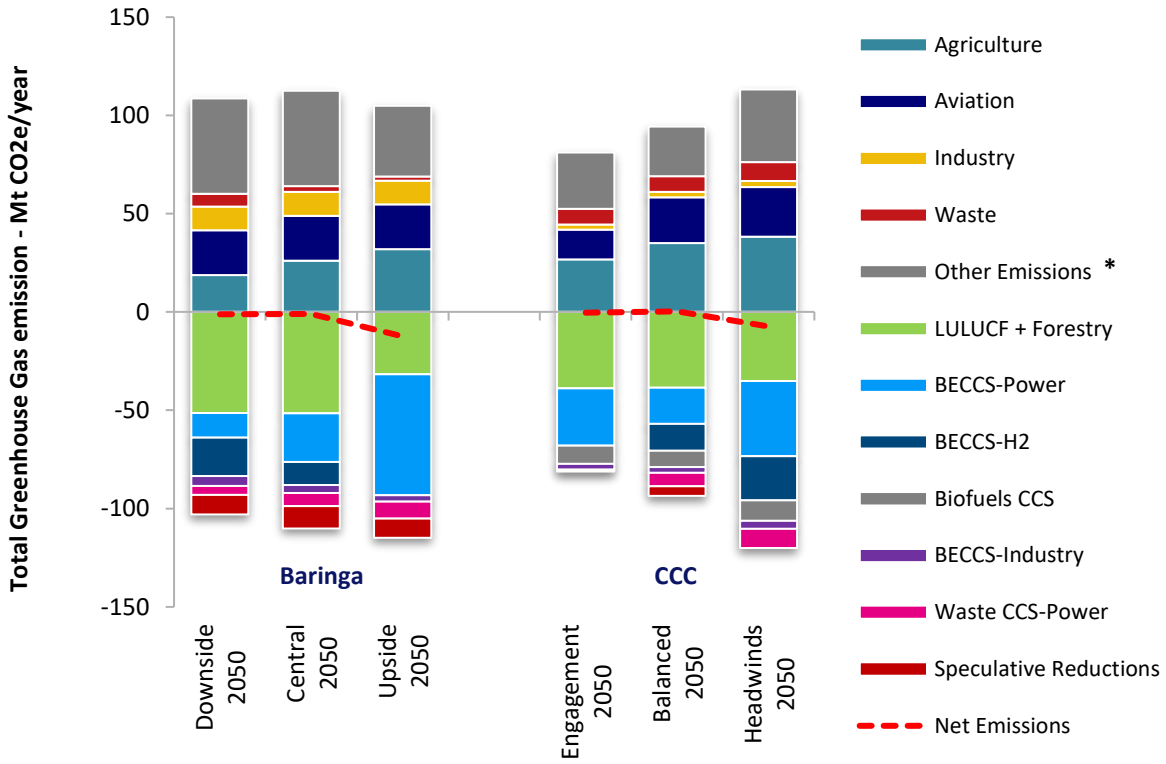
The need for negative emissions | Baringa Analysis

drax

Negative emissions are critical to achieving Net Zero.

- Negative emissions are required to offset residual emissions across the economy. Engineered solutions such as BECCS-Power can make a major contribution.
- Baringa analysis suggests there is strong demand for CO_2 removals (50-80MT CO_2) in additional to LULUCF to offset residual emissions from sectors that are harder to decarbonise.
- BECCS-Power provides a large portion of negative emissions in all cases, even in scenarios where conditions for BECCS-Power are less favourable compared to other BECCS negative emission routes.

Modelling pathways to net zero: Comparison of CCC and Baringa



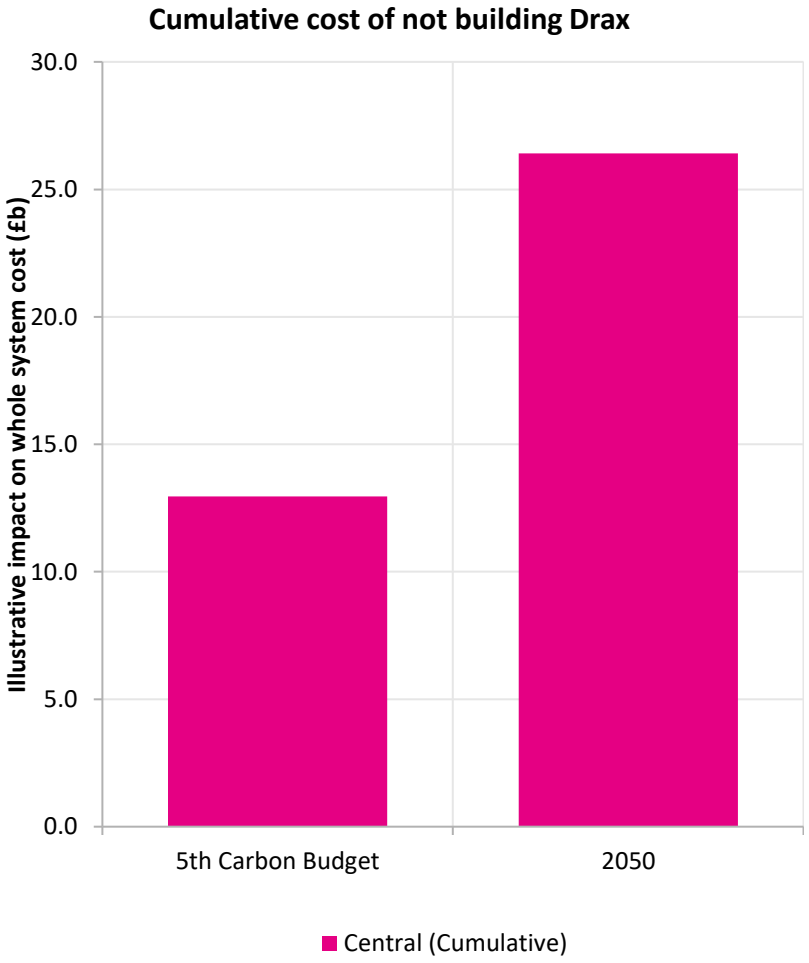
Baringa scenarios are framed by the degree to which assumptions are favourable or unfavourable for BECCS-Power, whereas CCC scenarios focus on different whole system pathways to Net Zero.

Baringa

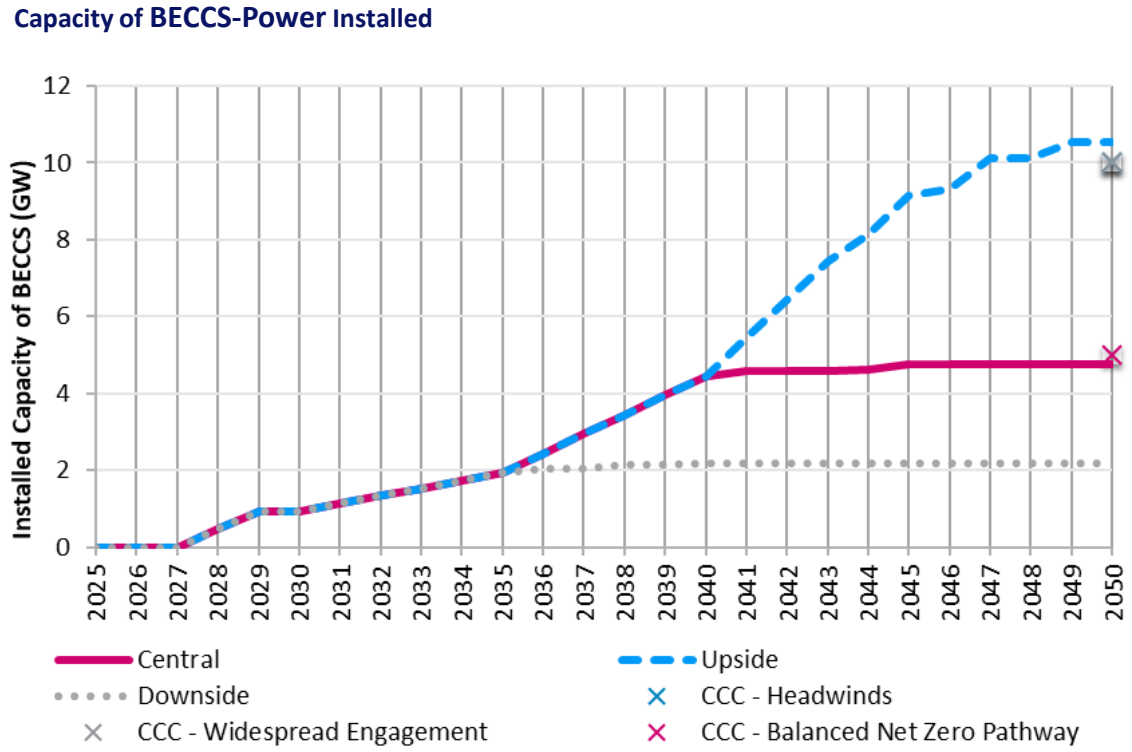
Achieving Net Zero is significantly more expensive without BECCS at Drax in 2027

It is much more challenging and more expensive to achieve the 5th carbon budget and net zero without early deployment of BECCS

- If the option to build Drax BECCS in 2027 is not taken, **it will cost the UK £13bn more to achieve the 5th carbon budget, and over £26bn more to achieve net zero.**
- **If you don't deploy Drax in 2027 you have to spend more money sooner**, because of the lead times for deployment – you have to build more wind, solar and storage in the period 2021-27.
- **If you don't deploy Drax in 2027, the UK will be more reliant on measures that require consumer action in heat and transport** – both of which are much more challenging to achieve than a single large negative emissions project delivered by a private company.



Drax BECCS in 2027 is "no regrets" in all scenarios



- Two Drax biomass units* are converted to BECCS in 2027-29 in all three scenarios. An additional 1 – 9 GW of new build BECCS is added from 2030 – 2050.
- In all cases, it is cost-effective to run the BECCS capacity at high load factors for a significant part of the pathway. In the last 10 years, some biomass is used for to BECCS hydrogen production, and BECCS in power operates more flexibly to complement intermittent renewables.

The deployment of BECCS-Power drives cost-optimal pathways to meet net zero.

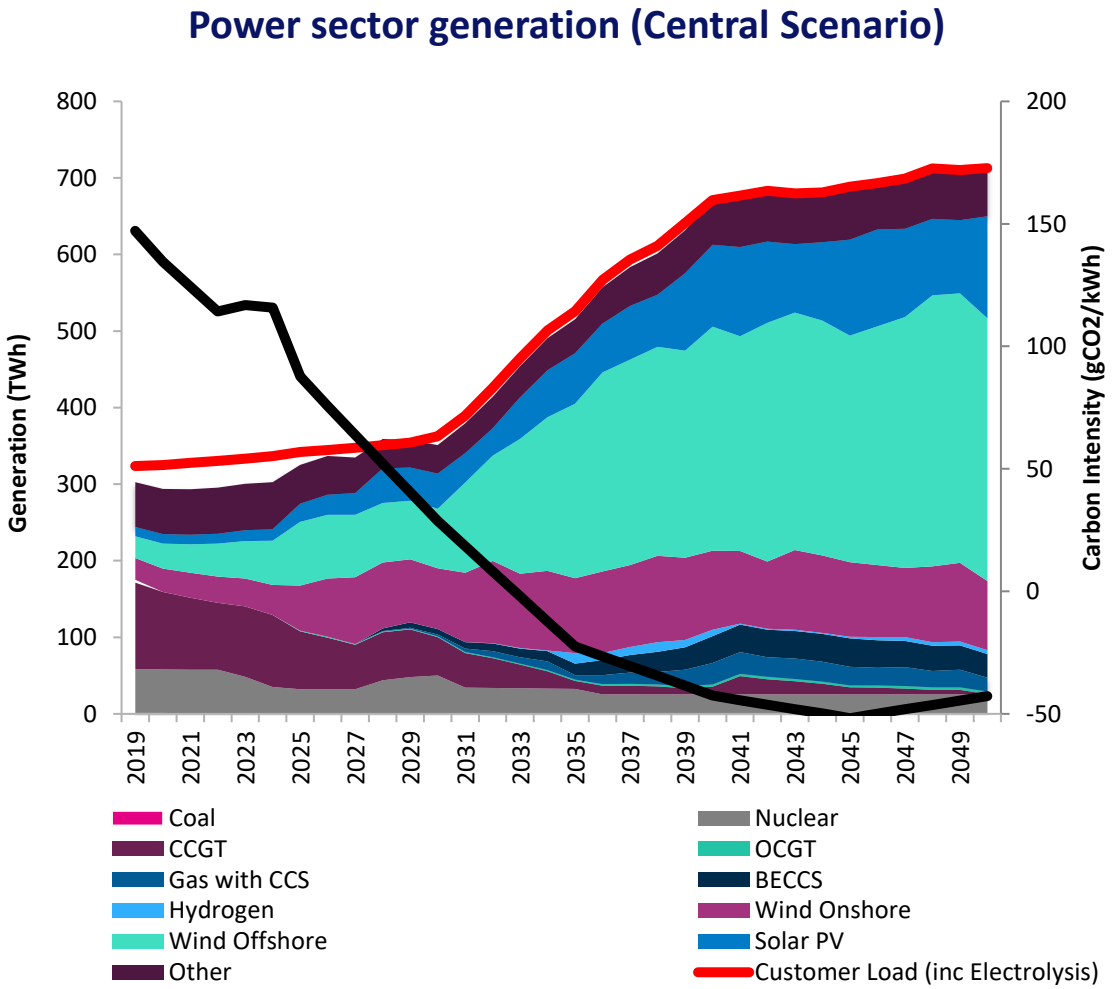
- BECCS-power is deployed in all scenarios – with 2-10GW of capacity in 2050 – providing 13-73 MTpa of negative emissions. This compares with the 5-12GW of capacity forecast by National Grid FES in 2050, and the central and downside scenarios are broadly in line with the 16-39 MTpa of negative emissions from BECCS-power suggested by the CCC.
- Running BECCS at high load factors will provide strategically important benefits, including:
  - Banking negative emissions to mitigate the risk of underperformance in other sectors
  - Providing a valuable source of firm, reliable negative carbon power to complement intermittent renewable technologies

When converted to BECCS, Drax units are derated from 630 MW to 460 MW

BECCS-Power is critical to decarbonisation of the power sector

Overall electricity demand doubles by 2050, with generation dominated by renewables

- Managing a grid with an increasing proportion of intermittent generation is a challenge.
- National Grid has committed to being able to run a zero carbon power system from 2025.
- Low and negative carbon technologies that provide inertia and other ancillary services, such as BECCS, are increasingly important.
- As the proportion of intermittent generation increases further towards 2050, BECCS is able to operate flexibly to help balance supply and demand.



BECCS at Drax in the late 2020s is a ‘no regrets’ option

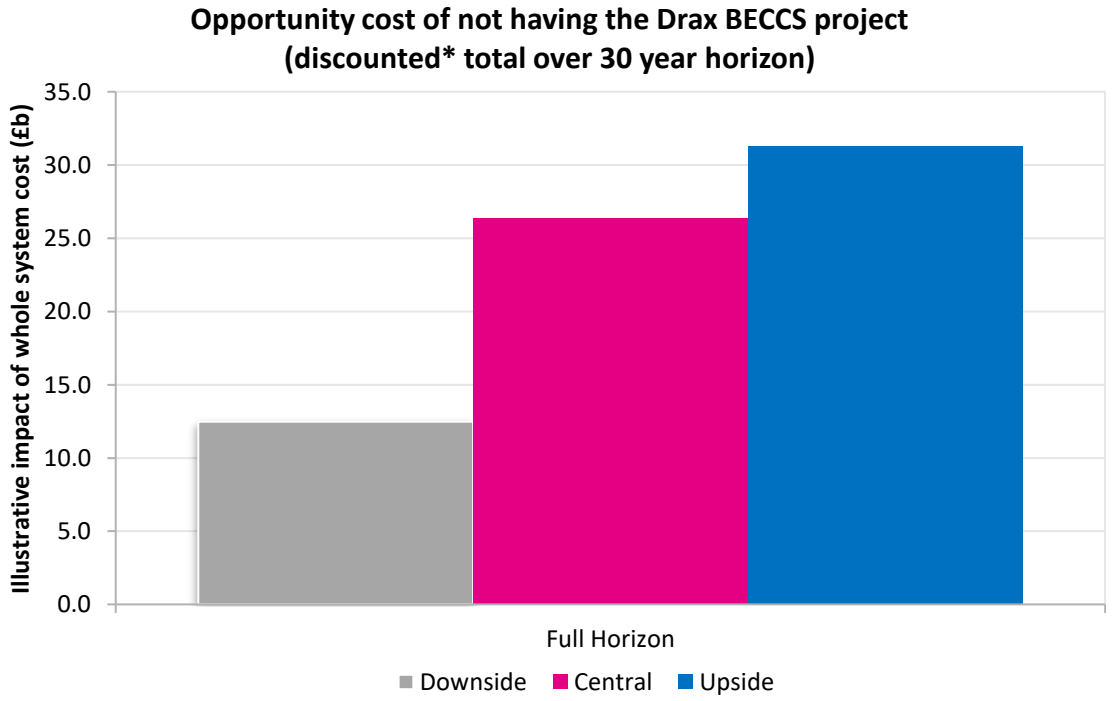
In all scenarios, the decarbonisation pathway is lower cost if BECCS at Drax is deployed in 2027

- Without BECCS at Drax, system costs rise significantly, ranging from £12-32bn across the pathway. By not deploying Drax BECCS in 2027, the system is unable to deploy any BECCS Power until the 2030s.

- There are additional innovation and learning benefits from the early deployment of Drax-BECCS:

    - Conversion of Drax’s existing biomass units can pave the way to a substantial programme of new build BECCS and other negative emissions technologies, with the optimum pathway being refined as technologies mature and costs evolve.

    - Drax-BECCS can also provide an important “anchor project” for development of the CO2 Transmission & Storage infrastructure as part of the Humber CCS cluster.



Drax BECCS is deployed in all scenarios – with between 1 and 9GW of additional new build capacity required by 2050.

The opportunity cost of not having the Drax-BECCS project is driven by both the lower cost of the Drax project compared to new build as well as the value of facilitating power sector and broader decarbonisation earlier in the pathway, particularly given the UK’s challenging target of a 68% reduction in emissions by 2030.

thank
you

APPENDIX C - CAPTURING CARBON AT DRAX: DELIVERING JOBS, CLEAN GROWTH AND LEVELLING UP THE HUMBER, VIVID ECONOMICS

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

Report prepared for Drax

March 2021

vivideconomics
putting economics to good use

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 two existing biomass operations at Drax Power Station to carbon capture and storage (CCS). This technology, also known as BECCS, would generate up to 8 million tonnes of 'negative emissions' per year – **equivalent to two thirds of the Humber region's industiral emissions 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 47,800 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 47,800 jobs in 2027.

- These jobs include up to 24,200 high quality jobs in construction, such as welders, pipe fitters, machine installers and technicians; with a further 23,600 supported across the supply chain and wider economy.

- **Developing BECCS at Drax itself** would support on average 8,100 direct, indirect and induced jobs per year during construction between 2024 to 2028, peaking at 10,300 jobs in 2027.

[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 [redacted]

- BECCS at Drax would also generate an additional £300 million on average in direct GVA each year during the construction period (2024 to 2028) – and an additional £100 million per year and £130 million per year in indirect and induced GVA respectively. Total GVA peaks at £0.7bn in 2027.

- Deploying CCS and hydrogen technologies in the Humber would also **deliver a peak of £3.1 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 18,200 direct jobs per year during the period 2024 to 2031 (peaking at 29,200 in 2027).

Levelling up through CCS and hydrogen

- At its peak, the Humber and wider UK deployment of CCS and hydrogen technologies could support almost **195,000 direct, indirect and induced jobs and almost £14 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 two biomass units with CCS can help accelerate the switch to BECCS-based carbon negative power in the UK. Additionally, Drax provides the opportunity for two 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 2 discusses the role of BECCS
- Section 3 discusses the assumptions underlying the deployment pathway for the scenarios analysed in this report
- 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 MtCO_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

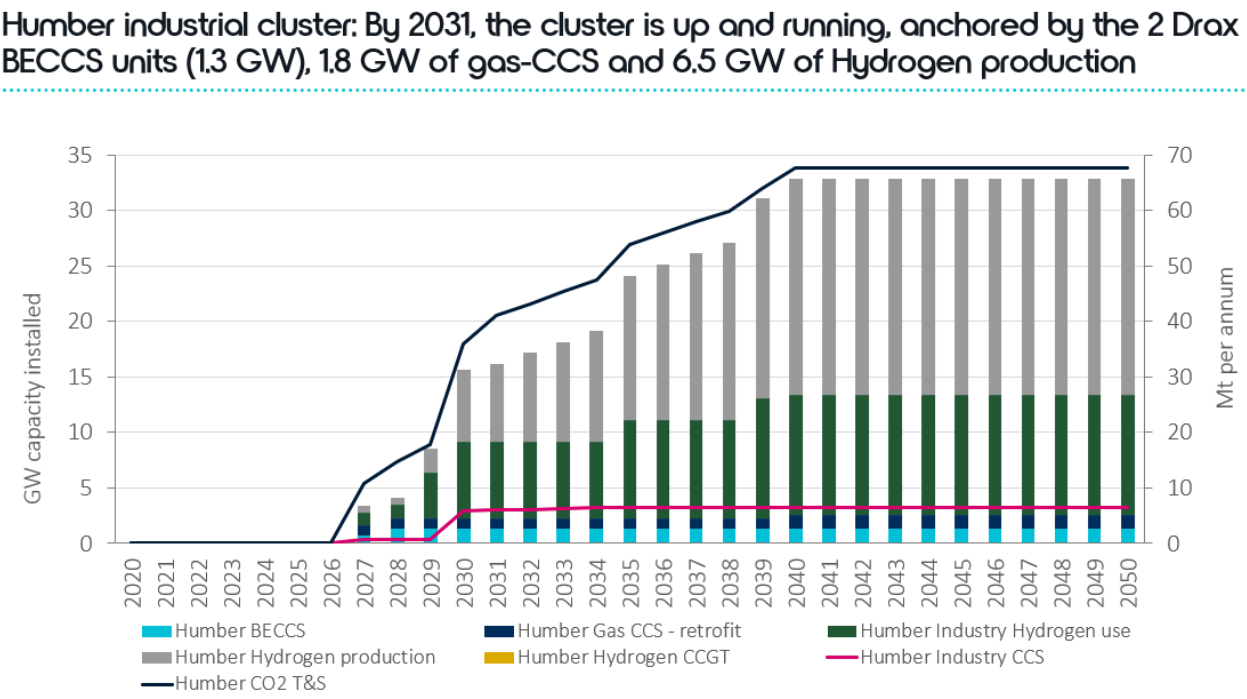
As part of the Zero Carbon Humber proposition, Drax is proposing to convert two of its four existing biomass units at Drax Power Station to CCS or BECCS. This would enable Drax to become the world's first carbon negative power station.

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:

- Two Drax BECCS units of 0.66 GW each, deployed as a staggered pair in 2027-2028
- 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 and one 100% decarbonised gas turbine at Keadby 3, coming online by 2030. Total gas-CCS capacity is 1.8 GW in the cluster by 2030
- Hydrogen use in industrial processes from the Equinor ATR unit
- ~6 $MtCO_{2\text{-}e}$ per annum of industrial CCS in the Humber

Figure 1 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.

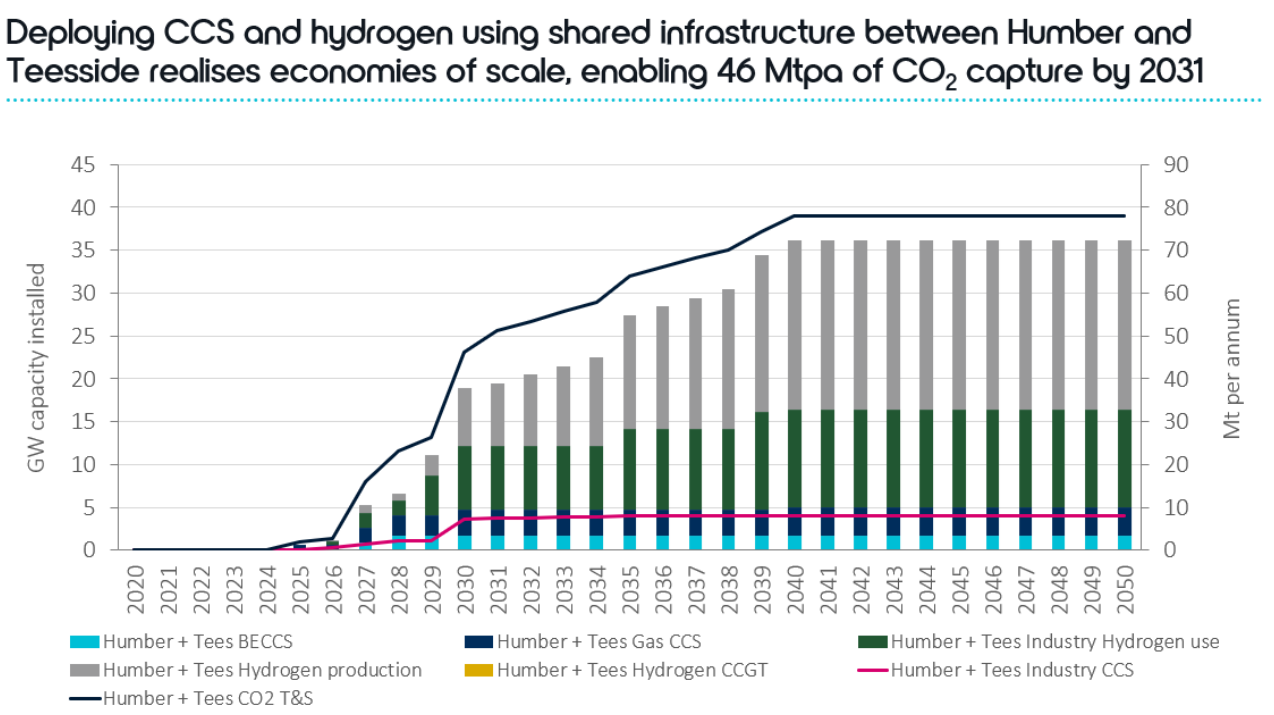
Figure 2 shows the deployment pathway for the combination of the Humber and Teesside industrial clusters combined. **The combination of Humber and Teesside enables significant deployment of CCS and hydrogen technologies, substantially accelerating the rollout of other CCS clusters.**

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 2 Deployment pathway for Zero Carbon Humber and Net Zero Teesside



Source: Vivid Economics

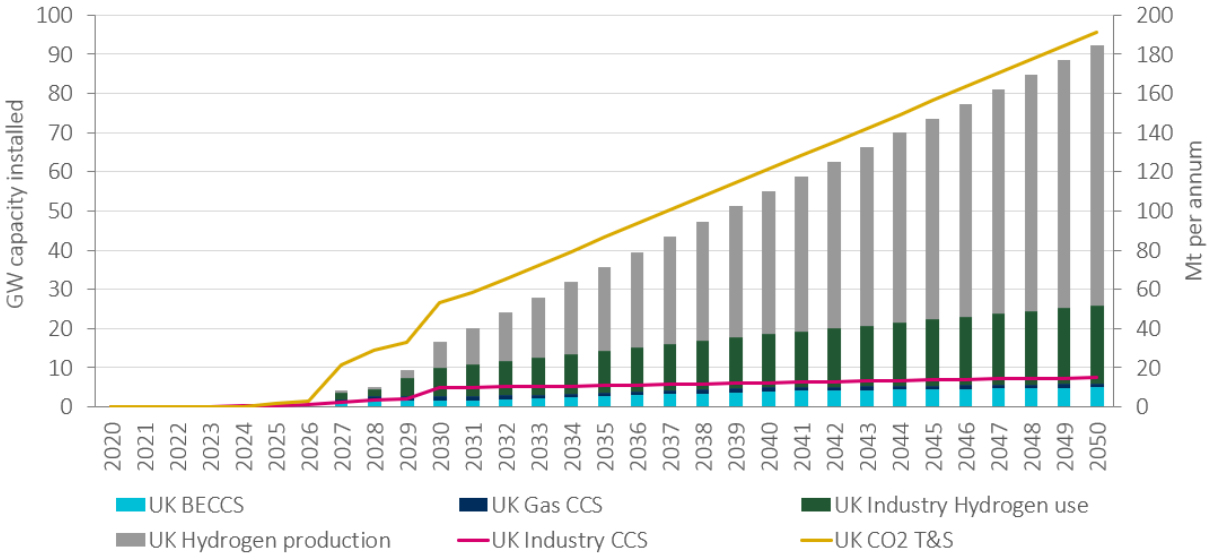
Taken together with two further clusters, the Scottish Acorn and North West HyNET clusters, 53.1 Mt CO_2 per annum can be captured and stored in the UK by 2031[7]. Figure 3 shows the deployment pathway at the UK level, comprising:

- The sum of the two Drax BECCS units and the Teesside BECCS units, totalling 1.7 GW in 2030
- Gas-fired CCS deployment comprising retrofits at Humber, totalling 1.0 GW in 2030
- 2.9 GW of new-build gas-fired CCS at Humber (Keadby 3) and Teesside
- The sum of industrial Hydrogen consumption from Humber and Teesside, totalling 7.4 GW in 2030
- Hydrogen production (SMR retrofits and ATR) 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
- CCS 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 2031 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 3 Deployment pathway at the UK level

UK-wide deployment of CCUS and Hydrogen: The Humber and three other clusters put CCUS on the map by 2030, helping put the UK on a path to meeting net zero by 2050



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 could support 4,000 direct jobs and £300m in direct GVA annually on average during the construction phase between 2024 and 2028, with a peak of 4,950 direct jobs in 2027.**
- Deploying CCS and hydrogen technologies in the Humber could support 15,000 direct jobs and £1.1bn in direct GVA annually on average during the construction phase from 2024 to 2031, with a peak of 24,200 direct jobs and £1.8bn in direct GVA in 2027.
- The Humber and Teesside industrial clusters combined could support 18,200 direct jobs and £1.4bn in direct GVA annually on average during the construction phase between 2024 and 2031, with a peak of 29,200 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

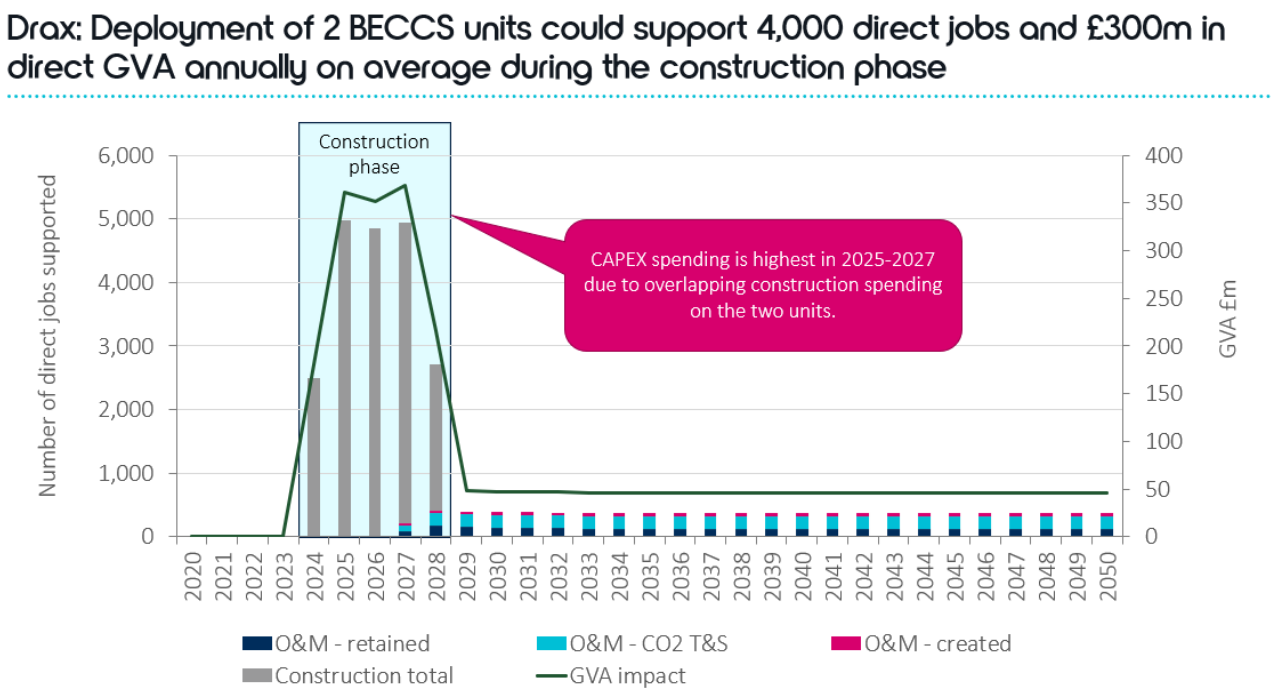
- Bill says that **CCUS is helpful not just for Drax, but in decarbonising cement and steel works on both sides of the river also**. He says that since up to 30 years might be needed to get to net zero, investors may be nervous to invest in a 10-year project without certainty for the next 30 years. The 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, 4,000 direct jobs could be supported and £300m in direct GVA created annually, on average, during the construction phase from 2024 to 2028. Construction work such as laying foundations and preparing the site will create jobs from as early as 2024. Beyond 2031, operations and maintenance (O&M) jobs provide a steady source of employment at the Drax facilities, enabling up to 375 staff to keep the BECCS units running smoothly in a combination of retained and new jobs. **At its peak in 2027 almost 5,000 direct jobs could be supported and £370m in direct GVA created annually.**

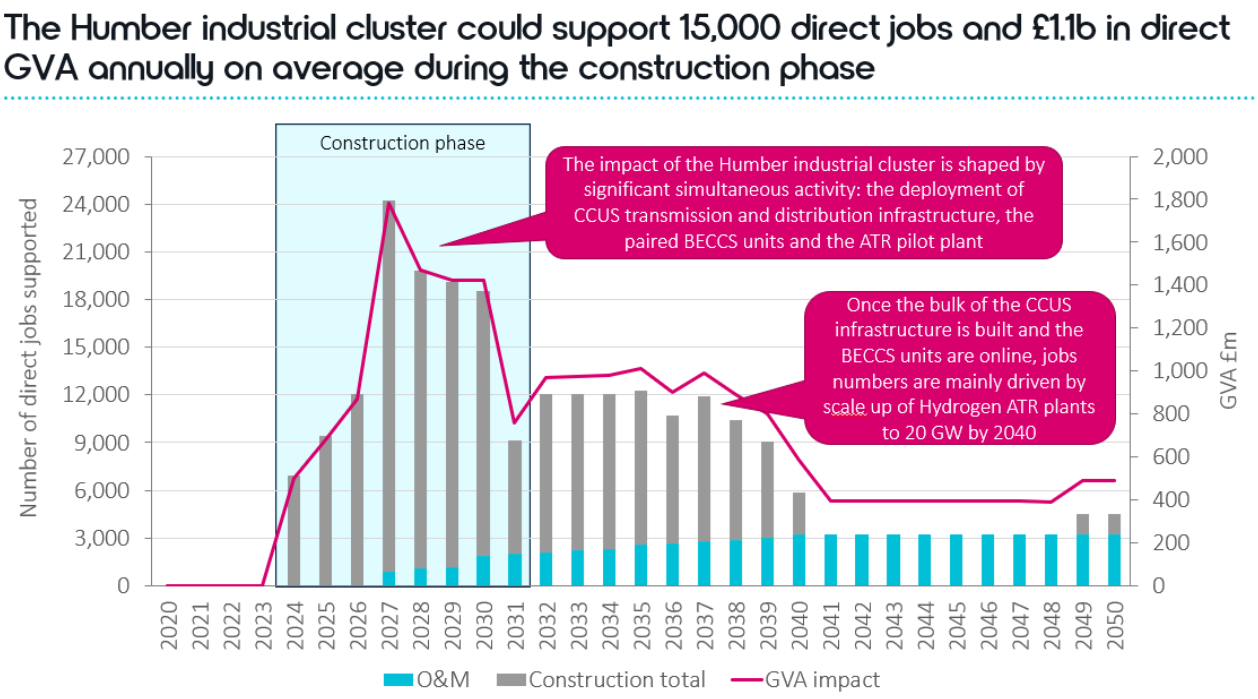
Figure 4 Direct economic benefits at the Drax level



Notes: The scope of this assessment includes 2 BECCS units and associated CO_2 T&S infrastructure
Source: Vivid Economics

At the Humber level, CCS and hydrogen projects support around 15,000 direct jobs and £1.1bn 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 staggered pair of Drax BECCS units – which comes online in 2027 - and a 0.6 GW Hydrogen production pilot plant – which comes online in 2026 - causes **direct construction jobs to peak at 24,200 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 second Drax BECCS unit in 2028, as well as scale up of hydrogen production to 6.5 GW in 2030. Once online, up to 2,950 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 5 Direct economic benefits of ZCH at the Humber level



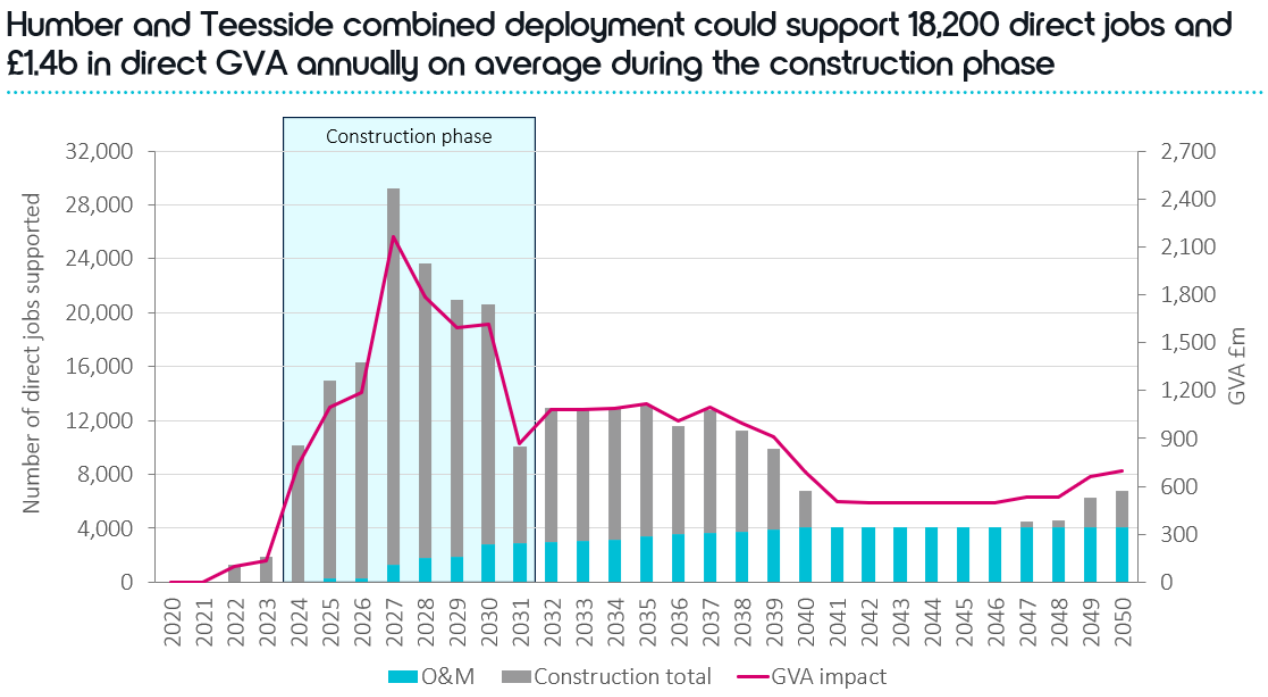
Notes: The scope of this assessment includes BECCS, gas CCGT with CCS, industrial CCS, industrial appliance conversion for hydrogen use, H_2 CCGT, hydrogen production units, and required CO_2 T&S infrastructure.

Source: Vivid Economics

At the 'East Coast Cluster' (Humber and Teesside) level, 18,200 direct jobs could be supported and £1.4 billion in direct GVA created annually, on average, during the construction phase from 2024 to 2031. In particular, the combination of the 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 29,200 and direct GVA of £2.2 billion in 2027**. Once both clusters are up and running, up to 3,800 operations and maintenance (O&M) jobs are supported annually on average between 2032 and 2050, along with £760 million on average in direct GVA during the same period.[11]

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

Figure 6 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

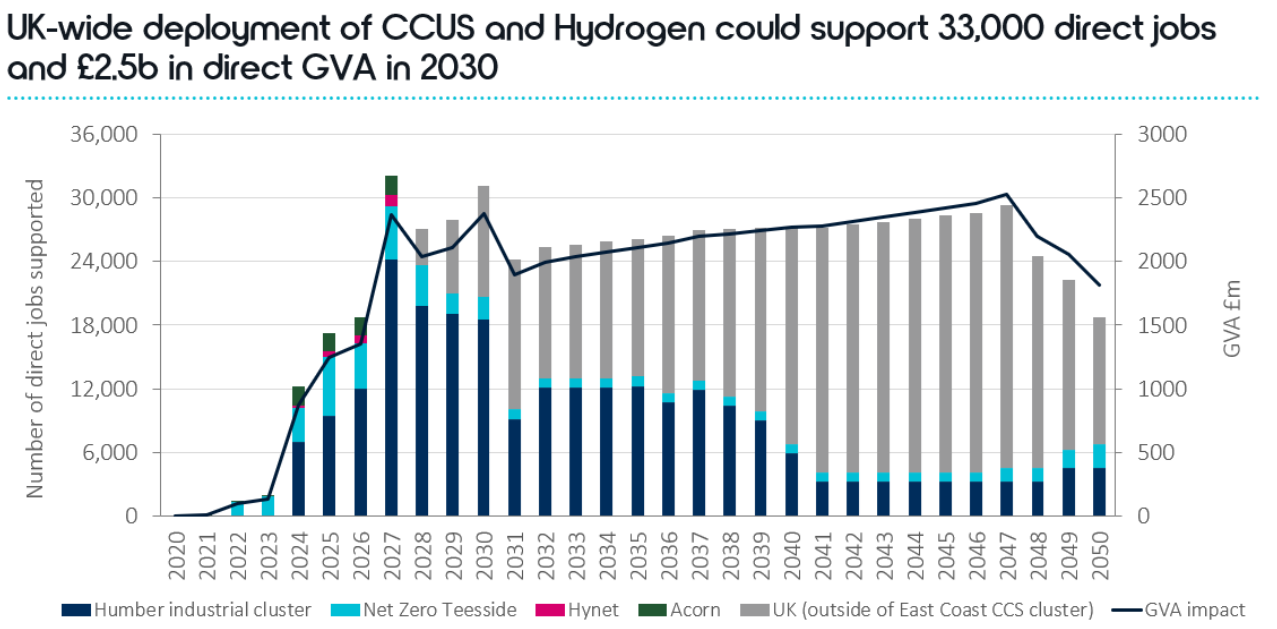
Source: Vivid Economics

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 32,000 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 7 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 1,600 indirect and 2,500 induced jobs, as well as £100 million in indirect and £130 million in induced GVA, annually, on average, during the construction phase between 2024 and 2028.
- **At its peak, the Drax BECCS plants could support a total of 10,300 direct, indirect and induced jobs and £0.7 billion in direct, indirect and induced GVA.**
- At the Humber level, CCS and hydrogen deployment could support 6,700 indirect and 10,200 induced jobs, as well as £420 million in indirect and £540 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 47,800 direct, indirect and induced jobs, as well as £3.1 billion in direct, indirect and induced GVA.**
- The Humber and wider UK deployment of BECCS, CCUS and Hydrogen could support 51,000 indirect and 48,000 induced jobs, as well as £2.1 billion in indirect and £4.3 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 almost 195,000 direct, indirect and induced jobs and almost £14 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 1,600 indirect and 2,500 induced jobs, as well as £100 million in indirect and £130 million in induced GVA, annually, on average, during the construction phase between 2024 and 2028. The coming online of the Drax BECCS units in a staggered pair in 2027-2028 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 (~500 jobs in 2030), whilst induced jobs concentrate in the retail and food and beverage sectors (~500jobs in 2030).

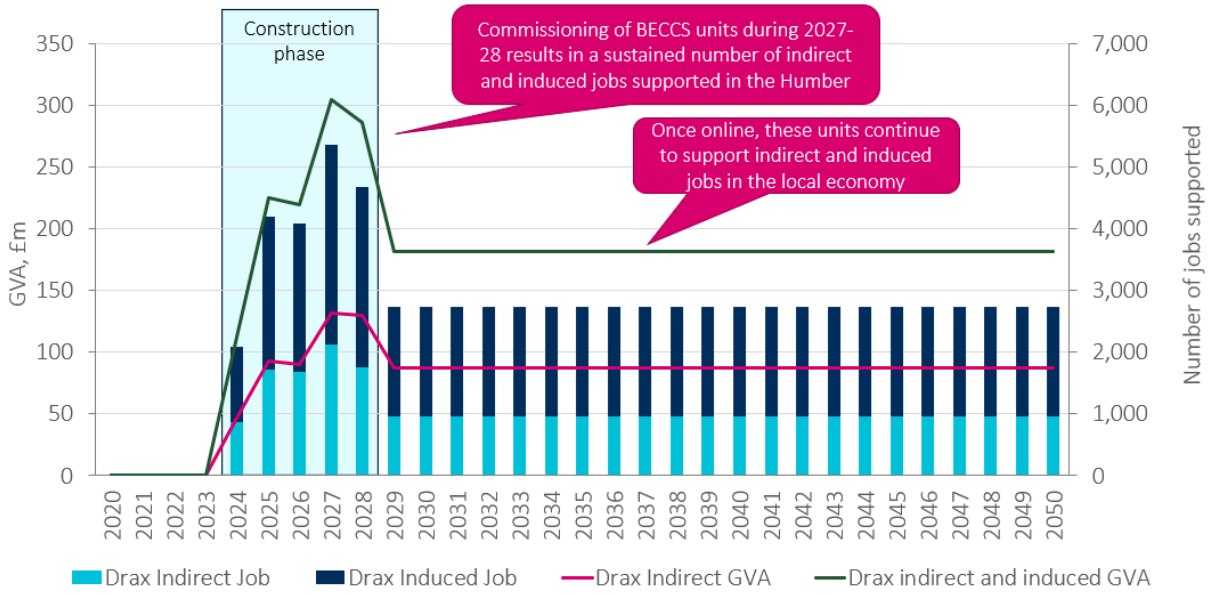
Once online, BECCS at Drax could support a further 960 indirect and 1,800 induced jobs, as well as £90 million in indirect and £94 million in induced GVA, annually, on average during the full operational phase from 2029 to 2050. The ~375 direct O&M jobs at the Drax level between 2029-2050 mean that the 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, whilst the retail and food and beverage sectors continue to see the highest number of induced jobs. Figure 8 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 10,300 direct, indirect and induced jobs and £0.7 billion in direct, indirect and induced GVA. The jobs could comprise of 4,940 direct jobs (48% of total), 2,120 indirect jobs (21% of total) and 3,240 induced jobs (31% of total). The GVA could comprise of £370 million in direct GVA (55% of total), £130 million in indirect GVA (19% of total) and £170 million of induced GVA (25% of total).[13]

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

Figure 8 Indirect and induced impact of Drax deployment in the Humber

Paired deployment of Drax BECCS units could support 1,600 indirect jobs and 2,500 induced jobs annually on average in the Humber during the construction phase



Source: Vivid Economics

At the Humber level, CCS and hydrogen deployment could support 6,700 indirect and 10,200 induced jobs, as well as £420 million in indirect and £540 million in induced GVA, annually, on average, during the construction phase between 2024 and 2031. The coming online of all 1.7 GW of Drax and Teesside 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 23,600 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 (~3300 jobs in 2030), whilst induced jobs are concentrated on the High Street, in the retail and food and beverage sectors (~4,600 in 2030).

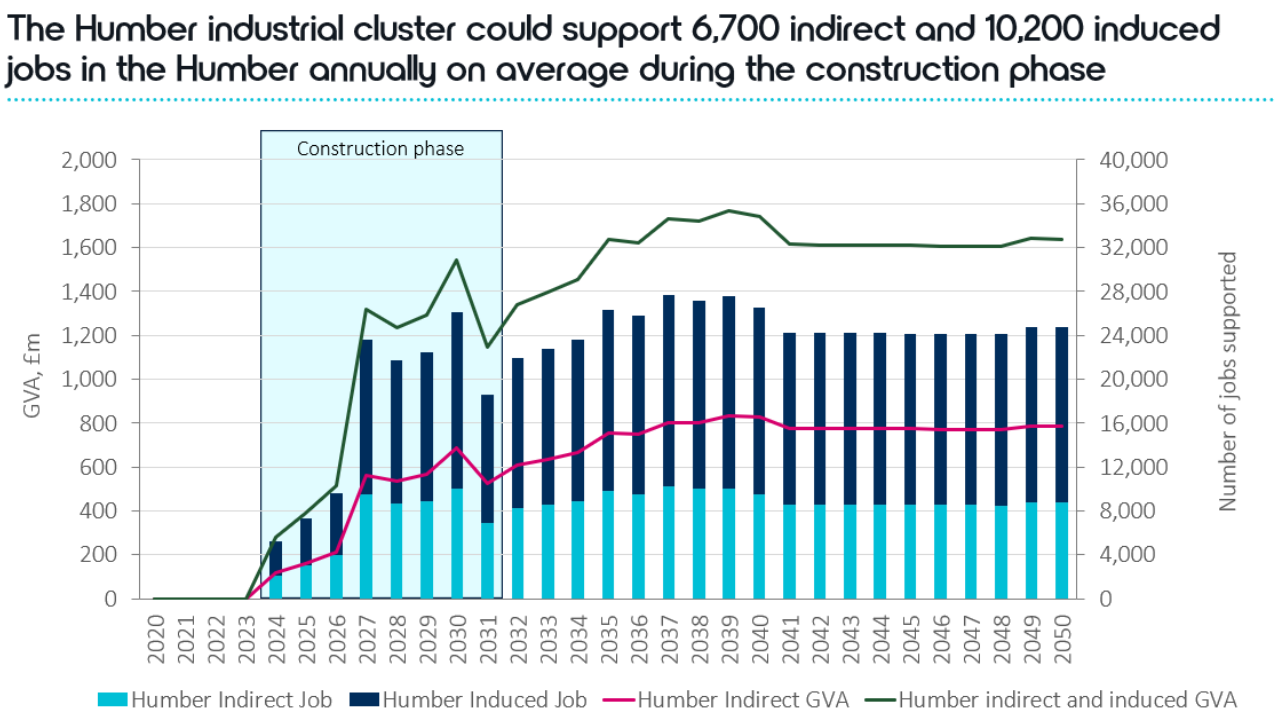
Once online, CCS and hydrogen projects in the Humber could support a further 9,000 indirect and 16,000 induced jobs, as well as £760 million in indirect and £850 million in induced GVA, annually, on average, at the Humber level, during the full operational phase from 2032 to 2050.[14] Operations and 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, whilst the High Street continues to see booming trade from induced spending.

At its peak, the Humber industrial cluster could support a total of 47,800 direct, indirect and induced jobs, as well as £3.1 billion in direct, indirect and induced GVA. The jobs could comprise of 24,200 direct jobs (51% of total), 9,500 indirect jobs (20% of total) and 14,000 induced jobs (29% of total). GVA could comprise of £1.8 billion in direct GVA (58% of total), £560 million in indirect GVA (18% of total) and £750 million in induced GVA (24% of total).[15]

[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.

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

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

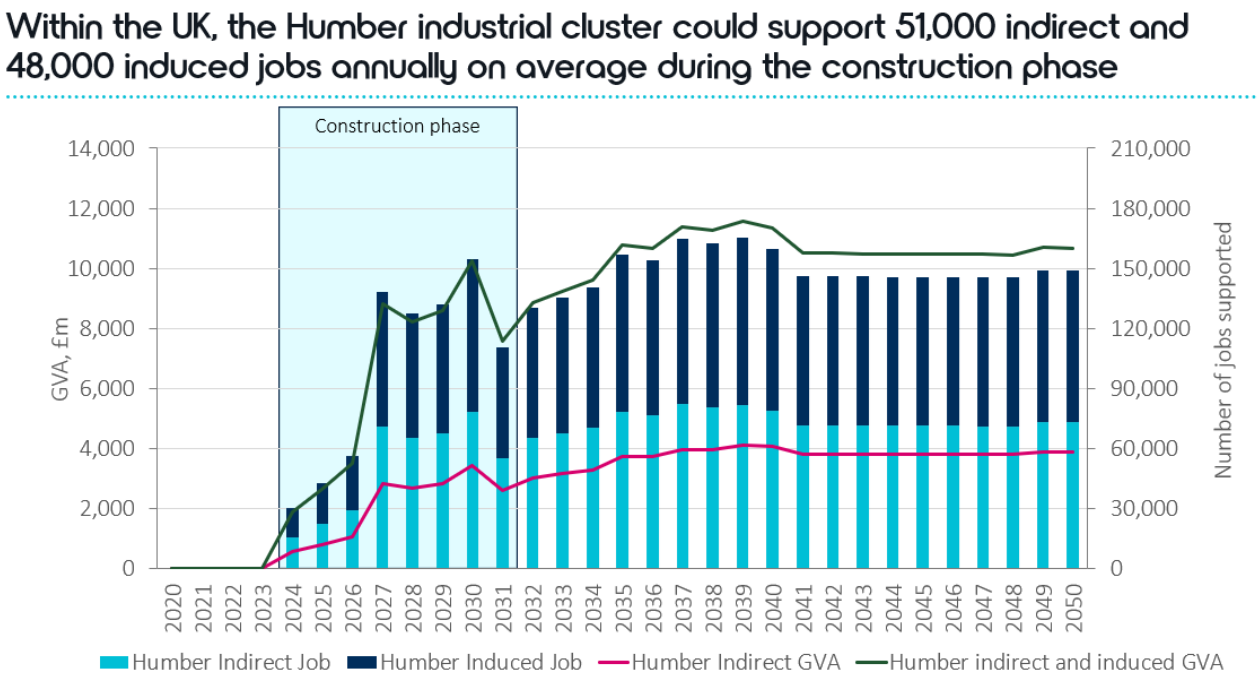


Source: Vivid Economics

Within the UK, the deployment of CCS and hydrogen projects in the Humber could support 51,000 indirect and 48,000 induced jobs, as well as £2.1 billion in indirect and £4.3 billion in induced GVA annually, on average from 2024 to 2031. Indirect supply chain spending is highest in the construction sector, supporting ~12,000 jobs in 2030. Induced spending is concentrated in food and beverage and retail (~ 55,000 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 74,000 indirect and 76,000 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 almost 195,000 direct, indirect and induced jobs and almost £14 billion in direct, indirect and induced GVA. Jobs could comprise of 27,740 direct jobs (14% of total), 82,000 indirect jobs (42% of total) and 83,450 induced jobs (43% of total). GVA could comprise of £2.3 billion in direct GVA (17% of total), £4.1 billion in indirect GVA (29% of total) and £7.5 billion in induced GVA (54% of total).[15]

Figure 10 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*

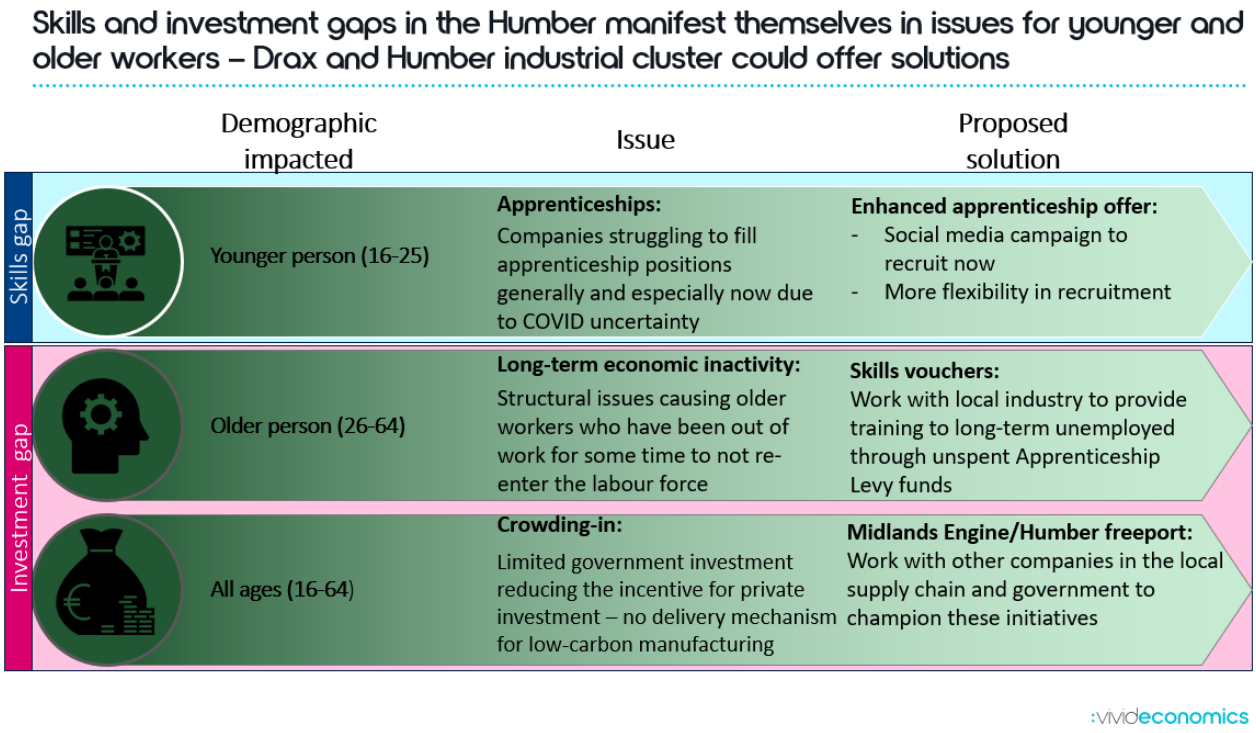
Investment gap:

- **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 118 summarises the issues and proposed solutions detailed and discussed in this chapter.

Figure 11 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 two 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 12 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 12 Skills shortage vacancies in the Humber compared to the Tees Valley and England

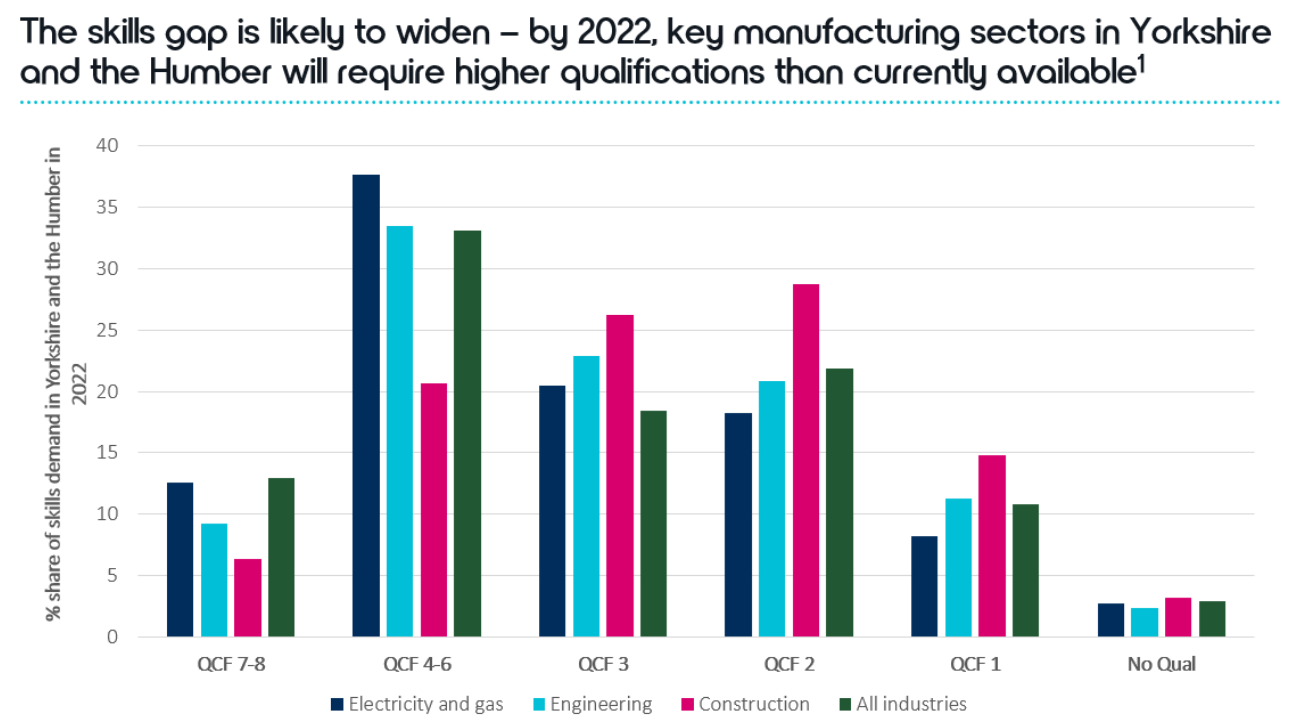
Where are the skills shortages in the local economy?

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

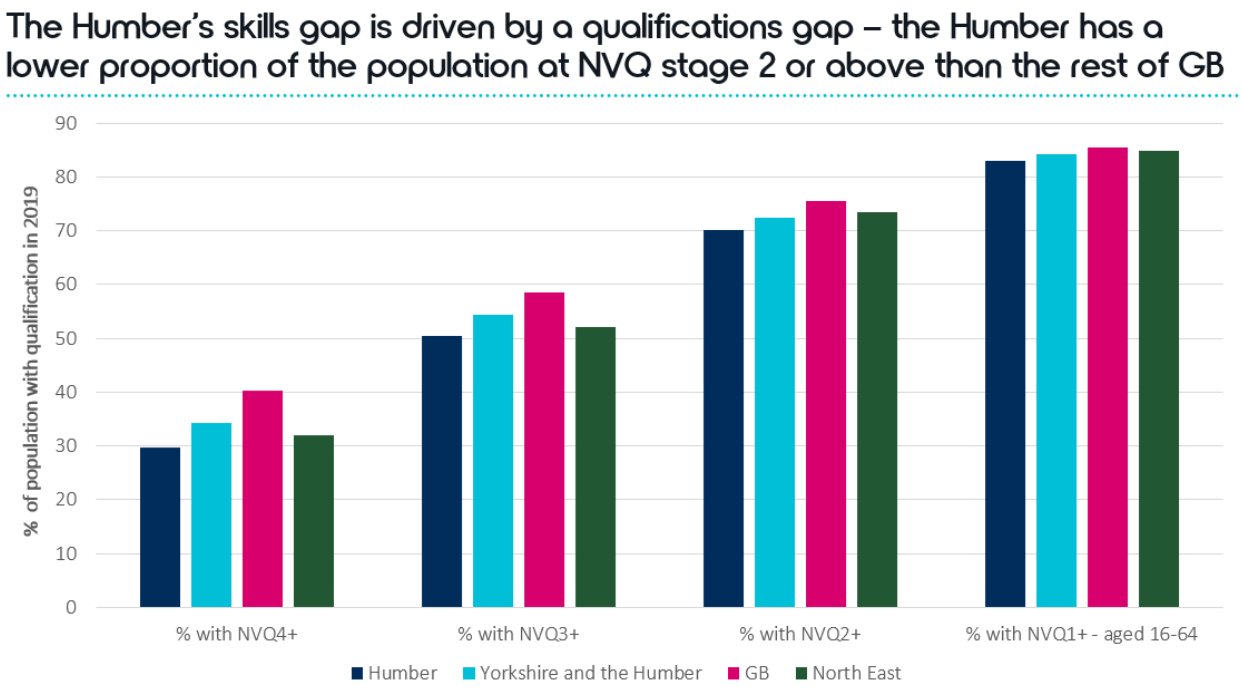


Notes: 1) The higher the QCF, the higher the qualification. QCF 3 translates to A-Levels, Level 6 translates to a Bachelors Degree and Level 8 to a PhD

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.

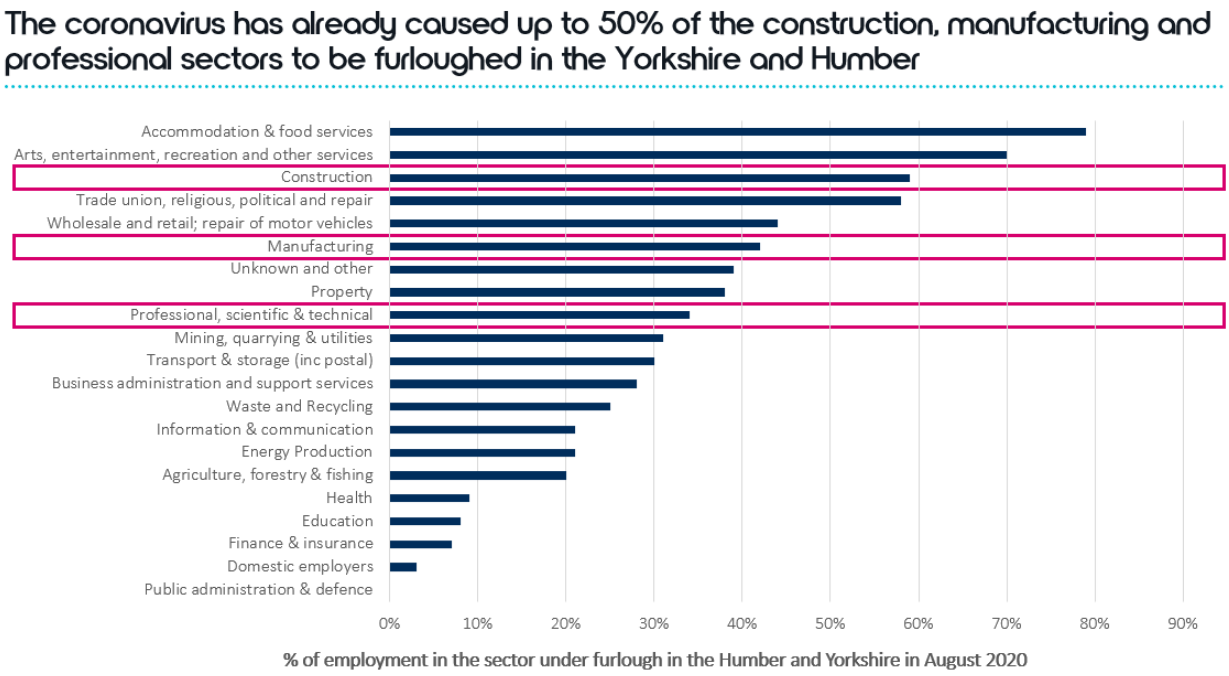
Figure 21 Distribution of qualifications in the Humber compared to the region and nationally



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 13 (HMRC, 2020).

Figure 13 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 14 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 14 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

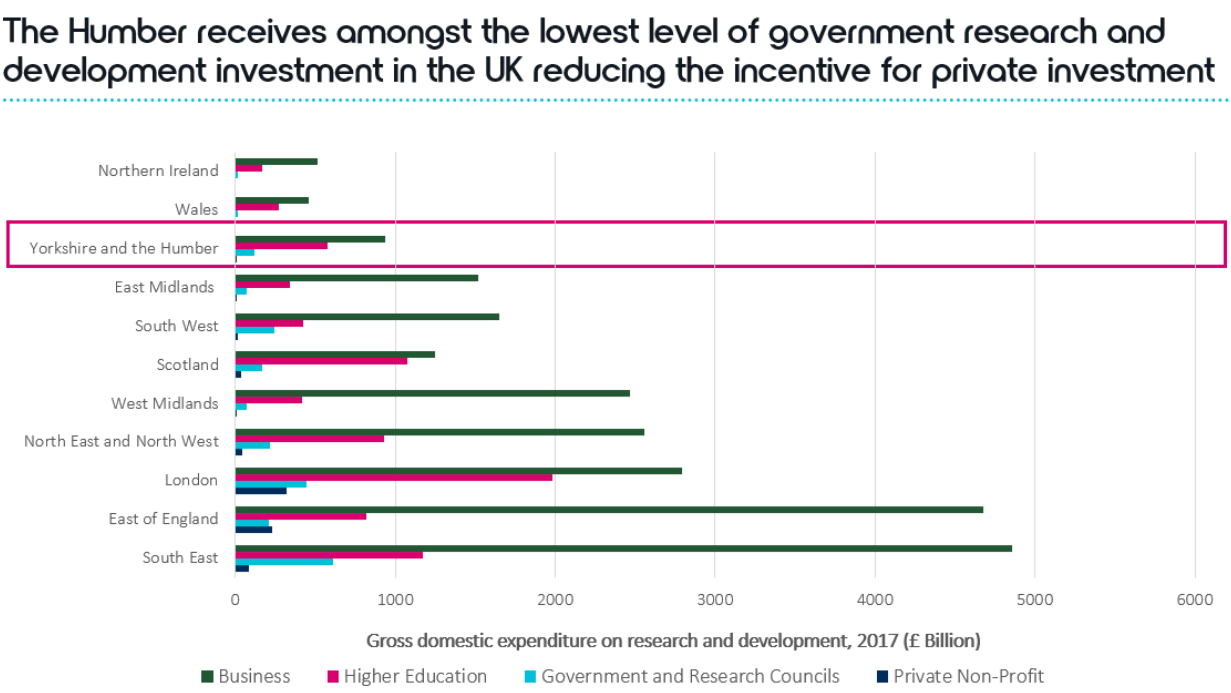
There are a number of ways in which Drax and other operators can offer enhanced apprenticeships, in order to help alleviate the qualifications and skills gaps and assist in the post COVID recovery. Two important, actionable and timely proposals include:

- **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 15 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.

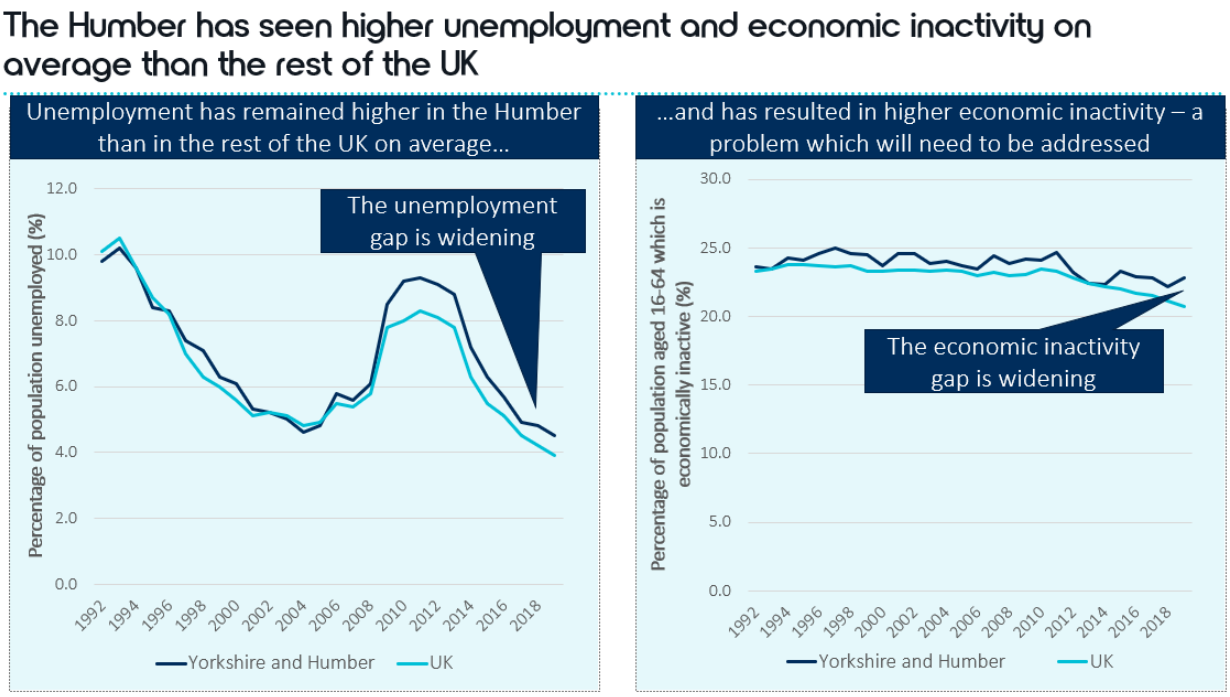
The first problem associated with an investment gap is that of long-term economic inactivity. Older workers who are already unemployed or economically inactive[17] (e.g. due to early retirement) in the region, may miss out on the high skilled jobs of the net zero economy. As shown in Figure 16 below, 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 16 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 2024-2028)	3,996	1,629	2,456	**8,081**
Humber (annual average between 2024-2031)	14,900	6,649	10,185	**31,733**
Humber & Tees (annual average between 2024-2031)	18,241	Not calculated	Not calculated	n/a
UK (annual average between 2024-2031)	23,114	50,584	48,457	**122,155**
Drax (peak) 2027	4,942	2,122	3,240	**10,304**
Humber (peak) 2027	24,203	9,518	14,092	**47,813**
Humber and Tees (peak) 2027	29,187	Not calculated	Not calculated	n/a
UK (peak) 2039	27,738	81,915	83,446	**193,098**
UK (peak) Direct jobs only 2027	32,052	n/a	n/a	n/a

Table 3 GVA Summary

	Direct	Indirect	Induced	Total
Drax (annual average between 2024-2028)	£295m	£98m	£130m	**£525m**
Humber (annual average between 2024-2031)	£1,113m	£421m	£544m	**£2,078m**
Humber & Tees (annual average between 2024-2031)	£1,381	Not calculated	Not calculated	n/a
UK (annual average between 2024-2031)	£1,733m	£2,098m	£4,343m	**£8,174m**
Drax (peak) 2027	£368m	£132m	£173m	**£673m**
Humber (peak) 2027	£1,783m	£564m	£753m	**£3,100m**
Humber and Tees (peak) 2027	£2,163m	Not calculated	Not calculated	n/a
UK (peak) 2039	£2,285m	£4,104m	£7,479m	**£13,867m**

Appendix

Direct benefits

Deployment assumptions

Context	Technology	Source	Description	Facility type
Drax	BECCS	Drax	- Clustered deployment of 2 units: 2027, 2028 - Results in 660MW x 2 at full capacity, capturing 8Mtpa	Retrofit on existing biomass plants
	CO_2 T&S	(Derived)	- In line with associated CO_2 capture scale at Drax - Which implicitly assumes that T&S infrastructure grows at a pace to match CCUS deployment	New
Humber	BECCS	Drax	- 1.3 GW from Drax	Retrofit on existing biomass plants
	Gas CCS	Drax	- Represents VPI Immingham and Keadby 3 - 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 - 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 - 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 - Assume capacity grows linearly from zero in 2026 to full capacity in 2030	Retrofit
	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 - Operational in 2024	Retrofit
	CO_2 T&S	Acorn phase 1	- Infrastructure capable of handling 5Mtpa - Operational in 2027	New

Context	Technology	Source	Description	Facility type
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 - Beyond 2030: extrapolate linearly to 4GW in 2040 and then 5GW in 2050, aligning with CCC's Net Zero Further Ambition scenario	Retrofit on existing biomass plants
	Gas CCS		- Sum of Humber and Tees - 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 - Beyond 2030: extrapolate linearly to a scale of capturing 15Mtpa in 2050	Retrofit
	Industry: H2 use		- Up to 2030: sum of Humber and Tees - 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 - 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 Humber, Tees, Hynet and Acorn - 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 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

Vivid Economics is a leading strategic economics consultancy with global reach. We strive to create lasting value for our clients, both in government and the private sector, and for society at large.

We are a premier consultant in the policy-commerce interface and resource- and environment-intensive sectors, where we advise on the most critical and complex policy and commercial questions facing clients around the world. The success we bring to our clients reflects a strong partnership culture, solid foundation of skills and analytical assets, and close cooperation with a large network of contacts across key organisations.

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