

Viking CCS

Transforming the
Humber into a
net zero SuperPlace



VikingCCS 

 Harbour
Energy

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Introduction

As the UK grapples with balancing energy security and decarbonisation alongside a cost-of-living crisis, private-sector investment in carbon capture and storage (CCS) will help secure our energy future, while providing a swift and significant reduction in CO₂ emissions and supporting national and local economic growth.

In 2022, the Committee for Climate Change stated that there is no route to net zero by 2050, nor decarbonising industry while safeguarding jobs, without deploying CCS at scale¹.

Located in the UK's most industrial and CO₂-emissions-intensive region, Viking CCS is a flagship project uniquely placed to help the UK decarbonise and grow, by providing a gateway for investment and the development of a regional low-carbon hub. The project plans to store 10 million tonnes of CO₂ (MtCO₂) a year by 2030 and 15 MtCO₂ a year by 2035, which would meet up to one third of the UK's CCS target².

This would significantly contribute to the UK's net zero targets and strengthen its ambition as a world leader in decarbonisation. Viking CCS will also be transformational for the Humber. It can equip the region with high-capacity, reliable low-carbon infrastructure to promote inward investment and attract new industries. Importantly, it can also support the challenge facing businesses with stranded emissions beyond the Humber region, through the future development of both shipping and expanding pipeline infrastructure networks.

Alongside a diverse range of Cluster members, including Associated British Ports, Phillips 66 Limited, RWE, VPI and West Burton Energy, Viking CCS will stimulate a suite of benefits for the Humber region. These benefits are summarised in this report³.

Existing emissions of 10 MtCO₂ a year stored by 2030

300 million tonnes world-class, securely-sealed storage

Investment of £7 billion by 2035 across the CCS value chain

Enabling 10,000 new jobs and 4,000 permanent jobs

Delivering GVA of £4 billion

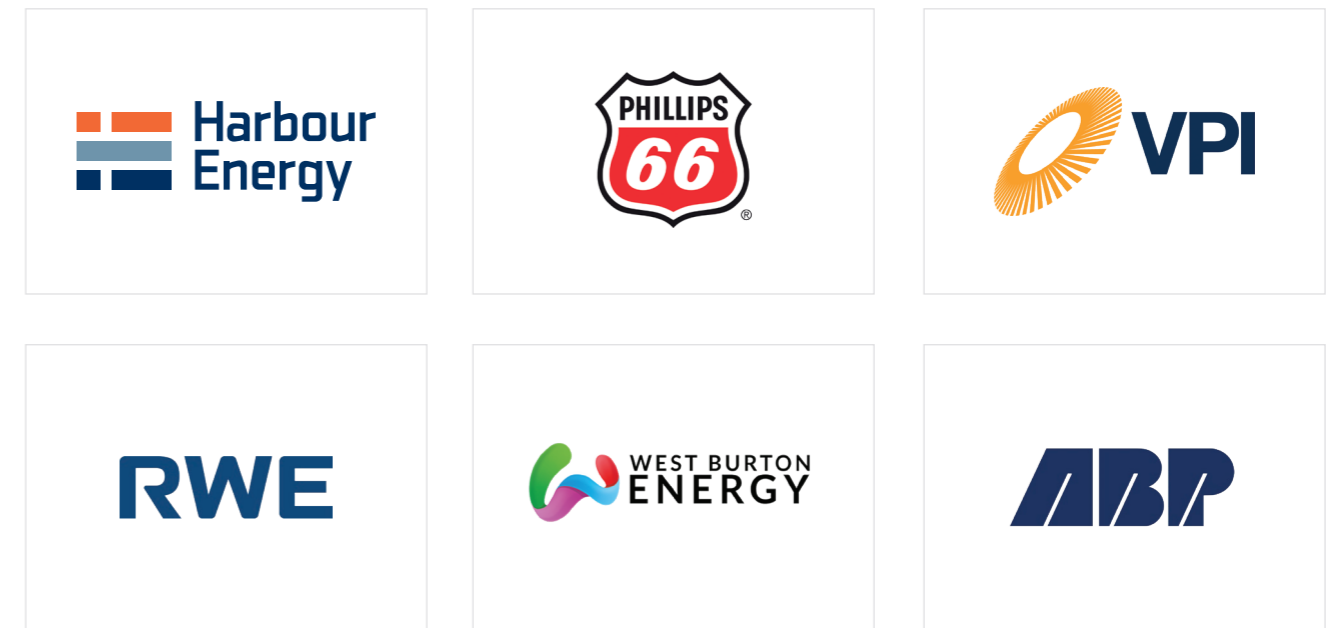
¹Mission Zero, Independent Review of Net Zero, 2023. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1128689/mission-zero-independent-review.pdf

²UK Government, Carbon Capture, Usage and Storage, page 7, 2022. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1045066/ccus-transport-storage-business-model-jan-2022.pdf

³Economic analysis undertaken by Element Energy on behalf of Harbour Energy. Economic improvements, such as GVA and job creation, are calculated from the investment figures by UK input-output tables and various business surveys produced by the Office of National Statistics (ONS). The macroeconomic model considers sectoral import/export statistics, average annual wages and division between direct and indirect impact.

About the Viking CCS Cluster

The members of the Viking CCS Cluster are working to develop a full-chain CO₂ capture, transport and storage network that will materially decarbonise industry in the Humber, Lincolnshire and Nottinghamshire regions.



The Cluster is committed to supporting the UK's net zero and energy security objectives by decarbonising existing and new-build strategic power and industrial assets. This will contribute to making the Humber, and the UK, leading centres of decarbonisation, while retaining and creating world-class industries.

Through the proposed development of infrastructure, from emissions capture to a pipeline network and a shipping import terminal, the Cluster will support cost-efficient sequestration of CO₂ emissions in Harbour Energy's high-capacity CO₂ storage sites in the southern North Sea.

The Viking CCS Cluster's final investment decision is planned from 2024, with first storage from as early as 2027, assuming government sequencing through its Track 2 process in 2023. The Cluster is targeting 10 million tonnes a year of CO₂ stored by 2030, rising to 15 million tonnes a year by 2035. The project is forecast to deliver £4 billion of gross value add (GVA) across the region.

The project would create new opportunities for highly skilled local employment for up to 10,000 people while safeguarding 20,000 high-value industrial jobs.

These opportunities include developing lower-carbon markets for electric vehicle manufacturing supply chain, sustainable aviation fuel (SAF) and flexible and dispatchable power generation that can supplement variable weather-dependent renewables. This will support a vibrant new lower-carbon industrial ecosystem, attracting and developing talented people.

10 million
Tonnes a year of CO₂ stored by **2030**

15 million
Tonnes a year of CO₂ stored by **2035**

Viking CCS: The gateway to UK decarbonisation

MtCO₂ = million tonnes of carbon dioxide (CO₂) emissions per year

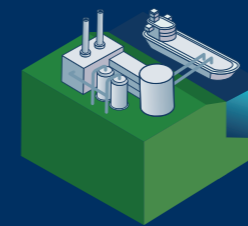
● Associated British Ports (ABP)



What is carbon capture and storage (CCS)?

Viking CCS Cluster

CO₂ emissions are captured from high-emission industries at Immingham and surrounding area Cluster members or imported by ship



Viking CCS pipeline

The Viking CCS pipeline safely transports captured CO₂ for 55km to join an existing subsea pipeline



Carbon storage

Carbon dioxide is stored in depleted gas reservoirs under the North Sea, 2.7km beneath the seabed and 140km from the Lincolnshire coast



Capture

Our Cluster members will capture over 90% of the CO₂ emitted by their industrial processes, removing it at source by adsorption and separation, so it can be directly routed to a pipeline for transporting to secure storage

Transport

We will transport the CO₂ through onshore and offshore pipelines designed to handle high volumes. The CO₂ will be transported safely from where it is captured to where it will be stored

Store

The CO₂ will be stored safely beneath a world-class superseal of high-strength salt layers

Viking CCS strengths



Re-use of existing infrastructure



Developed by a highly experienced team



Supported by large, reputable, securely financed members

300 million

Tonnes of storage capacity in our depleted Viking gas fields in the southern North Sea

up to 10,000

Jobs potentially created from the capital investment in the Viking CCS Cluster projects

up to £7 billion

Investment over ten-year period from 2025 to 2035

over 40 years

Of track record operating infrastructure projects in the North Sea

over 50%

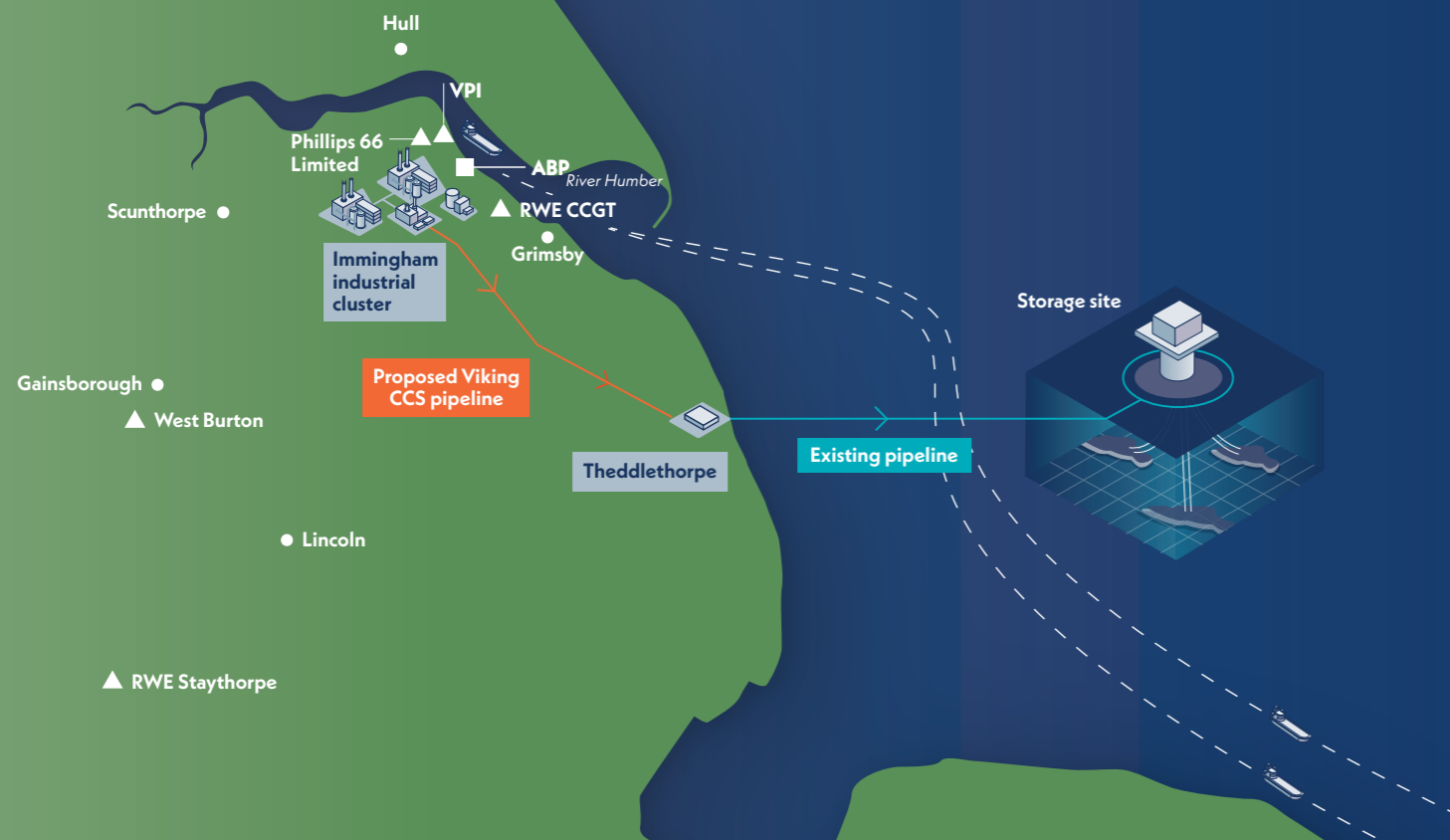
Of Humber emissions could be captured, transported and securely stored by our project

up to 40%

Of UK industrial and power emissions accessible via ABP's network of ports

Figure 1: Indicative map of Viking CCS

Key: ▲ Viking CCS Cluster member (emitter)
 ■ Viking CCS Cluster member (port)



Key growth opportunities

Viking CCS brings five key opportunities to the Humber and its surrounding regions. These opportunities will shape the area into a low-carbon hub defined by a world-leading CCS Cluster and a skilled workforce. This will underpin future low-carbon investment as well as the growth of new supply chain businesses and state-of-the-art products and markets.



Infrastructure investment

Viking CCS can lead to £7 billion investment by 2035 in both new and upgraded infrastructure in the Humber.



Economic opportunity

Deploying CCS in the Humber could produce around 10,000 new job opportunities.



Supply chain

The forecast £7 billion of capital investment through to the mid-2030s presents a significant opportunity for the UK supply chain and service sector.



Regional skills

Skills demand for a CCS industry presents a critical opportunity for the Humber region's workforce to develop new low-carbon expertise.



Low-carbon products and inward investment

Viking CCS low-carbon infrastructure will enable Cluster members to decarbonise current and future product lines, while attracting new low-carbon industries to the Humber region.

The role of Viking CCS in the Humber

Viking CCS will play a pivotal role in decarbonising the strategic industries located in the Humber, Lincolnshire and Nottinghamshire regions, home to Phillips 66 Limited, VPI Immingham, RWE and West Burton Energy.

The scale of investment from the Cluster members will enable Viking CCS to transform the Humber. The project's high-capacity, reliable low-carbon infrastructure can act to promote inward investment to the area and attract new industries, stimulating national and local economic growth, at the same time as supporting the UK in reaching its net zero targets. This transformation will be achieved by:

1. Progressing the development of the Viking CCS Cluster's projects to significantly reduce CO₂ emissions from as early as 2027 and contribute to the UK Government's ambitious net zero targets, subject to the necessary processes, business model support and final investment decisions.
2. Contributing to the creation of the jobs and skills required for a sustainable national CCS supply chain and UK export of lower-carbon products and services.
3. Working with communities and key stakeholders on CCS, sharing knowledge and lessons from the Viking CCS Cluster development.
4. Enabling the production of lower-carbon products and services, including promoting investment in decarbonisation technologies and future interconnection of CO₂ transport networks to increase the region's economic attractiveness to industry and investors.

Infrastructure investment



Harbour Energy is the developer of two key pieces of infrastructure for the Viking CCS project.

The CO₂ transport infrastructure: Part of the infrastructure we plan to use for CCS transportation is already in place. A legacy Harbour Energy company developed and operated a high-capacity offshore pipeline to transport extracted natural gas from the Viking gas fields to the former Theddlethorpe Gas Terminal. We therefore have the detailed knowledge and experience to reuse this pipeline for transporting CO₂ to the offshore storage site. An additional new spur line will carry the CO₂ for the final 20km of its journey to storage deep underground. To complete the chain of transportation, we plan to lay a new 55km onshore buried pipeline connecting the Immingham industrial cluster to the former Theddlethorpe Gas Terminal. The onshore pipeline is currently progressing through the Development Consent Order process.

World-class CO₂ storage potential: The Viking reservoirs are well-defined and understood – Harbour Energy's legacy companies have been extracting gas from them for the past 40 years. These reservoirs are now depleted and at low pressure, and so available for storing CO₂.

In what we believe is a northern hemisphere first, Harbour Energy commissioned ERCE to complete a Competent Person's Report on the storage capacity of the Viking CCS project, and to audit our storage estimate. This confirmed that our estimate of 300 million tonnes of storage for the Viking CCS project is fair and reasonable.

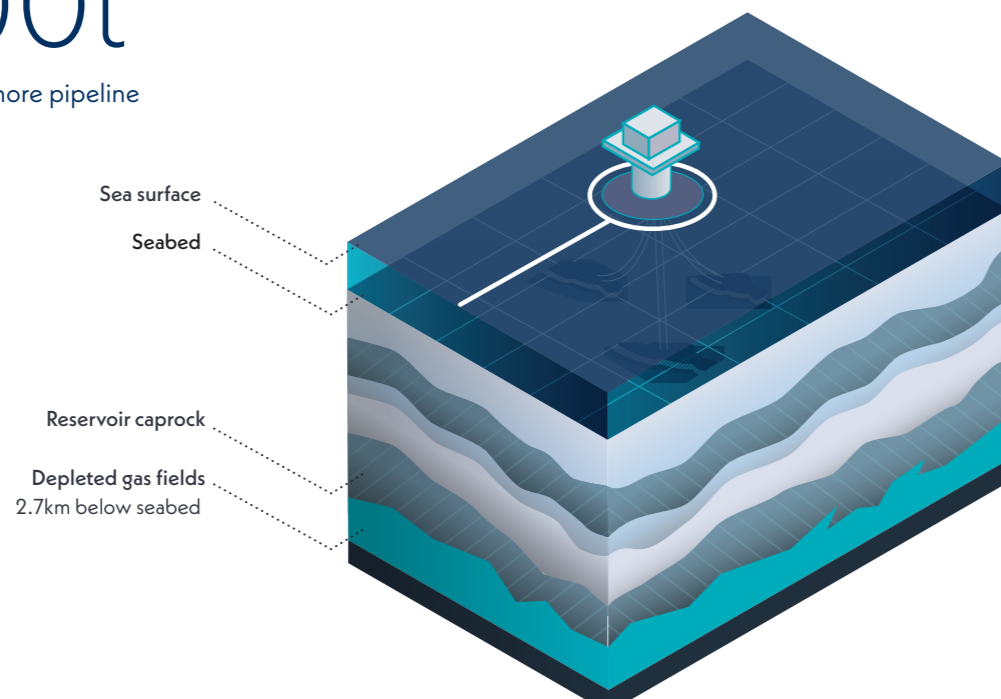
Working together, Harbour Energy and Associated British Ports plan to develop a CO₂ import terminal at the Port of Immingham, the UK's largest port by tonnage. This will link to Harbour Energy's Viking CCS CO₂ transport and storage network. The terminal will provide a large-scale facility to connect stranded CO₂ emissions from industrial companies around the UK to the high-capacity CO₂ storage sites in the southern North Sea.

2.7km

Depth of CO₂ storage site below the seabed

70,000t

CO₂ saved by reusing offshore pipeline



The Viking CCS Cluster includes large existing industrial emitters and power stations that plan to construct and operate CO₂ capture plants as well as the infrastructure needed:

Humber Zero

Humber Zero is a world-scale series of projects to reduce the carbon emissions of critical industry in the Immingham industrial area using carbon capture. The project is a consortium between Phillips 66 Limited and VPI Immingham LLP and aims to remove 8 million tonnes of CO₂ a year from the Immingham industrial area.

The carbon emissions from some processes at the VPI Immingham Combined Heat and Power Plant and Phillips 66 Limited Humber Refinery will be captured and compressed. As part of Phase 1 of the wider Humber Zero decarbonisation project, VPI Immingham (one of Europe's largest combined heat and power facilities, with a capacity of 1.3GW) aims to retrofit two of its gas and steam turbines with CCS, capturing up to 3.4 MtCO₂ a year by 2027. Phillips 66 Limited Humber Refinery is also developing new lower carbon business streams, so it can transition its business to one that is ready for the future and can contribute to decarbonising other sectors.

West Burton Energy

One of the UK's most modern and efficient natural gas plants will contribute to achieving net zero by deploying CCUS capabilities.

West Burton B is a highly flexible and efficient Combined Cycle Gas Turbine Plant with a combined output of 1.3 GW of energy, including 49 MW of battery storage capacity. West Burton B supplies electricity for the UK residential market, as well as providing essential services to the national electricity transmission system, so helping the transition to a low-carbon economy.

West Burton Energy intends to deploy post-combustion technology to capture up to 90% of its carbon emissions as part of its wider decarbonisation strategy. This will include deploying hydrogen co-firing, and building further electricity storage facilities.

More than

5GW

Of power decarbonised between VPI, RWE and West Burton's modern gas-fired power stations

Equivalent to

5 million

Homes' electricity supply decarbonised

RWE

RWE is the UK's largest operator of combined cycle gas turbine (CCGT) power plants. Its 7GW gas fleet complements a 2.8GW renewables portfolio by providing security for the UK energy supply. RWE's long-term vision is to be carbon-neutral by 2040 across its global operations, with its UK operations leading in achieving this goal.

RWE has a wealth of experience in the design and operation of carbon capture plants, having been involved in developing carbon capture technologies since 2008. RWE is developing low-carbon generation options using both carbon capture and hydrogen technologies to decarbonise its sites.

RWE has begun the necessary technical studies to investigate the feasibility of retro-fitting carbon capture technology at Staythorpe, and has started to develop a new state-of-the-art CCGT equipped with carbon capture technology near the Humber. Together, these projects could capture and remove roughly 6 million tonnes of CO₂ a year.

Associated British Ports

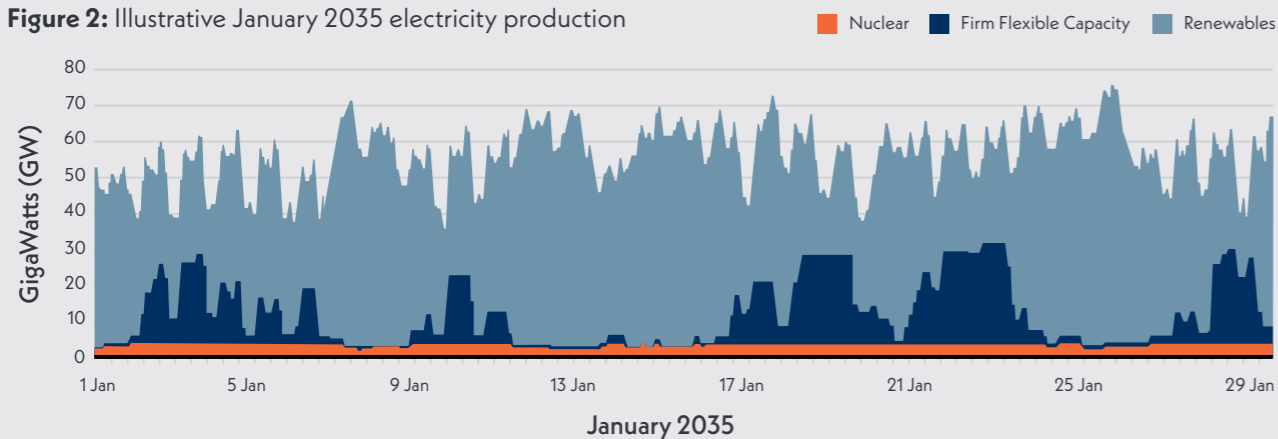
The Port of Immingham, owned and operated by Associated British Ports (ABP), is part of ABP's Humber ports along with Grimsby, Hull and Goole. Together they make up the UK's largest ports complex. ABP is investing in new infrastructure, with a new jetty to service the import and export of liquid bulk products. As well as handling green ammonia, the jetty is being designed to accommodate other cargo connected to the energy transition, including the import of liquified carbon dioxide (CO₂) from CCS projects, for sequestration in the southern North Sea – and so playing a significant role in the UK's energy transition.

This new infrastructure aims to provide a huge opportunity to connect otherwise stranded industrial clusters in the UK to Harbour Energy's high-capacity offshore CO₂ storage sites in the southern North Sea. This exciting development underpins both future inward investment to the Humber and Lincolnshire regions and acts to safeguard industrial jobs across the UK, in support of the UK government's efforts to decarbonise industry in the UK and meet its net zero emissions targets.



The need for abated gas-fired power

Figure 2: Illustrative January 2035 electricity production



In the UK Climate Change Committee's (CCC) Balanced Net Zero Pathway⁴, there is a doubling of electricity system demand between 2018 and 2050, from around 300TWh of electrical energy used today, to around 600TWh in 2050. This increase in electrical demand is mainly due to electric vehicles and similar, plus increased electrical home heating (such as heat pumps). The CCC Balanced Net Zero Pathway forecasts an increase of renewable electrical generation to 80% by 2050, particularly from offshore wind providing the backbone of the UK's electrical system, with the phasing out of unabated gas-fired power by 2035.

CCC see the need for 15GW of flexible low-carbon generation by 2050, particularly during low production of weather-dependent renewables. Abated gas-fired power generation – that is gas-fired power stations with CCS – can provide a firm, reliable source of dependable low-carbon supply to the UK electrical system. The Viking CCS Cluster plans to decarbonise over 5GW of low-carbon gas-fired power by the early 2030s, meeting one third of the CCC Balanced Pathway target and materially supporting the required 50TWh of low-carbon dispatchable generation needed to ensure security of supply by 2035.

⁴The Balanced Net Zero Pathway of CCC's Sixth Carbon Budget estimates a UK-wide CO₂ storage rate of 52.8 MtCO₂/year by 2035. <https://www.theccc.org.uk/publication/sixth-carbon-budget/>

The investment opportunity

More than 100 MtCO₂ could be permanently stored by 2035 through Viking CCS. (Figure 3 shows predicted volumes for specific years to 2035). The first volumes of CO₂ are expected to be captured by the VPI capture project in 2027, with other projects and ship imports following from as early as 2028. **The total annual CO₂ transported and stored by Viking CCS could reach 15 MtCO₂ by 2035**, with 3 MtCO₂ annually through shipping import from UK sources. This would represent almost one third of the UK needs for CO₂ storage in 2035 according to the Balanced Net Zero Pathway in CCC's Sixth Carbon Budget⁴, which estimates a need for over 50Mt a year of CO₂ storage by 2035.

The private-sector-led capital investment to develop all of the planned projects within the Viking CCS Cluster is projected to reach over £7 billion to 2035, across capture, transport and storage projects. This does not account for the private-sector investment in the export terminals or capture projects as part of an integrated shipping value chain.

As shown in Figure 4 below, annual investment for Viking CCS is projected to peak from 2026-2028 (with £1.6 billion projected in 2027) as most capture plants are planned to be built, and the CO₂ transportation and storage infrastructure is expected to become operational in this period. A secondary investment peak is expected in the early 2030s and is sustained (over £800 million in 2034) due to expansion of the CO₂ transportation and storage infrastructure and capture plants. The new infrastructure is a way to promote sustained inward investment, and can help underpin long-term job creation in the region.

A significant portion of the investment is associated with the CO₂ capture plants. The repurposing of existing infrastructure provides for a relatively low initial cost of the transport and storage infrastructure, with expansion of storage opportunities over time as the demand increases. Overall, 70% of all spending is associated with capital expenditure, leading to the creation of significant benefits in equipment manufacturing and construction activities.

Figure 3: Annual volumes of CO₂ captured or processed by different sources

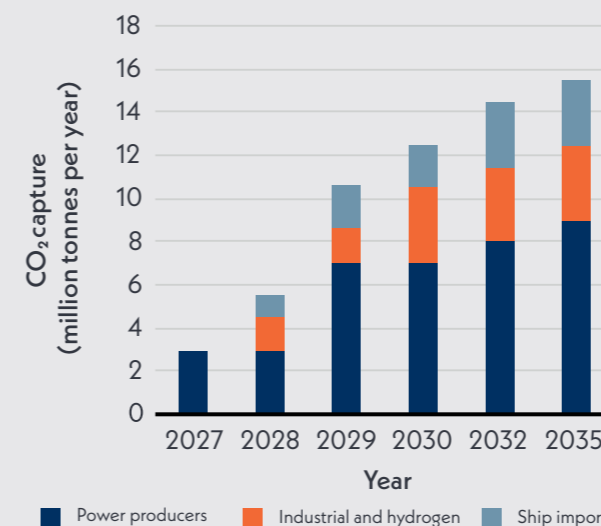
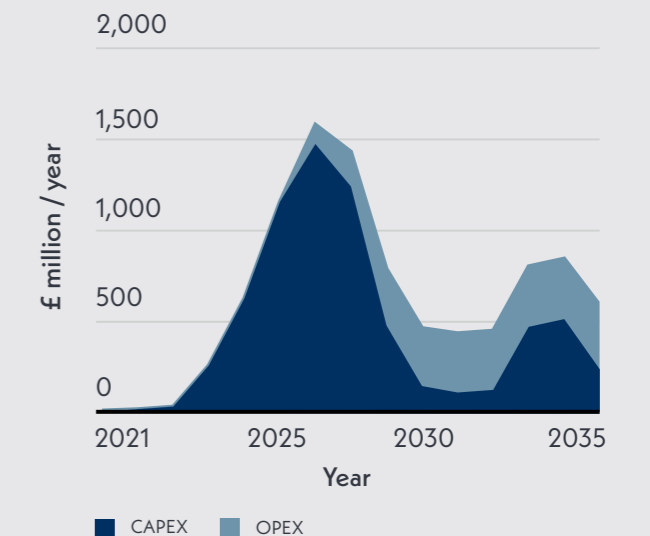


Figure 4: Annual total capital and operational spending across Viking CCS Cluster (includes capture, port, pipeline and storage projects)



Economic opportunity



The potential for the Humber and North East of England to benefit from the net zero transition economy was confirmed as "the economic opportunity of the 21st century" in the recent Government-commissioned Skidmore Net Zero Review⁵.

The Humber region has the opportunity to be at the epicentre of a UK infrastructure and industrial rejuvenation. The Humber is home to some of the largest UK offshore wind farms, has an existing large industrial base through refining, petrochemicals, manufacturing and power generation, and hosts the UK's largest port complex by tonnage, in the Port of Immingham.

Decarbonising the high-quality gas-fired generation assets of the Lincolnshire and Nottinghamshire regions will provide vital low-carbon energy security for the UK throughout the 2030s and 2040s. These facilities are foreseen to continue playing a critical role in the UK's decarbonised energy mix.

Infrastructure is seen as the key that will unlock net zero⁵. The Viking CCS network provides at-scale high-capacity CO₂ transportation infrastructure to the Humber region. Due to the planned development of this infrastructure, there is the potential to promote further inward investment to the region. RWE recently announced development plans to investigate the construction of a new gas-fired power station on the South Humber Bank, purpose built with carbon capture technology, with an investment in the region of £1 billion.

The new low-carbon energy infrastructure presents opportunities for developing broader supply chains, with the availability of decarbonised power, industrial skilled labour and access to CCS infrastructure acting as a magnet to other industries.

Viking CCS can bring significant opportunities for economic growth (presented in Figure 5), increasing the gross value added (GVA)^{6,7} and bringing new employment opportunities. GVA is a term used in economics to describe the measure of goods and services produced (in this case through the cluster's development activities), and can help government determine the important contributions to the UK's Gross Domestic Product (GDP) growth. Annual GVA contribution follows a similar pattern to overall investment, with two peaks in 2026-28 and 2033-35 when the bulk of the construction takes place. Across the modelled period to 2035, cumulative GVA is estimated to reach £4 billion, 56% of which is expected to be direct contributions⁸.

Figure 5: Annual direct and indirect GVA generated by Viking CCS

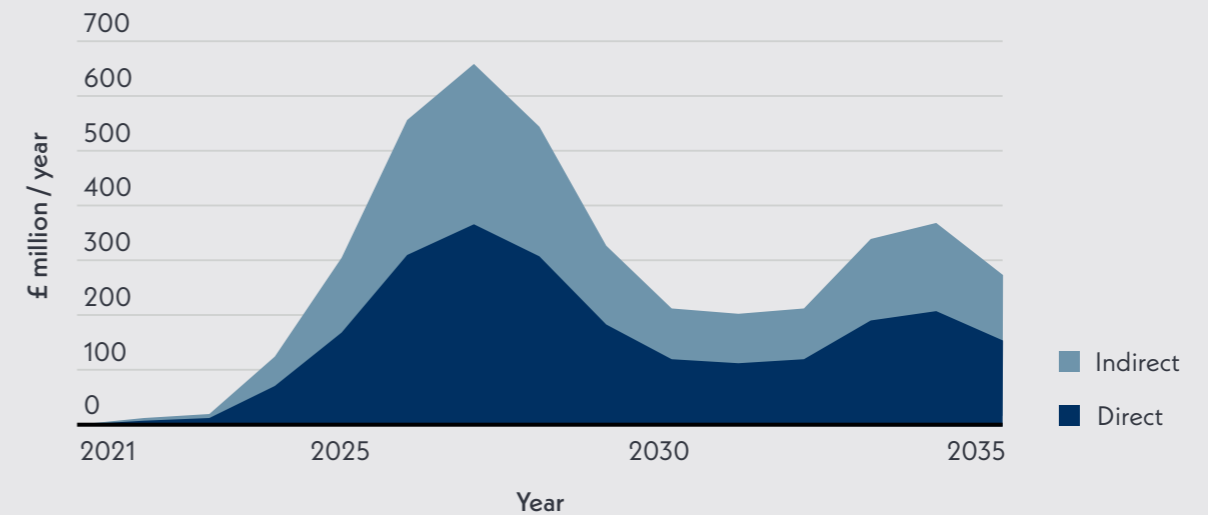
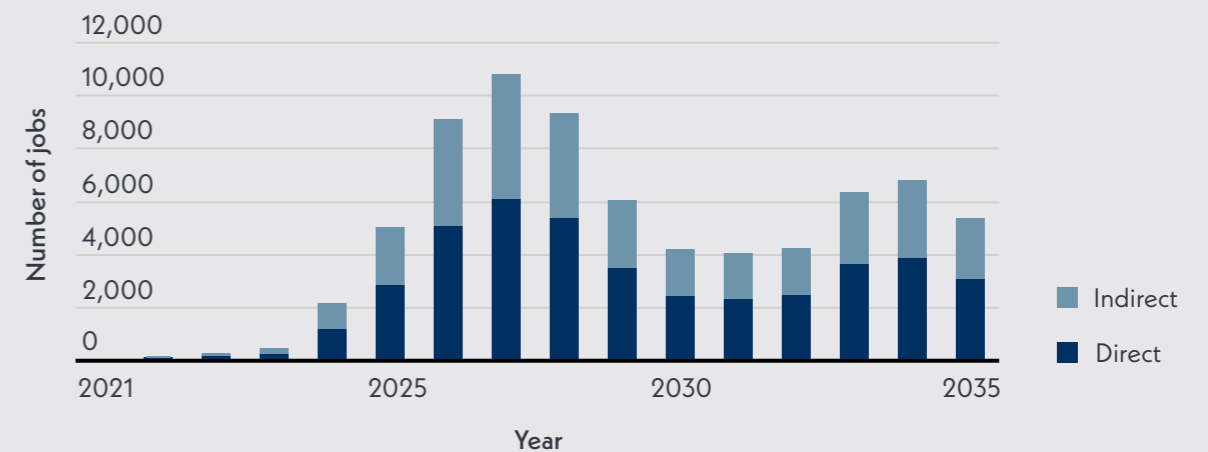


Figure 6: Annual direct and indirect jobs supported across the Viking CCS project proponents



Viking CCS is estimated to support⁹ around 10,000 jobs (56% directly) in 2027 at the peak of various construction activities (Figure 6), which is just under half as many construction-phase jobs associated with Hinkley Point C¹⁰. As the new infrastructure develops there is a foreseen shift from construction and engineering roles to permanent operational and maintenance roles.

The Viking CCS Cluster premises continued capital investment for the decade between 2025 and 2035, with a sustained need for large numbers of skilled workers. This is forecast to bring indirect benefits to the regional economics as workers maintain a presence in

the region for multiple years, over a series of projects, allowing secondary economic growth for housing and services in the local economies.

By 2035, approximately 4,000 permanent jobs are forecast to be supported, across a range of industries associated with operation of the carbon capture plants and other infrastructure. The job creation and economic growth opportunities at a site level are also significant, as shown for VPI Immingham in the case study on page 16.

⁵ Mission Zero, Independent Review of Net Zero, 2023. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1128689/mission-zero-independent-review.pdf

⁶ Gross value added (GVA) is the net positive economic impact an investment or activity has on an economy. It is calculated by adjusting investment levels according to value moving outside the UK.

⁷ Quoted GVA does not consider the secondary impacts of wages/profits to the wider economy

⁸ Direct GVA refers to value created in primary sectors delivering a project (e.g., a factory producing the carbon capture equipment).

Indirect GVA refers to value added through the supply chains of these primary sectors (e.g., energy used to produce the carbon capture equipment).

⁹ In this study 'jobs supported' refer to the number of full time equivalent (FTE) jobs associated with the Viking CCS Cluster each year. Some of these jobs may be newly created and others may be preserved or displaced from other parts of the economy.

¹⁰ https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/725960/HPC_Benefits_Realisation_Plan.pdf



The economic opportunity: VPI Immingham

VPI is a leading UK energy company with five combined cycle gas turbine (CCGT) assets. Its largest state-of-the-art facility, a combined heat and power (CHP) plant in Immingham, has a capacity of 1.3 GW, and is one of the major CO₂ emitters of the Humber industrial cluster. It supplies energy both directly to local refineries and to the grid.

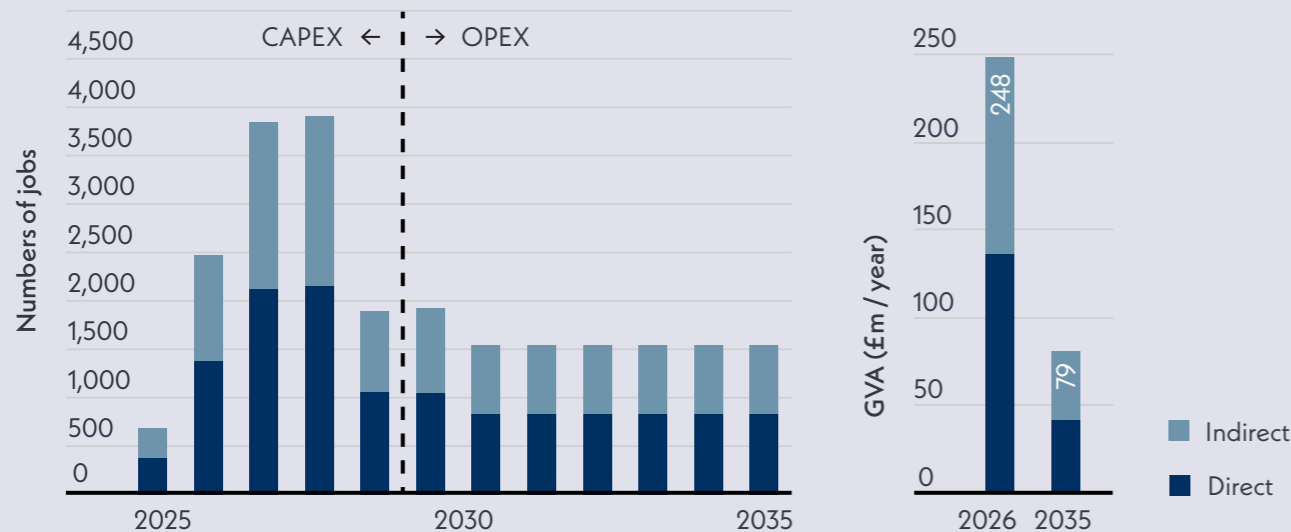
VPI Immingham has decarbonisation plans including CCS and fuel switching to hydrogen. As part of Phase 1 of the wider Humber Zero decarbonisation project, VPI Immingham aims to retrofit two of its gas and steam turbines with CCS, capturing up to 3.4 MtCO₂ a year by 2027. Phase 2 will then involve converting its third turbine (530 MW) to hydrogen, which is anticipated to be supplied mainly through a new hydrogen-generation plant on site. Up to 5.3 MtCO₂ captured on site through these efforts will be transported through Harbour Energy's Viking CCS pipelines and stored permanently in depleted gas fields offshore.

Over the 2024-2029 period, VPI Immingham's decarbonisation plan is estimated to cost more than £1.5 billion in capital investment. Once operational expenses are accounted for, this level of investment leads to a cumulative GVA of £1.4 billion by 2035.

As shown in Figure 7, peak annual GVA is expected to occur in 2026 (£250 million), where construction of CCS plants is expected to support just under 4,000 jobs annually, including the wider supply chain. During the operational phase of the decarbonisation projects (after 2028) around 1,500 permanent jobs are estimated to be supported across the supply chain, half of which are directly related to plant activities in the Humber region.



Figure 7: Annual direct and indirect jobs supported by CCS activities at VPI Immingham during project construction and operation phases (left), and annual direct and indirect GVA achieved in selected years (right)



Supply chain

The Viking CCS Cluster is forecast to begin construction from late 2024, with initial projects aiming for first storage and commercial operation from 2027. The forecast £7 billion of capital investment through to the mid-2030s will generate sustained demand for skilled jobs in the supply chain across the regional and national economies.

This private-sector capital investment demand presents a significant opportunity for the UK supply chain, and Viking CCS Cluster members are committed to contributing to the creation of the jobs and skills required.

Across the UK, there is forecast significant growth in industrial and infrastructure construction demand, including the expansion of the UK offshore wind industry and the potential for expansion of nuclear power. At the same time, there is a need to decarbonise the UK's existing industrial and gas-fired power assets by deploying multiple CCS clusters in the late 2020s and early 2030s.

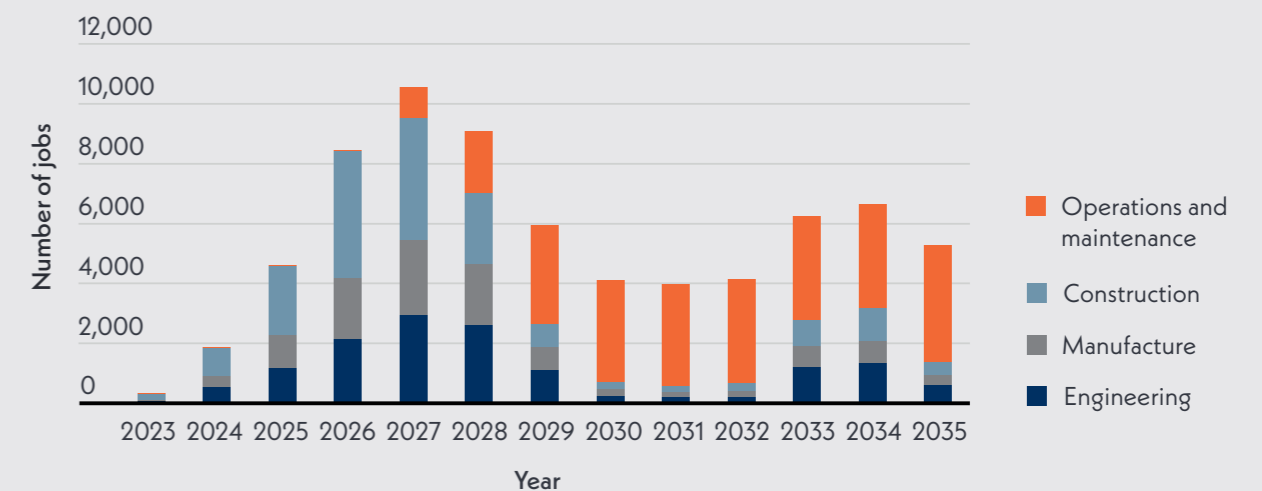
UK infrastructure deployment also coincides with an existing pipeline of other global projects, notably in the oil and gas sector, to meet sustained demand for hydrocarbons.

Adding to this demand, the number of CCS projects in development globally was at record levels in 2022, with over 150 projects in planning, led by the US and followed by Canada, UK, Norway, and Australia. As highlighted in the recent Chris Skidmore MP-led Net Zero review, this presents global competition, not only for investment capital but for the skilled labour required to develop these major capital projects.

Meeting the private-sector capital investment demand with UK supply chain capabilities is seen as both a key objective for the Viking CCS Cluster members, and also a major risk for the project's successful deployment, given the global demand for materials and skilled labour.

This analysis highlights key areas of the supply chain procurement needs across the range of industrial sectors, along with examples of where UK supply chain risks exist. The objective for this is to provide a platform for ongoing discussion with supply chain members and other relevant stakeholders such as government, trade industry bodies and skills suppliers.

Figure 8: Capital investment creates job demands across a range of sectors (includes capture, port, pipeline and storage projects)



Supply chain capacity by key area

This section provides a summary by key sector for UK supply chain capacity and foreseen availability within the deployment period for the Viking CCS Cluster.

Engineering

The UK has a well-established engineering supply chain for the oil and gas, oil refining and petrochemical industries. The technology and skills required to support CCS deployment are similar and generally compatible. It is foreseen that the established engineering service suppliers should be able to compete effectively to supply CO₂ capture, storage and transportation projects.

Given increased global demand for UK engineering, and a range of other labour-market factors within the UK (including UK-EU relations, the recent 2015-to-2017 UK energy industry downturns and the Covid-19 pandemic), capabilities for skills and personnel available to support the supply chain for project management and engineering services may have been affected.

Providing the Viking CCS Cluster front-end engineering and design (FEED) services has been completed through UK-sourced engineering services, leading to a significant investment of over £30 million in the sector to date. Feedback from the UK engineering providers regarding the skilled labour necessary for the increased demand for detailed engineering and procurement support indicates the labour market tightening, with competition for availability, and that the current market conditions should not be treated as business as usual.

This presents an opportunity for the Viking CCS Cluster members to engage early with engineering supply chain partners. However, it also presents a risk for the availability of the traditionally strong UK engineering service sector to meet the needs for projects. Plans to overcome this include:

- early discussions with engineering service providers to signal investment timing
- continuing to develop key strategic partnerships with engineering providers through FEED.

£7 billion

2025-2035 investment opportunity for the UK supply chain at risk

Manufacturing

Viking CCS Cluster members have a broad range of equipment-manufacturing and procurement needs; from large-scale capture plant processing equipment and pressure vessels, to significant quantities of high-grade steel line pipe, large numbers of valves and ancillary mechanical and process control equipment.

Detailed procurement mapping has been undertaken in the pre-FEED stages to understand the UK manufacturing base's capabilities for supply. During this mapping it was noted that many suppliers use competitive global supply chains. The location for manufacturing equipment is generally not specified until a detailed procurement proposal, often at the point of order, with suppliers reluctant to spend valuable bid-preparation time on queries at the early pre-FEED project stage. Therefore, there is a range of uncertainty about UK manufacturing for many of the process control and mechanical equipment items.

Material procurement and manufacturing items within the Cluster capital-investment programme include:

- Manufacture of large-diameter steel line pipe, in 24" and 36" diameter
- Fabrication of offshore structural jacket and topsides for the injection facilities
- Supply of large pressure vessels for CO₂ capture and processing equipment.

Line pipe

Procurement of line pipe represents a significant proportion of spending for the initial transportation and storage deployment on Viking CCS.

There is currently only one pipe mill in the UK capable of manufacturing the 24" and 36" line pipe to the relevant specification for Viking CCS. There are multiple European and global line pipe suppliers. With the requirement for a competitive sourcing process for the supply of line pipe, the ability of the UK supply chain to secure and deliver the order for Viking CCS is uncertain.

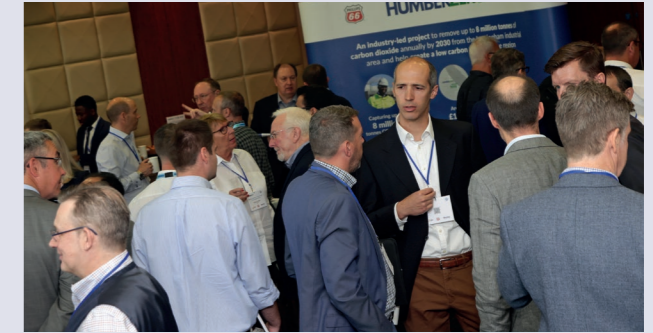
Future discussions with the sole UK provider regarding its future capacity and lead time is planned during FEED. In the global line pipe market, a lead time for manufacturing of 52 weeks is standard, however that is purely the manufacturing time. A further year to secure a manufacturing slot is also projected, which is material for project investment decisions and delivery schedule.

HUMBERZERO

Regional supply chain event

Humber Zero held an event for potential suppliers at the Forest Pines in Scunthorpe last year. Speakers included project leaders and Dr William Joyce from UKRI. The event was over-subscribed, with 180 UK companies interested in becoming suppliers to the Humber Zero carbon capture project.

Companies from as far afield as Aberdeen and Southampton made the journey and were given an overview of the project along with possible opportunities to supply goods and services. Humber Zero launched a specific supplier page on its website and invited companies to sign up to the Phillips 66 Limited and VPI Immingham strands of the project.



Offshore structure fabrication

The UK fabrication yards capable of offshore structure fabrication have seen recent sustained demand from the offshore wind industry. From engaging with UK fabrication yards it is currently forecast that there is no availability for the Viking CCS offshore injection platform. Of the many UK fabrication yards contacted, only one responded positively to having capacity for the Viking CCS structure fabrication, with a minimum of two years from order placement to a manufacturing slot. The remaining UK yards contacted either did not respond or confirmed they were no longer interested in jacket and topsides fabrications due to the growth of demand from offshore wind farms. It may therefore be necessary to source the injection platform from the European market, including fabrication sites in Norway, Netherlands or Spain.

Pressure vessels

There are no longer UK fabricators capable of building the type of large, low-pressure vessels needed for the scale of CO₂ capture equipment, with dimensions of up to 7m diameter and over 40m in height. Recent similar sized vessels required sourcing from the USA, Spain, Italy, India, South Korea and Japan. UK fabricators could develop this capacity, subject to investment. This would help shorten supply chains and encourage further investment. However, with firm contracts not yet tendered, there is a timing and investment confidence mismatch. Clear signals of the UK Government's commitment to CCS deployment would help bridge the UK market's investment confidence in this area.

Construction

Viking CCS is estimated to support up to 4,000 jobs at the peak of various construction activities. The Viking CCS Cluster construction phase from 2025 through to the early 2030s will be concurrent with the deployment of other CCS projects across the UK and with other infrastructure and energy projects.

It is estimated that there are 10,000 travelling construction contractors available in the UK, with approximately 5,000 of these engaged and committed at Hinkley Point C nuclear power station. Recent large maintenance programmes in both the downstream refining sector and the upstream offshore oil and gas sector have experienced challenges in securing adequate numbers and capabilities of contractors, with impacts to productivity. With peak construction resources for the Viking CCS Cluster projects of between 2,500 and 4,000 workers sustained from 2026 through to 2030, access to a high number of capable workers is a critical risk for the projects, and a significant opportunity to invest in UK skills and labour force.

Challenges to developing the number of skilled construction labour resources have included an ageing demographic, a lack of apprentices, and post-Brexit visa restrictions on non-UK semi-skilled labour, which together have significantly reduced the labour pool. The Humber Industrial Cluster Plan study on skills provision has shown that while there is a 10% reduction in the current available Humber workforce



Regional skills

Establishing a CCS industry in the UK, led by the major projects of the Viking CCS Cluster members, throughout the 2020s with sustained investment into the 2030s, presents a significant opportunity for the Humber region to benefit from skills development. It also presents an opportunity to de-risk delays by developing a regional talent pipeline.

By decarbonising the industrial basin in the Humber, Viking CCS and its industrial members are helping to ensure existing jobs directly and indirectly linked to these industries are safeguarded, while creating new job opportunities. To secure this economic opportunity for the Humber, sustained investment in skills development is required to develop a pipeline of local and regional talent who want to enter the CCS sector.

CCS is not a well understood or recognised industry by the UK public. To promote an inclusive and interesting career path for school leavers and current workers looking to change careers needs a programme of outreach to make the industry more accessible and appealing.

During the 14 in-person consultation events hosted by Viking CCS throughout 2022, as part of the Development Consent Order process for the new onshore pipeline infrastructure, members of the public showed a keen interest in the role for CCS in the UK's net zero targets and the technologies involved. These consultation events provided an insight into the depth of interest in the energy transition, raising awareness for the key opportunities, challenges and risk-management requirements for at-scale CCS deployment. While these consultation events were part of the DCO process, it has highlighted the importance of in-person events to

communicate the broader need for CCS as one of many technology pathways to net zero, and why the CCS pathway can contribute meaningfully to the future regional economies.

Building on this, Viking CCS is engaging with independent training providers across the Humber including CATCH UK and both the Hull and East Yorkshire Local Enterprise Partnership (HEY LEP) and the Greater Lincolnshire Local Enterprise Partnership, to fund two full-time roles, with the aim of increasing and promoting connections between industrial, schools, colleges and independent training providers. These roles will work across the energy transition sector.

Both Local Enterprise Partnerships in the Humber have Careers Hubs funded by the Department for Education through the Careers and Enterprise Company. Viking CCS has co-funded one full-time Enterprise Coordinator role to work across both Careers Hubs and engage over 90 schools and colleges within Lincolnshire and Yorkshire. This will ensure that industry skills and knowledge are better embedded in careers programmes.

This is a first step towards a sustainable effort at building knowledge and excitement in the future skills pipeline of students needed for the industrial investment demand to follow.

by 2030, there is an increase in demand by 30% – overall a 40% gap in requirements for skilled labour to meet the investment opportunity to rejuvenate and decarbonise the long-term industries of the region.

The Viking CCS Cluster members advocate for an early and massive increase to apprenticeship training and skilled craftspeople STEM career paths, to incentivise school leavers to return to UK industry and industrial regions, along with appropriate targets for certain skilled craftspeople's visas. The following section describes the early steps the Viking CCS Cluster members are taking, working with key skills and education providers in the region.

Summary

The Viking CCS Cluster procurement will take place within a globally competitive supply chain market, with constraints on availability. The current tight market conditions and the first-of-a-kind nature of the CCS industrial deployment in the UK leads to an elevated supply chain risk to schedule and costs.

Provision of engineering services is expected to be met through a majority of UK content, with a distribution of engineering jobs around the UK and not highly concentrated in any one region.

UK manufacturing capability and provision for large items of procurement such as line pipe, offshore structures and pressure vessels is less certain, with material constraints on both the number of providers and the interest in the CCS industry, given concurrent global demand and the rapid growth in the UK offshore wind sector.

UK and regional construction labour availability remains a key risk, for a rapidly approaching construction window from 2025 through to 2030. Competition and project retention for critical skills is likely to be a challenge in tight labour-market conditions. Sustained cross-industry and government investment in skills programmes to supply the number of construction workers needed is required, with a closing window for this to make a meaningful difference to the availability of labour in the initial construction period for 2025.

Case study

The search for tomorrow's industry champions

CATCH is a membership organisation for the Humber's energy-intensive industries, providing industry-leading training facilities for the Humber, Lincolnshire and Yorkshire regions.

Research undertaken by CATCH confirms that there will be a significant surge in demand for skilled labour from 2024, with up to an estimated 23,000 new industrial jobs required across all regional projects. The research highlighted that there will be a significant gap in skills supply that needs to be addressed within two years, for projects to start and be completed on time.

Coming in 2023, to complement training in process operations, mechanical, electrical and instrumentation standards, the CATCH Welding & Pipefitting Hub is an employer-led project to ensure the region has the right level of skills to meet the demand of existing process-industry projects, and help the UK with the huge construction projects industrial decarbonisation needs. The hub will have four main capabilities: Schools STEM Engagement (Harbour Energy is supporting a role within CATCH to enable this); Level 3 Apprenticeship training; upskilling existing employees in industry; and re-training programmes for new entrants and returners to industry.

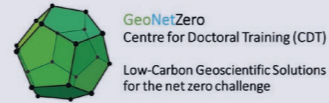


Commitment to academic research and training

Harbour Energy supports the UK's Centre for Doctoral Training (CDT) called GeoNetZero. A partnership between twelve UK universities to assess the role of geoscience in meeting net zero emissions targets, the CDT is led by Aberdeen University's Director for Energy Transition, Professor John Underhill.

The prime objective of the £23 million programme is to characterise the subsurface and seabed to inform renewable energy, marine planning and regulatory choices to help the UK meet its net zero targets.

The programme's projects focus on the UK Continental Shelf and span the full range of renewable energy.



Several projects focus on evaluating subsurface carbon-storage sites in the southern North Sea, including areas where Harbour Energy holds licences.

As well as research, the CDT runs a professionally accredited 20-week training programme for students to develop their understanding of the wider energy-transition landscape.

Since its launch in 2014, the CDT has enrolled 170 PhDs. Eighty have graduated from the GeoNetZero CDT programme to date, all of whom have been employed in a relevant discipline, underlining the relevance, quality and need for the scheme.

Empowering future generations

Educational outreach

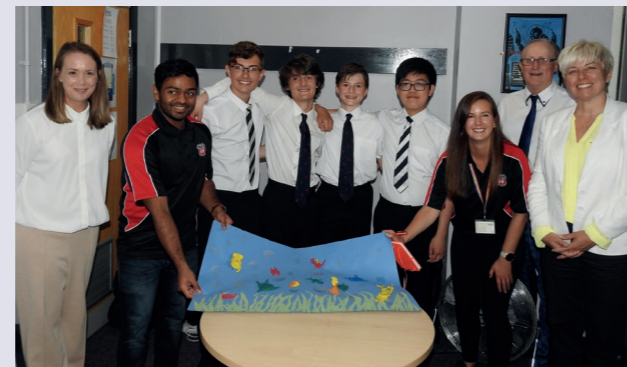
Phillips 66 Limited has a long-standing relationship with the Humber region and completed a wide range of educational outreach programmes in 2022. This forms connections between businesses and education, and seeks to encourage growth of a local skilled workforce.

Waterline Summit 2022 – Phillips 66 Limited was a partner for this event organised by Marketing Humber and supported by the University of Hull. Bringing together a variety of different stakeholders, including students, academics and businesses, the Summit provided information for students and attracted new investment across the Humber. An Energy of the Future session detailed how Phillips 66 Limited and others plan to support decarbonisation, create jobs and boost the economic profile of the local area.

Schools Sustainability Challenge¹¹ – During 2022, Phillips 66 Limited launched a Sustainability Challenge to involve over 30 local schools on a variety of sustainability issues. Students were asked to recommend solutions for a wide range of sustainability challenges.

School and college support

Phillips 66 Limited works with many schools across the Humber region to help form connections between businesses and education by contributing to careers activities and events. As part of its commitment to this, Phillips 66 Limited is a partner to Engineering UTC Northern Lincolnshire¹², supporting activities such as health and safety talks, one-to-one mentoring, and work placements.



¹¹ Phillips 66 Limited UTC Engagement, 2022. Available at: <https://www.enlutc.co.uk/partner-profile-phillips-66/>

¹² Phillips 66 Limited, Battery Coke Article, Page. 63, 2022. Available at: <https://www.criticalmineral.org/esgpaper>



Low-carbon products and inward investment

The successful completion of Viking CCS will enable project members in the Humber and beyond to decarbonise their current and future product lines – shaping the Humber into a low-carbon hub.



Phillips 66 Limited: The refinery of the future

Phillips 66 Limited is developing new lower-carbon business streams, enabling the company to transform its business to one that is fit for the future and can contribute to decarbonising other sectors.

Supporting the electric vehicle supply chain¹²

Phillips 66 Limited produces one of the essential elements of electric vehicle batteries. The battery anode graphite, produced at the Humber Refinery, forms a key component within electric vehicle batteries and supports advanced manufacturing in the steel-recycling industry. The Humber Refinery is the sole European producer of this critical product.

Figure 9: Phillips 66 Limited's role in the electric vehicle supply chain

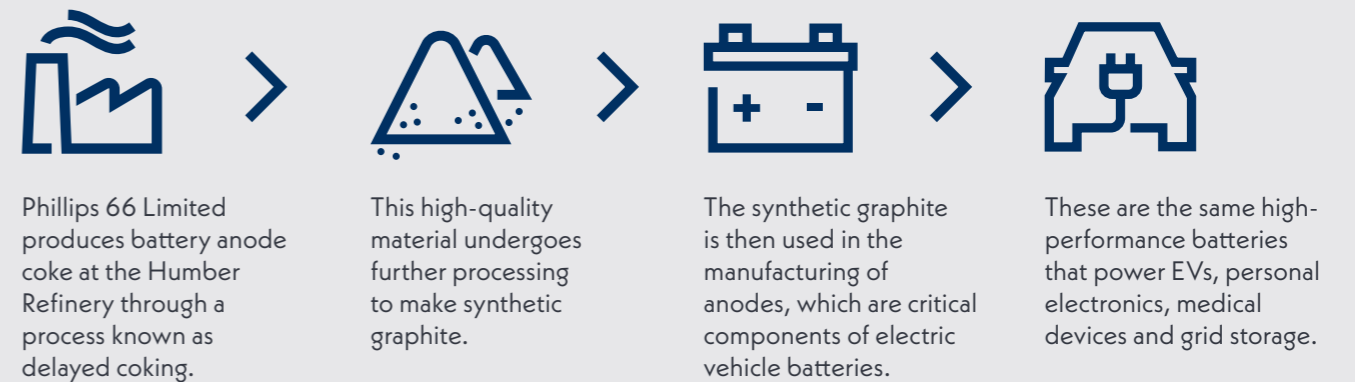
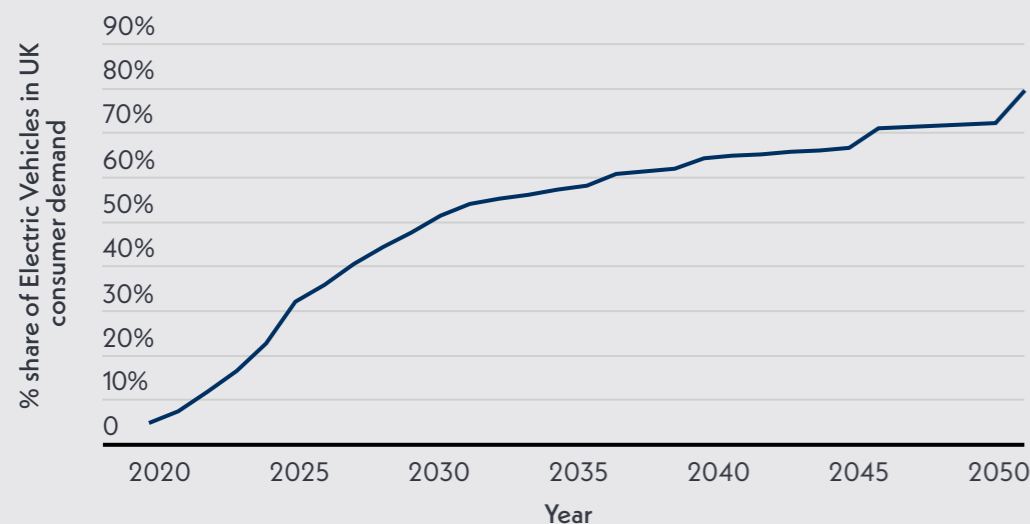




Figure 10: UK projected growth in electric vehicle demand leading to increased battery demand¹³



Electric vehicles are expected to play a critical role in decarbonising transport, leading to a rapid increase in demand for synthetic graphite (Figure 10). CO₂ capture from the production process would reduce Phillips 66 Limited's emissions, lowering the carbon intensity of the electric vehicle supply chain.

Developing the electric vehicle supply chain industry in the Humber will provide economic benefits to the local communities, creating and maintaining local jobs.

Lower-carbon fuels¹⁴ and sustainable aviation fuels (SAF)¹⁵

Phillips 66 Limited's Humber Refinery is moving its operations towards developing fuels required for a low-carbon economy.

For example, the Humber Refinery was the first in the UK to produce high-performing, advanced second-generation biofuels at scale, using waste. Used cooking oil was the main waste feedstock introduced to the refinery processes, in 2017. In 2020, Phillips

66 Limited invested significantly in increasing this capacity threefold, with the addition of a new lower-carbon fuel module.

Phillips 66 Limited lower-carbon fuels production also allows the refinery to produce SAF, which is vital to decarbonising the aerospace industry, one of the 'hard to abate' sectors¹⁶. SAF can play a key role by displacing some fossil-fuel-derived kerosene that emits CO₂, with a lower-carbon alternative. This can reduce lifecycle CO₂ emissions by over 80% compared to traditional jet fuel.

Currently, the Humber Refinery produces around 20,000 metric tonnes of SAF a year, and it plans to more than double production by 2025.

Phillips 66 Limited has already signed a partnership with British Airways. This will reduce British Airways' lifecycle CO₂ emissions by almost 100,000 tons, the equivalent of powering 700 net zero CO₂ emissions flights between London and New York on its fuel-efficient Boeing 787 aircraft.

¹³ Element Energy, Electric Mobility: Inevitable, or Not, 2022. Available at: <http://www.element-energy.co.uk/wp-content/uploads/2017/03/20161024---Towards-a-European-Market-for-Electro-Mobility-FINAL.pdf>

¹⁴ IAG Cargo, Phillips 66 Limited Used Cooking Oil Processing Report, 2022. Available at: <https://iagcargomagazine.com/2022/11/08/phillips-66-leading-the-way-with-sustainable-aviation-fuel/>

¹⁵ Phillips 66 Limited and British Airways Press Release, 2022. Available at: <https://www.phillips66.com/newsroom/british-airways-phillips-66-limited-sign-sustainable-aviation-fuel-supply-agreement/>

¹⁶ A sector in which transition to net zero is complex due to a lack of low carbon technological developments and high costs of transition.

A low-carbon green energy future at ABP's Port of Immingham

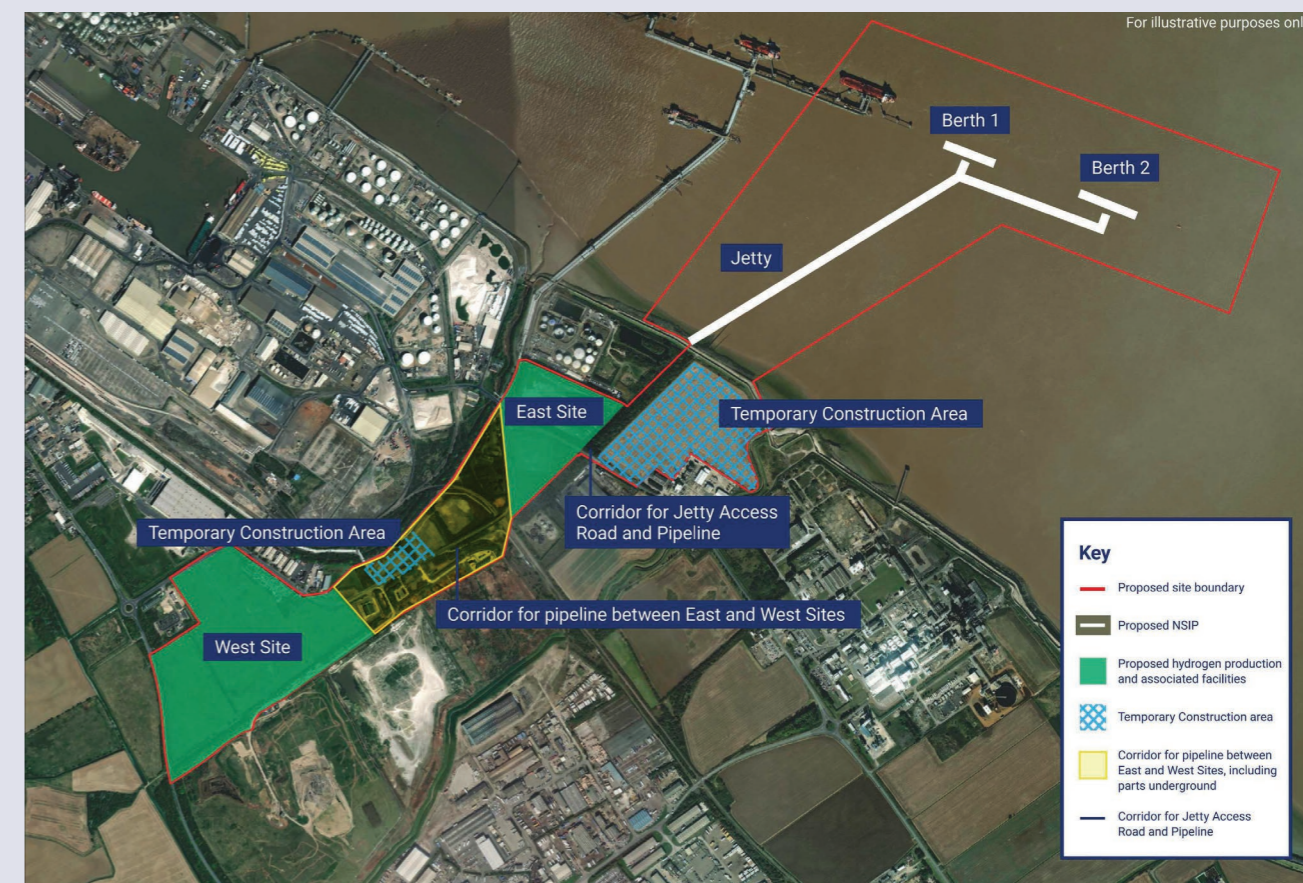
ABP's Humber port complex is the largest in the UK, handling more than 60 million tonnes of trade in 2021, or around £75bn of imports and exports¹⁷. This critical ports complex contributes £2.5bn of value added to the UK economy, with over 1,200 people directly employed at the port and 34,900 jobs supported across the Humber region¹⁸.

The ABP Humber port complex already plays a leading role in the UK's energy transition, with the UK's only wind-turbine manufacturing factory, in Hull, and the UK's largest offshore wind operations and maintenance hub at Grimsby. Recognising the scale of economic opportunity that the energy transition and net zero

economy represents, ABP is further investing in growing the Humber port complex's leading role with a new green-energy jetty and associated infrastructure, along with innovation such as a world-first trial for using hydrogen in port equipment.

The new jetty will be in dual use for both the import of green ammonia for conversion to hydrogen, and CO₂ imports. It can enable access to geological CO₂ storage for up to 40% of UK industrial and power emissions in otherwise stranded industrial clusters, via the broader ABP port network including regions such as South Wales and the Solent (see page 6).

Figure 11: ABP's green-energy terminal plan with new imports berths and hydrogen production



¹⁷ Department for Transport "Port and domestic waterborne freight statistics" <https://www.gov.uk/government/statistical-data-sets/port-and-domestic-waterborne-freight-statistics-port>

¹⁸ "Serving the economy. Serving the Nation" ABP Economic Impact Report <https://www.abports.co.uk/media/55cfqmyy/abp-economic-impact-study.pdf>

The potential for growth

We believe the Humber can be the UK's first net zero SuperPlace, combining industrial-scale green energy generation and new CCS infrastructure to enable an industrial renaissance and new energy ecosystem. Viking CCS can deliver a material acceleration to this transition and cement the Humber's position of first UK SuperPlace by 2030.



We welcome the Government's commitment to CO₂ capture and storage as a principal means of accelerating the nation's net zero ambitions.

The UK has the potential to be a global leader in carbon capture and storage, and the Viking CCS project is well-positioned to play a key role. By working in partnership with the power sector and infrastructure and transport providers, Viking CCS offers a route to deliver one third of the UK's target of 30 million tonnes of CO₂ capture by 2030.

I now urge Government to initiate the Track 2 cluster selection process so that the Viking CCS project can remain on track to realise these goals.

Linda Z. Cook
CEO Harbour Energy

The Viking CCS Cluster investment spans the critical transport and storage infrastructure, the CO₂ capture plants of Cluster members, in addition to the opportunity of ABP's port network, and is projected to bring £7 billion of private-sector-led capital investment between 2025 and 2035.

This scale of sustained private-sector investment will generate significant demand for skilled jobs across a broad range of industries, and develop secondary benefits across the region as these new workers seek services in the local economies. Securing these skilled jobs within the UK and regional economies, where there are already supply chain and labour constraints, won't be easy and will require sustained engagement from industry and government to attract talented school leavers and apprentices across the range of sectors needed. This will require collaboration between government, developers, the supply chain, and the education and skills providers. However, with over 10,000 jobs potentially generated by the Viking CCS Cluster, at the peak of construction in 2027, this is a huge opportunity that the Humber and north-east of England is uniquely placed to take, as the future epicentre of the UK's net zero economy.

Access to the CCS infrastructure and growth in the market for lower-carbon products, such as sustainable aviation fuel, the electric vehicle battery supply chain and abated power and steam, can attract other inward investment to a new net zero SuperPlace – as evidenced by RWE's recently announced development partnership with Viking CCS to explore the development of a new-build modern gas-fired power station with carbon capture, on the South Humber bank.

The potential investment in the Viking CCS Cluster, subject to the necessary processes, business model support and final investment decisions, will help secure the UK's energy future, ensuring a fast and material reduction in CO₂ emissions, while stimulating both regional and national growth. With the Viking CCS final investment decision planned for 2024, and first storage as early as 2027, swift action is needed from government to ensure the UK's unique position as a global leader in CCS and the net zero supply chain is not at risk.





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 **GeoNetZero**
Centre for Doctoral Training (CDT)
Low-Carbon Geoscientific Solutions
for the net zero challenge

CATCH

 **HEY** Hull and
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