



InnovateUK
KTN

Virtual Global Expert Mission China – Industrial Decarbonisation February 2022



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Executive Summary

Some of the world's most impressive industrial decarbonisation projects are being delivered in UK industrial clusters. UK Research and Innovation's Industrial Decarbonisation Challenge programme is supporting a series of major infrastructure projects which will enable the at-scale rollout of carbon capture and storage (CCS) and hydrogen networks in the mid-2020s.

The UK will create the world's first net zero industrial clusters by 2040, utilising the significant amount of storage capacity available offshore. This important asset, combined with the projects in advanced stages of development, will enable the UK to become a world leader in industrial decarbonisation technologies.

China is the world's largest emitter of CO₂ and was responsible for 28% of global CO₂ emissions in 2020. Significantly, President Xi set a binding target to achieve net zero by 2060. Major industrial decarbonisation initiatives in China, specifically CCS and low carbon hydrogen, therefore, present significant market growth opportunities.

Furthermore, it will be necessary for the UK and China to work closely together to share knowledge and promote collaboration as the global market develops at pace.

Moreover, this year marks the fiftieth anniversary of UK-China ambassadorial diplomatic relations. Industrial decarbonisation presents a major area for both countries to progress dialogue, strengthen relationships and develop important and strategic opportunities to work together¹.

This report focuses on two main areas, CCS and scalable, low carbon hydrogen production, key technologies which require significant development to support and accelerate global decarbonisation strategies.

Experts from the UK and China have identified areas for collaboration between the two countries in CCS and hydrogen production. There are clear opportunities for UK businesses to work with Chinese companies, organisations and academia to develop state-of-the-art technology to serve the needs of the industry best and help governments meet emissions targets. These areas include the development of long-term business models, the design of new regulatory and policy frameworks, the creation of a knowledge exchange platform and the development of large-scale projects.

Acronyms and Definitions

1+N	Part of a carbon neutrality policy framework formulating China's sustainable development
14th Five-Year Plan	The 14th Five-Year Plan (2021-2025) for National Economic and Social Development and Vision 2035 of the People's Republic of China
Carbon-neutral	A state of net zero carbon dioxide emissions which can be achieved by balancing emissions of carbon dioxide with its removal or by eliminating emissions
CCS	Carbon Capture and Storage
CCUS	Carbon Capture Utilisation and Storage
CO ₂	Carbon Dioxide
COP26	More commonly referred to as COP26, the 26th United Nations Climate Change Conference was held in Glasgow, Scotland, United Kingdom, from 31 October to 13 November 2021
CPC Central Committee	The Communist Party of China (CPC) is the party in power. The CPC has both central and local organisations, at the top is the Central Committee
Decarbonisation	The reduction of carbon and an economic system that sustainably reduces and compensates the emissions of carbon dioxide (CO ₂)
Fossil Fuel	A hydrocarbon-containing material formed naturally in the earth's crust from the remains of dead plants and animals that can be extracted and burned as a fuel. Fossil fuels include coal, crude oil and natural gas
Fuel Switching	Transitioning from fossil-derived fuel to renewables
Industrial Cluster	A geographic concentration of interconnected firms, suppliers, and institutions in a particular field
Knowledge Exchange	An exchange between researchers and research users, to share ideas, research evidence, experiences and skills
MtCO ₂	Metric tons of carbon dioxide, a metric measure used to compare the emissions from different greenhouse gases based upon their global warming potential
NECCUS	An alliance of industries and experts leading the Scottish Net Zero Roadmap (SNZR)
Net Zero	A target of completely negating the amount of greenhouse gases produced by human activity which can be achieved by reducing emissions and implementing methods of absorbing carbon dioxide from the atmosphere

Paris Agreement	Also referred to as the Paris Accords or the Paris Climate Accords, it is an international treaty on climate change adopted in 2015. It covers climate change mitigation, adaptation, and finance
Renewable Energy	Also referred to as renewables; energy produced from sources such as the sun and wind that are naturally replenished and do not run out
State-of-the-art	The most recent stage in the development of a product or technology incorporating the newest technology, ideas, and features
UKRI	United Kingdom Research and Innovation
Zero Carbon Hub	A type of industrial estate based around industrial processes

1.0 Introduction

Following COP26, there has been renewed interest and commitment by businesses, government, and academia to achieving net zero by 2050. To support this transition, the UK government launched the Industrial Decarbonisation Strategy in March 2021². This details the long-term strategy and investments required to achieve net zero by 2050. It focuses on the UK's manufacturing industry which contributes £170 billion to the economy and plays an essential role in society. The strategy offers a promising direction and provides wide-ranging measures that need to be implemented to support innovative technology in decarbonisation while encouraging competitiveness.

At the same time, China launched its 14th Five-Year Plan in March 2021³ to reduce its dependence on carbon-intensive resources and invest in modern, efficient, reliable, and green infrastructure. The new policy promotes an energy revolution, supporting low-carbon and clean growth technologies focusing on CCS and hydrogen generation on a large scale. The China Hydrogen Alliance, a government-supported industry group, predicts the hydrogen energy industry will be worth \$152 billion by 2025⁴. Along with the Hydrogen Council in China, a comprehensive roadmap, the Path to Hydrogen Competitiveness - A Cost Perspective, was published detailing cost, production, and applications in hydrogen energy. In addition, China has 16 large-scale carbon capture utilisation and storage (CCUS) projects to meet carbon neutrality by 2060⁵.

Decarbonising industry is a global challenge. With 28% of all global CO₂ emissions, China has the opportunity to build on international expertise to reach targets from the Paris Agreement and COP26. Research conducted by China's Environment Ministry in July 2021⁶ concluded that as much as 1.82 billion tonnes of CO₂ needs to be cut via CCS to achieve the country's net-zero targets by 2060.

China is among the leaders in renewable technology producing over 70% of the world's photovoltaics and having 75% of the global manufacturing capacity for lithium-ion battery cells, which are essential for electric vehicles⁷. The state creates a conducive environment for innovative companies by pledging to invest trillions in novel renewable technologies. The country may achieve its ambitious goal of becoming carbon-neutral by 2060 and a value-added industry leader.

Mission Objectives

The Global Expert Mission (GEM), part of Innovate UK's Global Missions Programme, plays a vital role in building strategic partnerships with countries and overseas organisations. The Expert Mission is an important tool to support the UK's Industrial Strategy ambition and to be the partner of choice for research and innovation. The GEM programme delivers this by deep diving into the research and innovation ecosystem in the selected countries to help identify opportunities for UK innovation and shape future programmes.

The objective of a mission is to:

1. Inform UK businesses and government.
2. Identify opportunities and build international collaborations.
3. Promote and share UK capabilities.

The mission reviewed technology and infrastructure gaps in both countries, focusing on large-scale production of blue hydrogen and carbon capture and storage. The mission also captured insights into the synergies between the two countries in decarbonisation and determined the appetite for collaboration.

The mission highlighted key future market opportunities for innovative products and services to UK businesses that may be interested in collaborating with China. This included insights into UK research and investment, and emerging market opportunities and challenges for developing innovative products and services when considering collaboration with China.

Research Scope

Carbon Capture and Storage (CCS): This is the process of capturing CO₂ from industrial processes followed by transporting and storage in permanent carbon sequestration in a geological formation. The mission reviewed CCS technology maturity in both countries to identify areas of synergy.

Blue hydrogen: This form of hydrogen is primarily produced from natural gas via the steam methane reforming (SMR) process. The output of the process produces hydrogen with CO₂ as the by-product. The CCS process enables the environmentally sustainable production of hydrogen, as it prevents the release of CO₂ into the atmosphere. The mission explored both onshore and offshore hydrogen production and transportation with a focus on large-scale deployment.

Fuel switching: National strategies discuss transitioning from fossil-derived fuels to renewables. The mission focused on the integration of clean energy technologies into existing infrastructures.

Policy and partnership building: The mission reviewed the policy and long-term investment strategy in industrial decarbonisation, explored national support programmes and identified short- and long-term collaborative and joint funding opportunities.

2. Overview of the UK's Industrialisation Decarbonisation Strategy and Innovation landscape

Both China and UK decarbonisation strategies focus on developing clean technologies such as low carbon hydrogen, which is a suitable replacement for fossil-derived fuels providing flexible energy for power, heat and transport. Most hydrogen produced by the UK and China comes from fossil fuels. Both countries have a long-term strategy to transition towards blue and green hydrogen production along with large-scale deployment of CCS technologies. This will enable the decarbonisation of energy-intensive and consumer industries by utilising existing infrastructure and blending hydrogen with natural gas. There is a clear mutual benefit for both countries to engage in collaborative discussions to accelerate developments in CCS, hydrogen production and fuel switching technologies.

Approximately half of CO₂ emissions in the UK are in clustered sites around the coast, and there is a plan to decarbonise industry in these geographical areas (and beyond). To enable this, a number of competition processes have launched and are going through consultation on the next steps. The UK has also set ambitious targets including capturing a significant amount of CO₂ from industry by the end of this decade. For example, the Net Zero Strategy by the Department for Business, Energy and Industrial Strategy (BEIS) set a target of capturing 6 million MtCO₂ of industrial emissions per year by 2030. This is encouraged and supported by a significant increase in government investment, ambition and policy.

The UK has established several clusters to meet net zero and make sure these vital industrial regions thrive in the future. It is imperative that there is a priority within the industrial network to share knowledge and best practices, establish research programmes and support plans for investment. The success of the UK's industrial cluster programme is critical to meeting the net zero targets by 2050.

The industrial clusters developing in the UK include many of the largest emission sites from industries such as steel, cement, refining, chemicals and fertilisers. These clusters are located near the coast enabling them to utilise the abundant CO₂ storage opportunities in the North and Irish Sea, as well as the easy shipment of CO₂. Low-carbon hydrogen is also being developed and will play an essential role in decarbonising industries. The UK government is committed to £1 billion of funding to deploy CCS networks in four industrial clusters by 2030, with at least two by the mid-2020s. The UK will capture between 20-30 million MtCO₂ across the economy a year by 2030 through CCS and low carbon hydrogen deployment, and aims to achieve the world's first net zero industrial clusters by 2040.

In March 2021, UK Research and Innovation announced a significant milestone in decarbonisation with the award of £171 million to nine projects, which includes three offshore CO₂ storage sites, CO₂ capture and/or hydrogen production projects in the North West, Scotland, Teesside, Humberside and South Wales. These first-of-a-kind decarbonisation projects will develop the engineering and technical requirements to decarbonise industrial clusters.

2.1 Industrial Decarbonisation Challenge Deployment Portfolio

The £171 million deployment investment will enable significant reductions in industrial CO₂ emissions in industrial clusters. The deployment projects include⁸:

HyNet

HyNet plans to develop a full-chain hydrogen project in the North West of England including repurposing old oil and gas assets for CO₂ transport and storage.

<https://hynet.co.uk/>

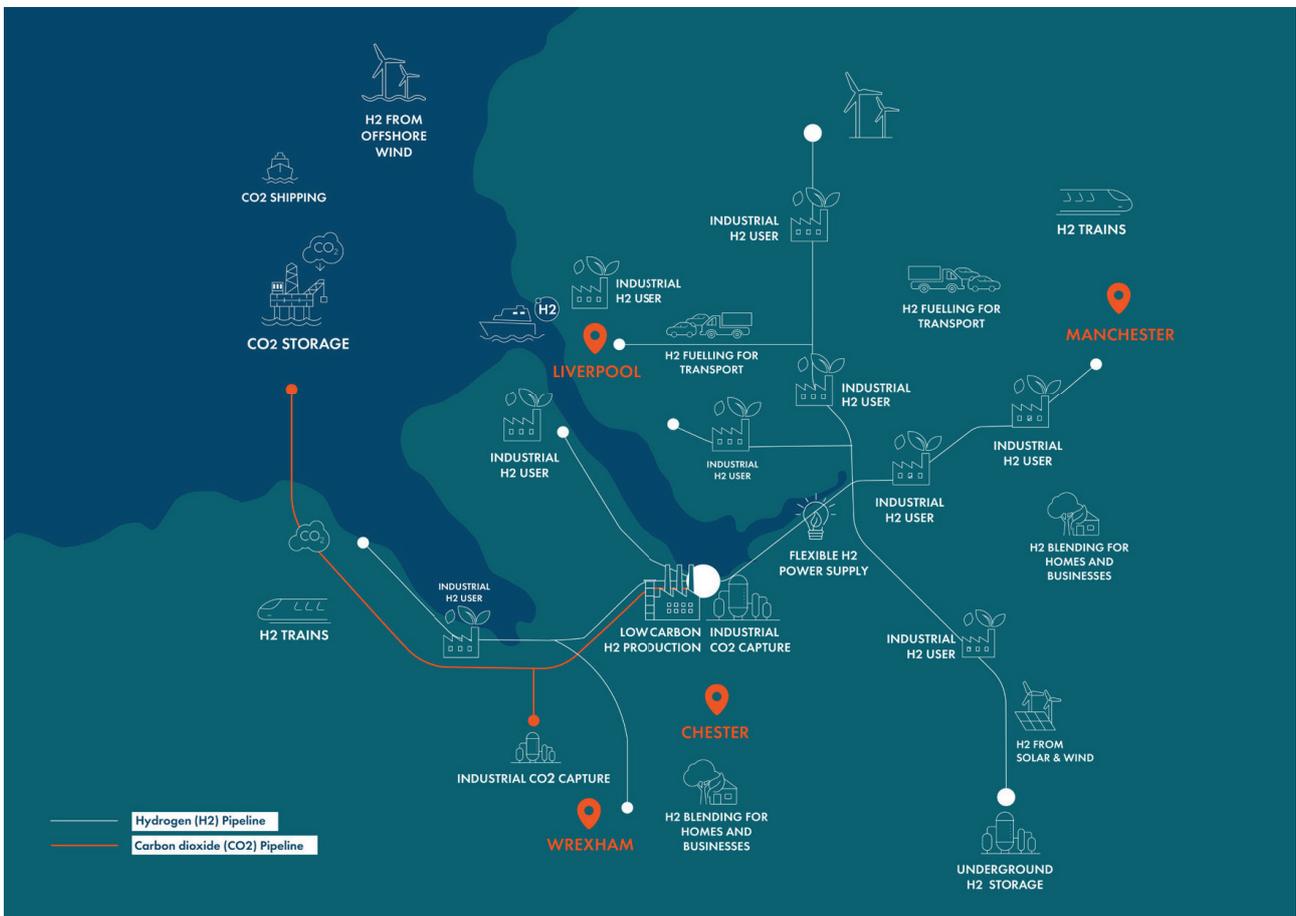


Figure 1: Schematic of the HyNet project

UKRI Funding award: £19.5 million onshore, £13.3 million offshore.

UK Partner organisations: Cadent, CF Fertilisers, Essar, Eni, Castel Cement, Inovyn, Progressive Energy and the University of Chester.

Humber Zero

Humber Zero is a project to decarbonise the regional industrial complex at Immingham, representing approximately 8 MtCO₂ per year emissions by the late 2020s via a combination of technology pathways.

<https://www.humberzero.co.uk/>

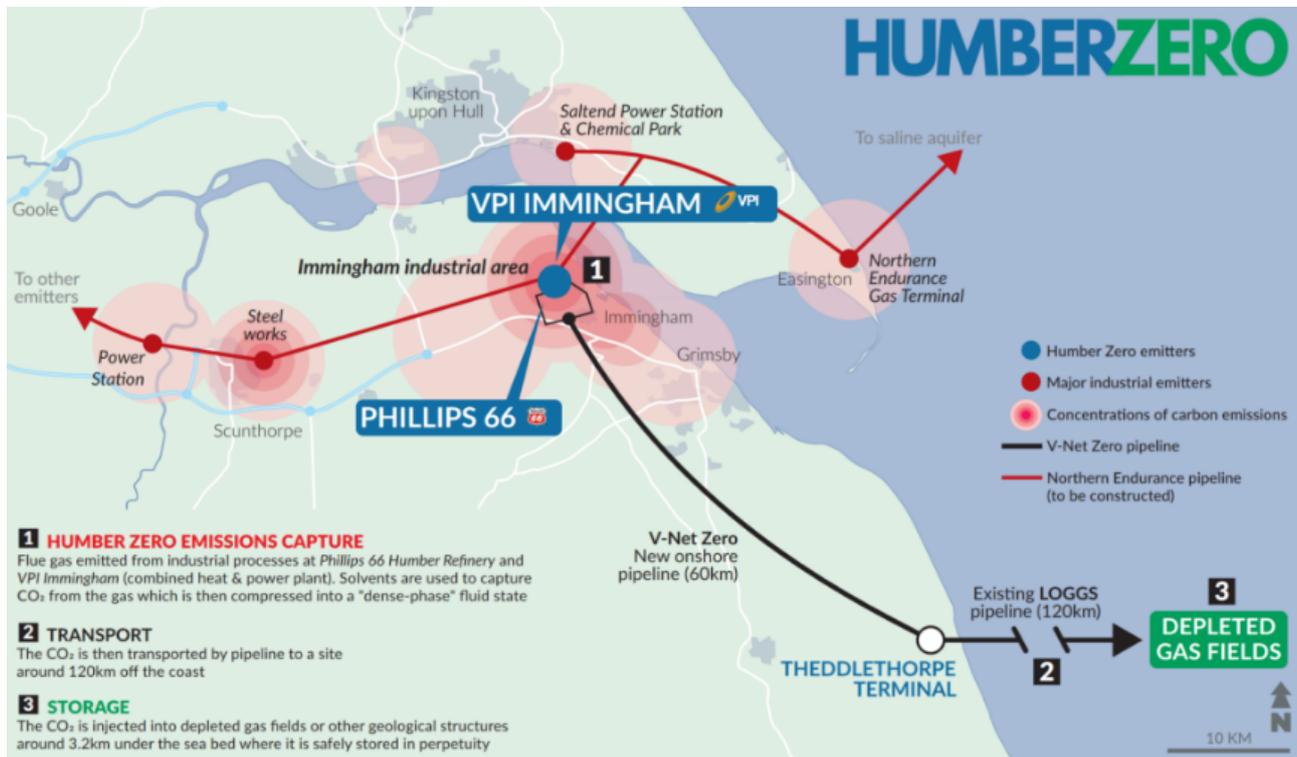


Figure 2: Schematic of the Humber Zero project

UKRI Funding award: £12.7 million.

UK Partner organisations: Vitol, Phillips 66.

South Wales Industrial Cluster

The South Wales Industrial Cluster plans to provide the UK with lower-carbon steel and reduced-carbon cement products to benefit the wider UK infrastructure.

<https://www.swic.cymru/>

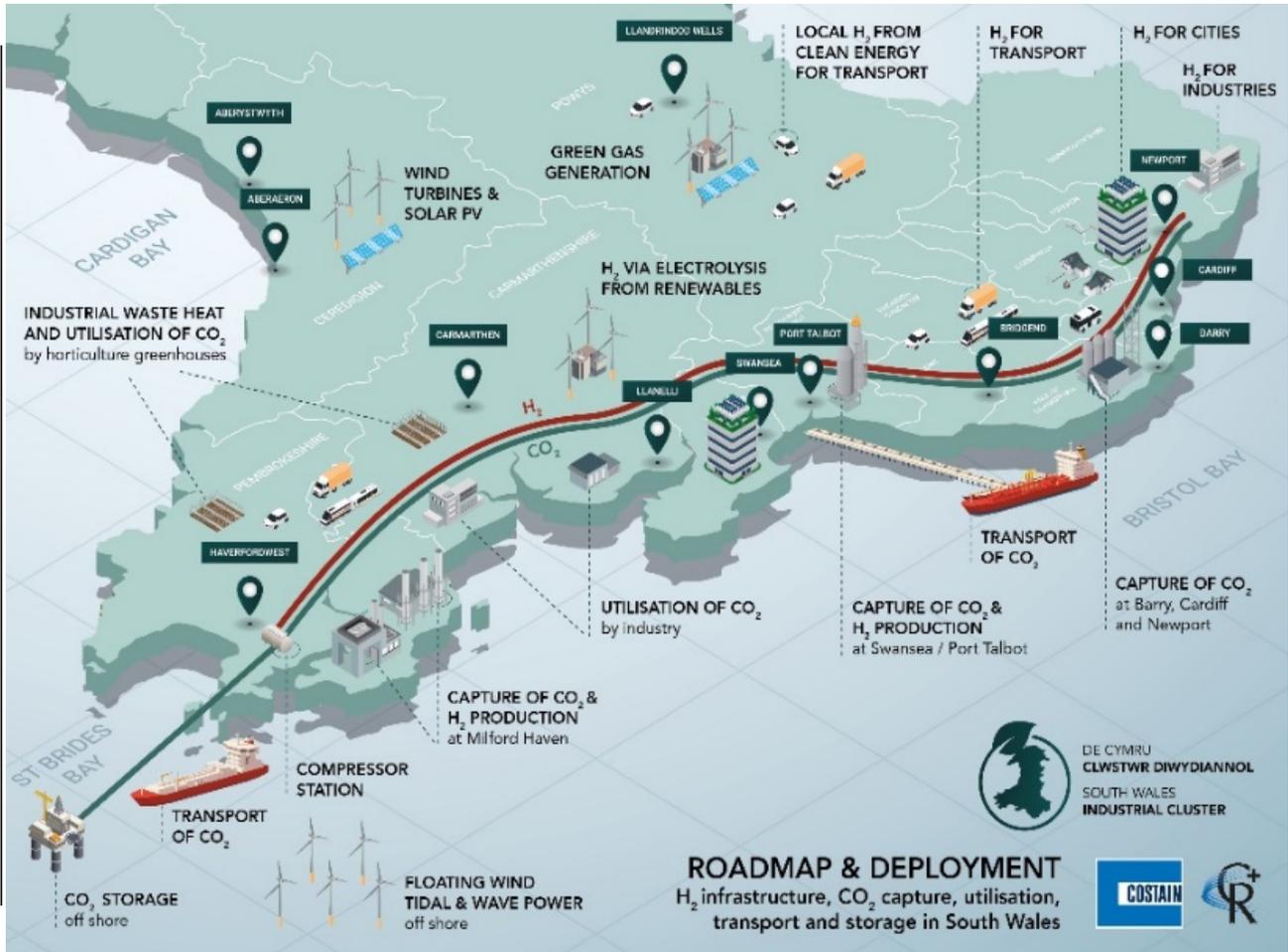


Figure 3: Schematic of the South Wales Industrial Cluster project

UKRI Funding award: £20 million.

UK Partner organisations: Costain, Tarmac, Tata Steel, Valero Energy, Shell, BP, University of South Wales, Progressive Energy, Milford Haven Port Authority, RWE, CR Plus, Capital Law, Associated British Ports, Sector Development Wales Partnership, Simec Uskmouth Power, Lanzatech.

Zero Carbon Humber

Zero Carbon Humber will deliver low-carbon infrastructure, comprising CO₂ and hydrogen transmission pipelines linking the region's major emitters. A 600 MW autothermal reformer will provide low carbon hydrogen to the Saltend Chemicals Park.

<https://www.zerocarbonhumber.co.uk/>

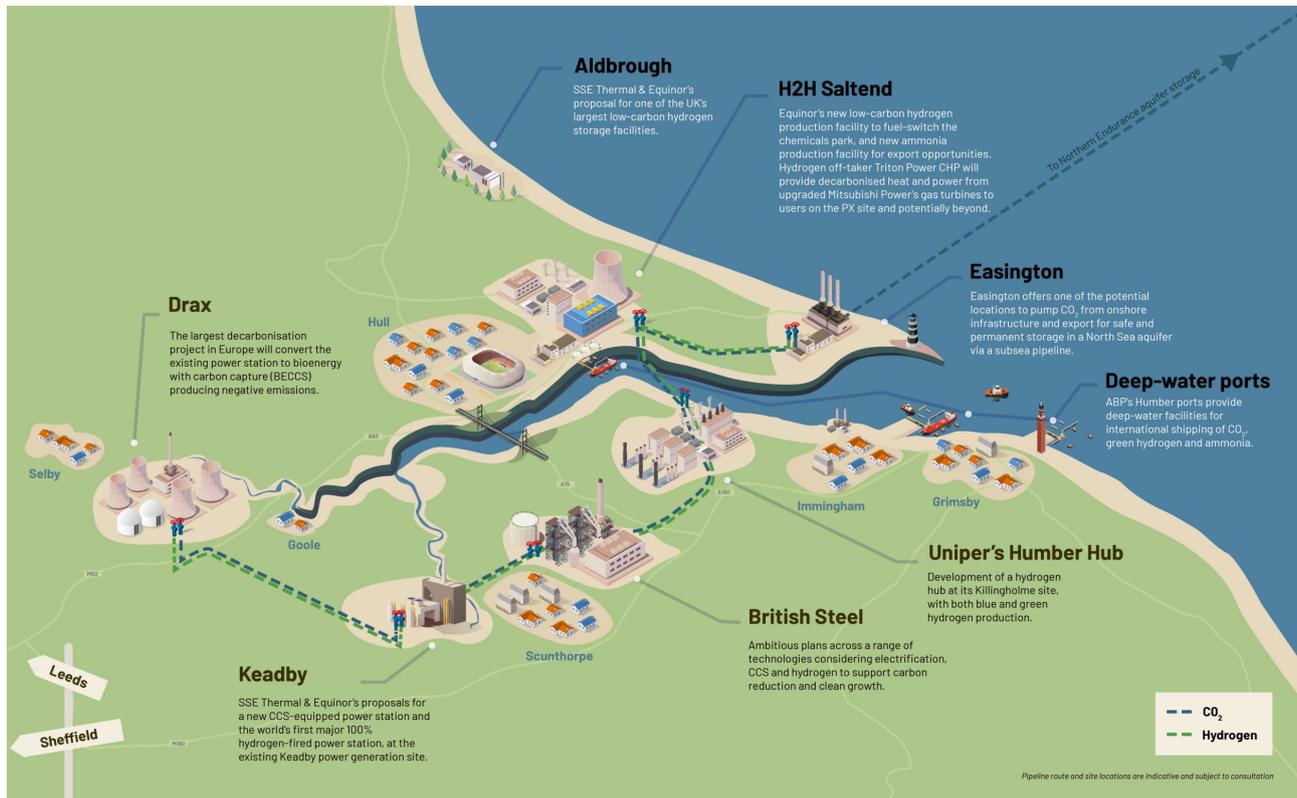


Figure 4: Schematic of the Zero Carbon Humber project

UKRI Funding award: £21.5 million.

UK Partner organisations: Equinor, British Steel, National Grid, Centrica, Drax, Uniper, Mitsubishi, SSE, Associated British Ports, University of Sheffield, Saltend Cogeneration Company, PX.

Net Zero Teesside

Net Zero Teesside will create the world’s first flexible gas power plant with CCUS, decarbonising 750 MW of dispatchable power. CO₂ will be safely stored under the North Sea.

<https://www.netzeroteesside.co.uk/>

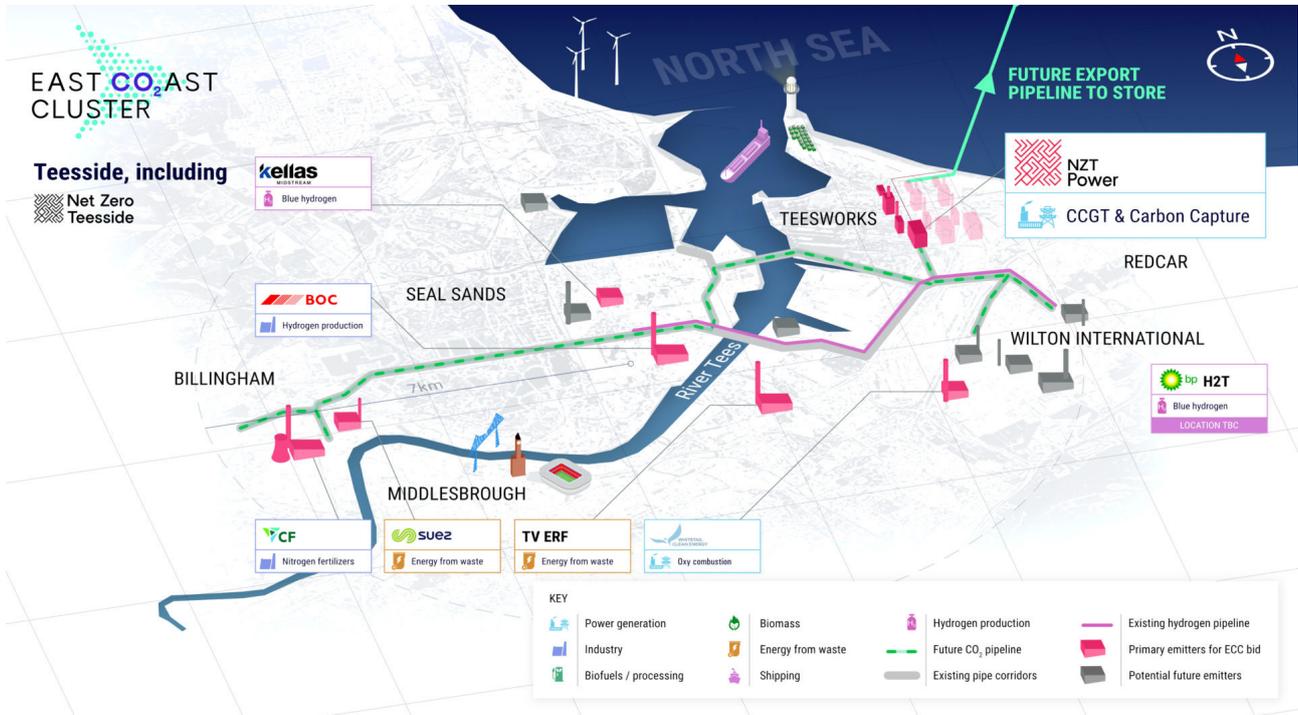


Figure 5: Schematic of the Net Zero Teesside project

UKRI Funding award: £28 million.

UK Partner organisations: BP, Sembcorp, Shell, CF Fertilisers, Eni, National Grid, Total, Tees Valley Combined Authority, Boc, the North East of England Process Industry Cluster.

Northern Endurance Partnership

The Northern Endurance Partnership will create an offshore CO₂ transport and storage system connecting two innovative onshore capture projects into one initial geological store.

<https://www.netzeroteesside.co.uk/northern-endurance-partnership/>



Figure 6: Schematic of the Northern Endurance Partnership project

UKRI Funding award: £24 million.

UK Partner organisations: BP, Shell, Eni, Equinor, National Grid, Total.

Scotland's Net Zero Infrastructure (Onshore and Offshore)

Large-scale industrial emissions will be captured at the Grangemouth industrial cluster, and the offshore project will focus on developing the Acorn storage site and associated offshore infrastructure.

<https://theacornproject.uk/>

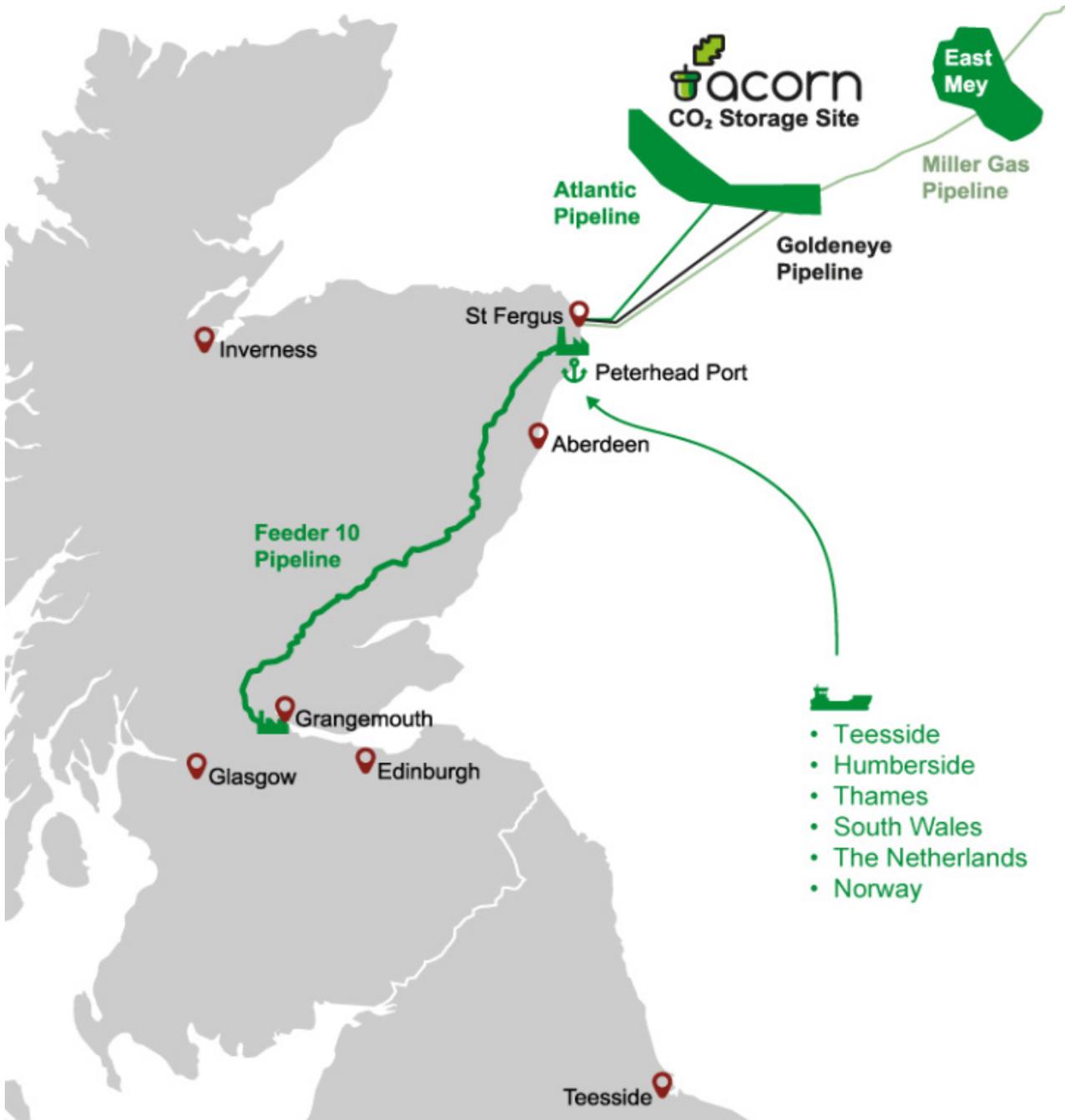


Figure 7: Schematic of Scotland's Net Zero Infrastructure project

UKRI Funding award: £20 million.

UK Partner organisations: National Grid, SSE, GBTron, Petrofac, University of Strathclyde, NECCUS, Pale Blue Dot.

2.2 Industrial Decarbonisation Challenge Cluster Plan Portfolio

The six projects receiving funding from UKRI's Industrial Decarbonisation Challenge programme are⁹:

South Wales Industry – A Plan for Clean Growth

The South Wales Industrial Cluster (SWIC) sets out to develop the mechanisms and skills to achieve a world-leading sustainable industry, shared objectives for decarbonisation and clean growth, deliver job security, and tackle the commercial and operational challenges facing industry in South Wales. Also, to meet the societal needs of 2030, 2040, 2050, and beyond. Its plans include the hydrogen economy, circular economy innovations, energy efficiency, CO₂ avoidance, CCUS and low carbon power generation. Led by CR Plus consultancy, the South Wales Industry - A Plan for Clean Growth project centres on a five-stepped approach to net zero carbon. Five spatial zone types will allow SWIC to take immediate steps with a low chance of incurring "regret capital"¹⁰.

Repowering the Black Country. Phase 2 Cluster Plan

Repowering the Black Country is an industrial cluster decarbonisation project funded by BEIS and UKRI. It includes more than 3,000 energy-intensive manufacturing businesses, many still engaged in the region's traditional metal processing operations. Without radical action, Black Country industry will be responsible for 2.3 MtCO₂ emissions a year. They are supporting the Industrial Decarbonisation Strategy by developing approaches in the Black Country which can then be rolled out more broadly. The project also sets out to help companies benefit from new supply chain opportunities and supports resource efficiency initiatives in manufacturing processes. The project is led by the Black Country Consortium, a partnership of private, public and voluntary sector organisations. It aims to reduce these emissions to zero by 2030 through a coordinated programme of transformational projects focused on a new type of industrial estate; the zero carbon hub. Zero carbon hubs will be based around anchor industrial processes, strategically selected to match Black Country skills and strengths (for example, aluminium reprocessing). Each hub will contain a mix of businesses carefully chosen to complement each other taking into account their energy and waste flows¹¹.

Net Zero Tees Valley. Cluster Plan Stage 2

The Tees Valley is geographically and industrially suited for large-scale decarbonisation and sets out to achieve long-term decarbonisation at an affordable cost. The region produces more than 50% of the UK's hydrogen, has a hydrogen transport hub, blue and green hydrogen projects, biomass and net zero power plants.

The Tees Valley is the UK's most compact and integrated industrial cluster with a radius of five miles. The cluster includes several of the UK's top CO₂ emitters and sets out to store 6 MtCO₂ each year.

The Tees Valley industrial cluster:

- Generates £12 billion of exports annually.
 - Employs over 12,000 people.
 - Contributes some £2.5 billion to UK gross value added.
-

The cluster plan will be led by the Tees Valley Combined Authority. It will identify the most appropriate range of technologies and potential pathways for the various industrial producers and energy generators in the Tees Valley, taking into account both existing and future entrants. The plan is expected to combine carbon capture at scale, fuel switching to hydrogen, the integration of renewables, low carbon energy sources and feedstock changes, along with improved process and energy efficiencies¹².

Scottish Net Zero Roadmap

The Scottish Net Zero Roadmap (SNZR) is part of the challenge to develop net zero industrial clusters by 2040. The aim is to develop a road map to show how the industrial cluster along Scotland's East Coast, responsible for approximately 80% of Scotland's industrial emissions, can be decarbonised. The project also sets out to investigate the infrastructure required for renewables, hydrogen and carbon capture.

Led by NECCUS, an alliance of industries and experts, the SNZR will provide the roadmap that enables the deployment of options to ensure competitive decarbonisation through continued and growing prosperity across the economy.

Scotland is in a strong position to lead this new large-scale CO₂ management industry, and offshore has some of Europe's best characterised and largest CO₂ storage sites. CCS and hydrogen will create opportunities for jobs and economic development and help transition staff employed in sectors such as oil and gas¹³.

Net Zero North West Cluster Plan

The Net Zero North West Cluster Plan, led by Peel Environmental, sets out to transition industry in the North West of England and the North East of Wales to net zero and will describe the investments, technologies, infrastructure changes and sequencing required to fulfil the UK's Industrial Clusters Mission.

Industry and public sector bodies, building on the preliminary research completed in phase one, will collaboratively promote and engage on plans to decarbonise. The plan sets out to ensure businesses have a strong voice in planning decarbonisation activity in line with current and future business needs whilst leveraging inward investment opportunities.

The Net Zero Cluster Plan aims to significantly reduce commercial, domestic and transport emissions to achieve:¹⁴

- Over 33,000 new jobs.
- Over £4 billion investment.
- The world's first net zero industrial cluster.

Humber Industrial Cluster Plan

The Hull and East Yorkshire Local Enterprise Partnership (HEY LEP) and membership organisation CATCH will lead the project and work with industrial partners to develop the Humber Industrial Cluster Plan (HICP), which will enable the cluster, the UK's largest by carbon emissions, to achieve net zero by 2040.

The Humber emits more CO₂ than any other industrial cluster (30% more than the South Wales cluster, the next largest). The area is also one of the most vulnerable to climate change. A quarter of the Humber's gross value added and one in ten jobs depend on these industries, so safeguarding their competitiveness is imperative for the local economy as well as being strategically important for the UK.

A phased approach will:

- Prioritise near-term deliverable investments to see quick results, significantly reducing the Humber's emissions by 2030.
- Map out how CCS and hydrogen infrastructure can be scaled up.
- Identify the full range of interventions required to achieve net zero by 2040.

HICP will also outline the potential to support decarbonisation beyond the industrial cluster. This includes:

- Maritime in the UK's largest ports complex.
- Road/rail transport.
- Decarbonisation of the gas supply (25% of the UK's supply passes through the Humber).

Linked opportunities and implications for renewable energy, especially bioenergy with CCS (bioenergy carbon capture and storage) and offshore wind, which are integral to decarbonising industry, will also be identified¹⁵.



3. Overview of China's Industrial Decarbonisation Strategy and Innovation Landscape

China and the UK are important partners in addressing climate change. China is working towards a carbon neutrality target by 2060. The Chinese government attaches great importance to low-carbon, green and sustainable social development. To realise carbon neutrality and carbon peaking, China, via institutions including the Administrative Centre for China's Agenda 21 (ACCA 21), promotes the implementation of China Agenda 21. The centre is also formulating the country's sustainable development through the 1+N carbon neutrality policy framework. The framework includes the opinions of the CPC Central Committee and the State Council on the complete, accurate and comprehensive implementation of the new development concept to achieve carbon neutrality. The new framework prioritises the importance of promoting low-carbon processes and innovation in industrial sectors.

The 2030 carbon peaking action plan¹⁶ points out that “the industrial sector should accelerate green and low-carbon transformation and high-quality development and strive to take the lead in achieving carbon peaking”. To implement and support carbon peaking and carbon neutrality, the Ministry of Science and Technology (MOST) has set up a steering committee to identify key tasks for accelerated implementation. Tasks include formulating the Carbon Peak Carbon Neutral Science and Technology Innovation Action Plan¹⁷ as a guideline for overseas innovation-driven carbon peaking and neutrality work.

3.1 China's Industrial Clusters

Within China's vast industrial network, there are several clusters developing around key carbon storage sites. The Guangdong cluster in South China is analogous to the UK industrial clusters and has benefited from close collaboration with the UK as part of the UK-China CCUS centre. In Guangdong, three source clusters match three sink clusters in the offshore Pearl River Mouth Basin. Around China, it is not just clusters which are developing as there are large individual emitters further inland, and in remote places. Therefore, a different innovation landscape is emerging.

Carbon neutrality has been highlighted in China's 14th Five-Year Plan, and more than 60 national policies have emphasised CCS as a crucial technology, according to the Annual Report on CCUS in

China (2021). CCS has been recognised as the only technical choice for the low-carbon utilisation of fossil energy and the main technology to keep the power system flexible under the goal of carbon neutrality.

Current CCUS Projects in China

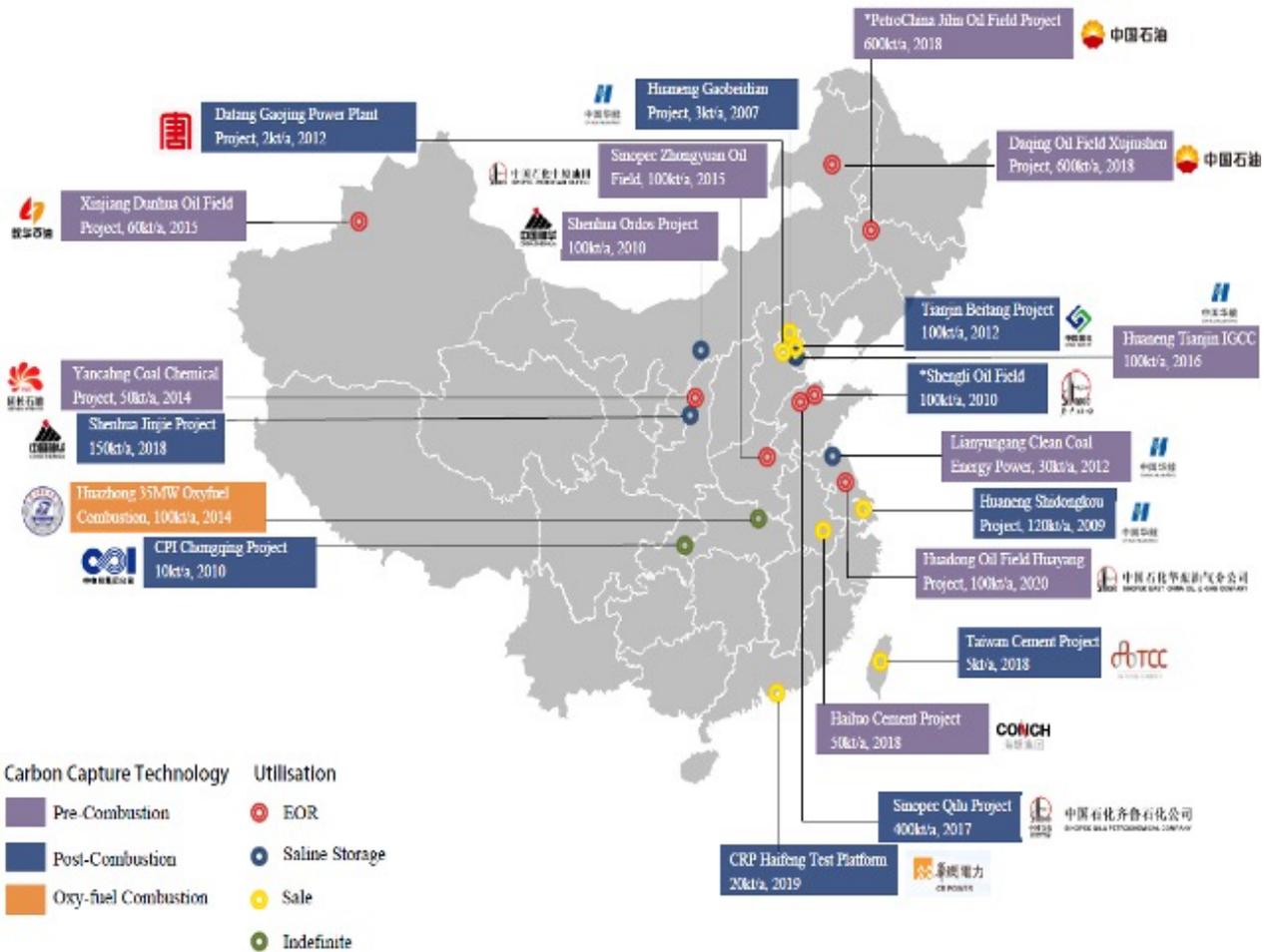


Figure 8: Chinese projects in operation since 2020.

China has 21 projects in operation since 2020, with a 2 million tonnes capacity per year. More than 20 projects have been under construction since 2021. These projects are spread across 19 provinces¹⁸.

The next steps in Guangdong are to carry out a storage capacity assessment (Figure 9) and match it with source sinks in the Pearl River Mouth Basin (Figure 10).



Figure 9: Storage capacity assessment in the Pearl River Mouth Basin¹⁹

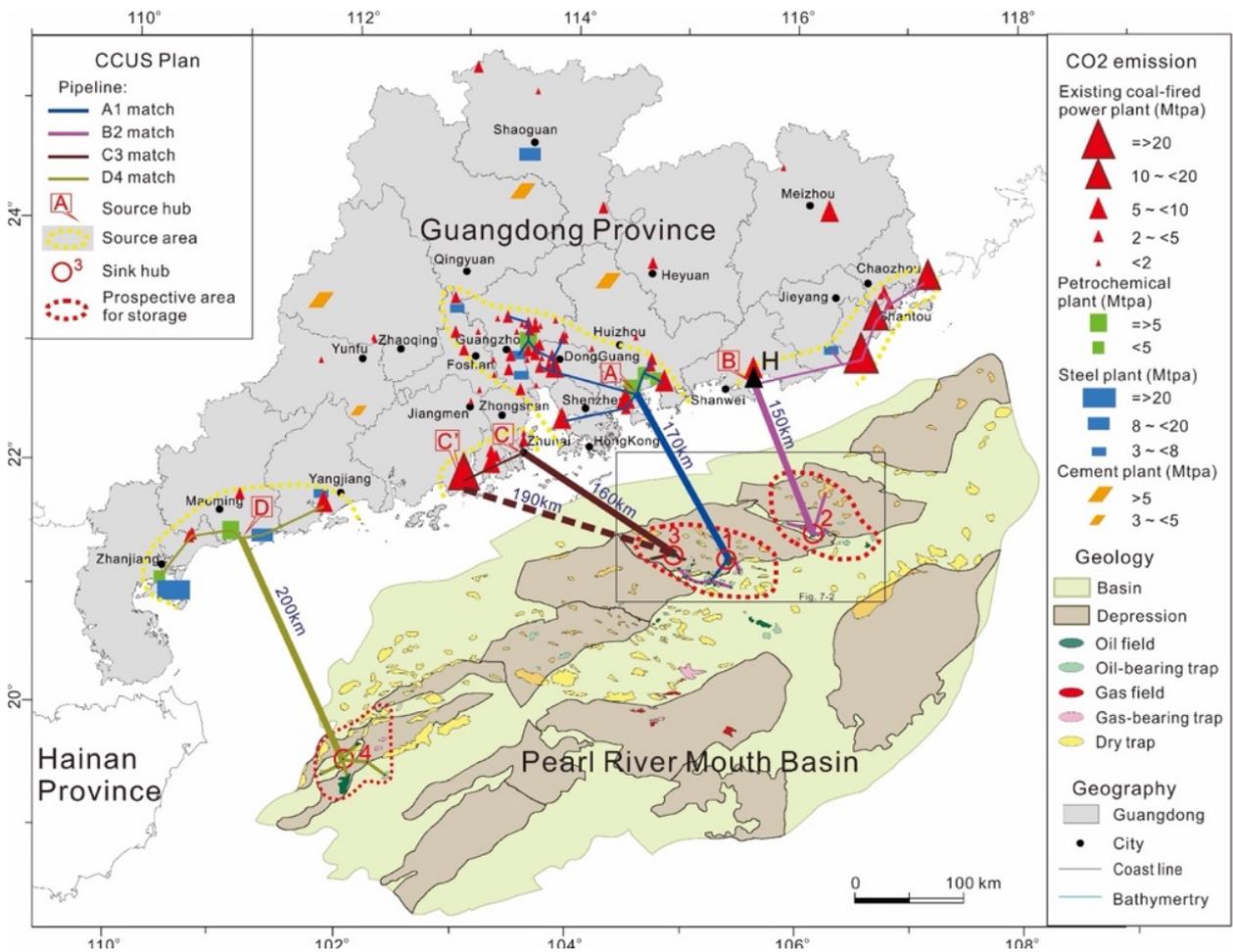


Figure 10: Source-sinks in the Pearl River Mouth Basin²⁰

The research pathway and stages of each technology are: to review Chinese and international CCUS development, evaluate the role of CCUS, assess the value through a bottom-up model, through a top-down computable general equilibrium model, consult stakeholders on CCUS value and propose business strategies.

Low-carbon hydrogen is also being developed and is at an early stage.

According to the Annual Report on CCUS in China (2021), there are about 40 demonstration projects in operation or under construction, with a capture capacity of 3 million MtCO₂ and a cumulative injection and storage of more than 2 million MtCO₂ with CO₂ capture capacity of 2.96 million MtCO₂ per year.

Among them are eight projects involving hydrogen production. The CHN Energy Ordos CCS Demonstration Project has successfully implemented CCS with a scale of 0.1 million MtCO₂ per year; Sinopec million-ton-level CCUS project has been put into operation; PetroChina deploys 20 hydrogen purification projects in seven regions, including Bohai Sea, Shaanxi-Gansu-Ningxia, South China, Southwest China, Xinjiang, Heilongjiang and Jilin, to realise blue hydrogen supply by combining existing hydrogen production capacity and by-product hydrogen resources with CCUS^{21,22}.

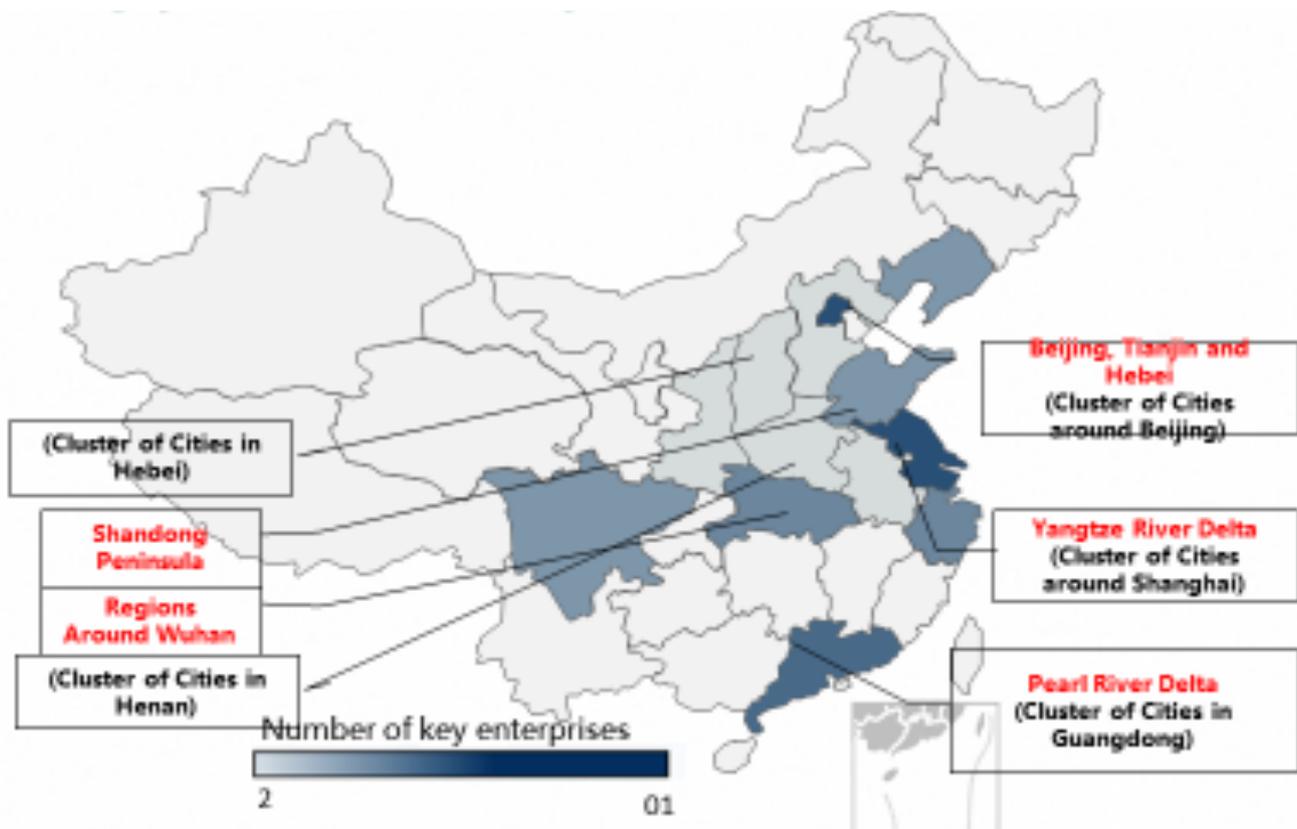


Figure 11: Development of the hydrogen energy industry in China²³

A development pattern has taken shape, comprising five pioneer areas and the 3+2 fuel cell vehicle application demonstration cities and cluster of cities in Hebei, Henan, Guangdong around Beijing and Shanghai.

3.2 China Company Profiles

China Energy Investment Corporation (China Energy)

China Energy Investment Corporation (China Energy) was formed in 2017 from a merger between China Guodian Corporation and Shenhua Group. They are a key state-owned enterprise directly supervised by central government. They operate in eight business areas, including coal, thermal power, new energy, hydropower, transportation, coal chemicals, industrial finance and environmental technology.

www.ceic.com

China Energy Engineering Group Ltd (Energy China)

Energy China are one of the largest solutions providers for the power industry in China and globally. They have strong capabilities across the entire industrial chain and, in particular, in survey and design, which enables them to provide customers with one-stop integrated solutions and full life-cycle project management services. They undertook the construction of the Three Gorges Project, which has the largest hydropower station in the world in terms of installed capacity.

<http://en.ceec.net.cn/>

Huaneng Clean Energy Research Institute (CERI)

Huaneng Clean Energy Research Institute (CERI) are a subsidiary of the state-owned China Huaneng Group, the largest power generation company in the world regarding total installed capacity. The research institute is a leader in clean energy technology, including carbon capture, renewable energy, coal gasification, energy storage and utilisations, and emissions reduction methodologies.

<http://en.hnceri.com/>

3.3 Chinese Government Organisations and Research Institutes

The Administrative Centre of China's Agenda 21 (ACCA21)

ACCA21 works to facilitate the implementation of China's Agenda 21 to pursue ways and approaches of balancing comprehensive and multi-level development of the economy, society and environment by means of technological innovation and to promote sustainable development in China. ACCA21 operates within the fields of science and technology management, strategy and policy research, local sustainable development demonstration and climate change.

Ministry of Science and Technology, People's Republic of China (MOST)

MOST formulates and facilitates the implementation of strategies and policies for innovation-driven development and plans and policies for science and technology (S&T) development and the attraction of foreign talent. MOST coordinates the development of the national innovation system and the reform of the national S&T management system, working with government departments to improve incentive mechanisms for technological innovation. MOST facilitates the reform and development of research

institutes, enhances the innovation capabilities of enterprises, promotes military-civilian integration and develops the consulting system for major national S&T decision-making, therefore leading fund and resource allocation, alongside the formulation, implementation, evaluation and supervision of research projects and the promotion and application of major R&D and innovation outcomes.

MOST oversees the work of the National Natural Science Foundation of China (NSFC) and carries out macro-management, coordination, supervision and evaluation of the operation of the National Natural Science Fund.

UK-China CCUS Centre

The UK-China (Guangdong) CCUS Centre is a non-profit organisation initiated by the Guangdong Electric Power Design Institute (GED) of China Energy Engineering Group, Shenzhen Linkschina Advisory Ltd, UK CCS Research Centre (UKCCSRC) and Scottish CCS Centre. Launched on December 18, 2013, the centre aims to boost industrial development and academic cooperation in CCUS and near-zero emission technologies in Guangdong to combat climate change.

China-UK Low Carbon College, Shanghai Jiao Tong University

China-UK Low Carbon College was established by Shanghai Jiao Tong University (SJTU) with the joint efforts of the University of Edinburgh and Shanghai Lin-gang Government. The aim is to become a world-class innovative higher education and research institute with international influence and provide scientific research, graduate education and executive training. They focus on research and education in low carbon energy, low carbon cities, low carbon environment, carbon finance and carbon management.

<https://lcc.sjtu.edu.cn/EN>

Guangdong Electric Power Design Institute

Guangdong Electric Power Design Institute (GEDI) is a subsidiary under Guangdong Power Grid Company (GPGC) of China Southern Power Grid Company Ltd (CSG). The institute provides high-quality and efficient engineering, consulting and project management services for investors and project owners in the fields of power plants (nuclear, fossil-fuel fired, liquefied natural gas, renewable energy etc.), power grid (electricity power system planning, substation and transmission), IT, communication and automation, architecture and more. Services cover all phases of power sectors, from pro-phase consultancy and project building to project reconstruction.

Appendix 1: List of UK Participants

Camirus Ltd

Energy Research Institute, University of Chester

Hull and East Yorkshire Local Enterprise Partnership (HEY LEP)

Johnson Matthey

NECCUS

North West Business Leadership Team Ltd

Progressive Energy Ltd

Royal Academy of Engineering

Storrega Ltd

Technopolis Group Ltd

Tees Valley Combined Authority

UK Industrial Decarbonisation Research and Innovation Centre

University of Edinburgh

University of Sheffield

Vitol Group

Appendix 2: List of Chinese Participants

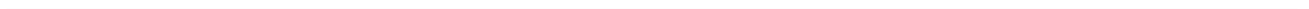
The Administrative Centre of China's Agenda 21 (ACCA21)
Beijing Tsinghua Industrial R&D Institute (BTIRDI)
British Consulate General Chongqing
British Consulate General Guangzhou
British Consulate General Shanghai
British Embassy Beijing
China Energy Engineering Group Ltd (Energy China)
China Energy Investment Corporation (China Energy)
China Hydrogen Alliance
China Hydrogen Development, and Innovation Alliance for Urban Gas
China National Offshore Oil Corporation (CNOOC)
China National Petroleum Corporation (CNPC)
China Oil & Gas Climate Investments
China Petroleum University and China CCUS Committee
China Resource Environment
CISDI Group
Department for International Trade (DIT) | British Embassy
Guangdong Electric Design Institute (GEDI)
Guizhou Institute of Environmental Sciences Research and Design
Huaneng Clean Energy Research Institute (CERI)
Low Carbon Technology Research Institute, CISDI Group
MCC Overseas Business Department
Ministry of Science and Technology (MOST)
Peking University
Shanghai Jiao Tong University (SJTU) China-UK Low Carbon College
Shanghai Science and Innovation Centre

Sichuan University

UK-China (Guangdong) CCUS Centre

Xinan Jiaotong University

Zhejiang University



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Innovate UK
KTN

Head Office

Innovate UK KTN
Suite 218 Business Design Centre
52 Upper Street
Islington
London N1 0QH

Telephone: 03333 403251
Email: enquiries@ktn-uk.org
ktn-uk.org
[@KTNUK](https://www.instagram.com/KTNUK)

Contact Persons

Innovate UK KTN

Geraldine Durand, Knowledge Transfer Manager - Global Alliance
geraldine.durand@ktn-uk.org

Technical writer: Jeff Tucker, Director of Sustainability, Pacific
Basin Economic Council (PBEC)