Delivered by Innovate UK and EPSRC

Industrial Decarbonisation Challenge

Celebrating our Impact

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Contents

Foreword

It is my privilege to have led the UKRI's Industrial Decarbonisation Challenge (IDC), a programme that has confronted the difficulties of industrial cluster decarbonisation head on. Greenhouse gas emission reduction is the defining challenge of our time. Mitigating the worst of climate change is critical to ensuring our planet can sustain us in the future and requires transformation of the economy as we know it. Achieving decarbonisation, especially of industrial processes, is not straightforward.

Industrial cluster decarbonisation is non-negotiable if the UK is to meet its legally binding emission reduction targets. The programme was designed in response to the scale and urgency of the challenge, to define the actions and conditions needed to establish at least four low-carbon clusters by 2030, and the world's first net zero industrial cluster by 2040. I am proud that we have delivered projects set to achieve those ambitious targets.

Industrial cluster decarbonisation success will be measured by the future strength of the UK economy, the revitalisation of industrial communities across the country, and the global competitiveness of the UK as a provider of low-carbon products and services. Over the past four years, we have worked alongside hundreds of individuals and organisations committed to driving industrial decarbonisation in the UK. I am confident that the outputs of the Challenge will scale beyond the six clusters to significant impacts worldwide. So, yes, industrial decarbonisation is a challenge, but not an insurmountable one, and one that will reward those who invest now and succeed. My hope is that the collaboration between government, industry, and other stakeholders underpinning this programme will continue, and that the opportunities industrial cluster decarbonisation presents will benefit all.

Dr Bryony Livesey

ISCF Challenge Director – Industrial Decarbonisation

1 Executive Summary

This report gives an overview of the IDC delivered by Innovate UK and the Engineering and Physical Sciences Research Council (EPSRC), detailing the projects, impacts and benefits of this transformative programme.

The UK's industrial sector accounts for a substantial portion of the country's carbon emissions, making decarbonisation imperative for meeting climate targets and essential for sustainable development. The IDC has been a pivotal initiative aimed at mitigating climate change by significantly reducing carbon emissions from industrial activities. Grounded in the UK's commitment to achieving net-zero greenhouse gas emissions by 2050, the IDC has focused on transforming key industrial regions through the development of low carbon technologies such as Carbon Capture and Storage (CCS) and Hydrogen production and distribution.

Specifically, the IDC has addressed this challenge through a multi-faceted approach that has produced targeted 'Cluster Plans' in six industrial regions that map the path to net-zero, development of engineering designs for vital low carbon technologies, and the multidisciplinary research and innovation needed to support decarbonisation of the UK's industrial clusters. This was underpinned by the promotion and facilitation of industry collaboration and knowledge sharing to enable a faster more cost-effective route to deliver industrial decarbonisation in the UK.

1.1 Key Achievements

The IDC has provided grant co-funding that has resulted in the following key achievements;

- Six credible Cluster Plans that have provided an understanding of the emissions and the options to abate them in key industrial areas of the UK, including the Humber, South Wales, Tees Valley, North West, Black Country and Scotland.
- Nine deployment projects that have developed advanced engineering designs that will enable the deployment of onshore and offshore decarbonisation infrastructure across five of the UK's key industrial regions.
- Unlocking of £22 billion of investment which will protect and create jobs in the key industrial areas of the UK.
- 100 challenge-driven research projects, co-designed and co-delivered with industry, resulting in over 60 innovative new prototypes, processes, models, and tools to accelerate industrial decarbonisation through the Industrial Decarbonisation Research and Innovation Centre.
- Enabling Net Zero: A Plan For UK Industrial Cluster Decarbonisation. This key report detailed the national vision and strategy for UK industrial cluster decarbonisation and provided recommendations for industry and government to achieve the vision and curb industrial emissions beyond the clusters.
- The delivery of the IDC has developed a platform for government and industry to progress large scale decarbonisation in UK clusters rapidly and cost-effectively, and to de-risk opportunities for future cluster decarbonisation. The majority of the IDC-funded deployment projects are central to the Government's Cluster Sequencing Programme which is determining the natural sequence for locations to deploy Carbon Capture, Utilisation and Storage (CCUS) in the UK to achieve the target of four CCUS enabled industrial clusters by 2030[1]. Through the successful delivery of the IDC projects, the programme has built the foundation for the development of a new CCUS industry in the UK by readying the technology and the path to net zero for the UK's industrial clusters.

[1] Great Britain. Department for Business, Energy & Industrial Strategy (2020). The Ten Point Plan. Available at: **Cluster Sequencing for Carbon Capture Usage and Storage Deployment: Phase-1 – background and guidance for submissions (publishing.service.gov.uk)** (Accessed 01 May 2024)

2 Background

In 2019, six major industrial clusters were mapped by the former Department for Business, Energy, and Industrial Strategy (BEIS) and reported in the Industrial Clusters Mission. These clusters are vital to the UK economy and secure 1.5 million jobs and annually export goods and services worth £320 billion. However, they also release around 40 million tonnes of carbon dioxide per year, equating to one third of all business and industrial emissions. These clusters comprise energy intensive industries, with emissions that are hard to abate, such as iron and steel, cement, refining and chemicals. The decarbonisation of these industrial clusters is not only key to achieving the UK's net zero ambitions but also to protecting jobs and the economic benefits of these key regions through the transition to net zero. Crucially, the decarbonisation of the clusters provides significant new economic opportunity for the UK.

2.1 Addressing the challenge

The IDC was created and launched by UK Research and Innovation (UKRI) in July 2019 as one of eight clean growth challenges supported by the 'Industrial Strategy Challenge Fund' (ISCF). These challenges were designed to encourage partnership between the public and private sectors to address the biggest societal challenges facing UK businesses today, including the decarbonisation of the UK's major industrial regions. Since then, the IDC has invested £210 million of public money, paired with over £261 million of matched funding from industry, to boost the development of low-carbon technologies, specifically, Carbon Capture Utilisation and Storage (CCUS) and hydrogen production and distribution, to increase competitiveness of key industrial regions and support the UK's drive for clean growth.

The UK's independent advisor on climate change, the Climate Change Committee (CCC) has said that CCUS is a 'necessity and not an option' if the UK is to achieve its net zero ambitions.

To achieve this, the IDC designed a process to support the development of projects along three strands:

- The first to design the infrastructure required for CCUS and hydrogen production at full commercial scale ("deployment projects")
- The second to produce plans to reach net zero in each cluster ("cluster plans")
- The third to create a dedicated research centre bringing together academia, industry and government to support technology development for the transition to net zero ("Industrial Decarbonisation Research and Innovation Centre").

2.2 Programme Structure

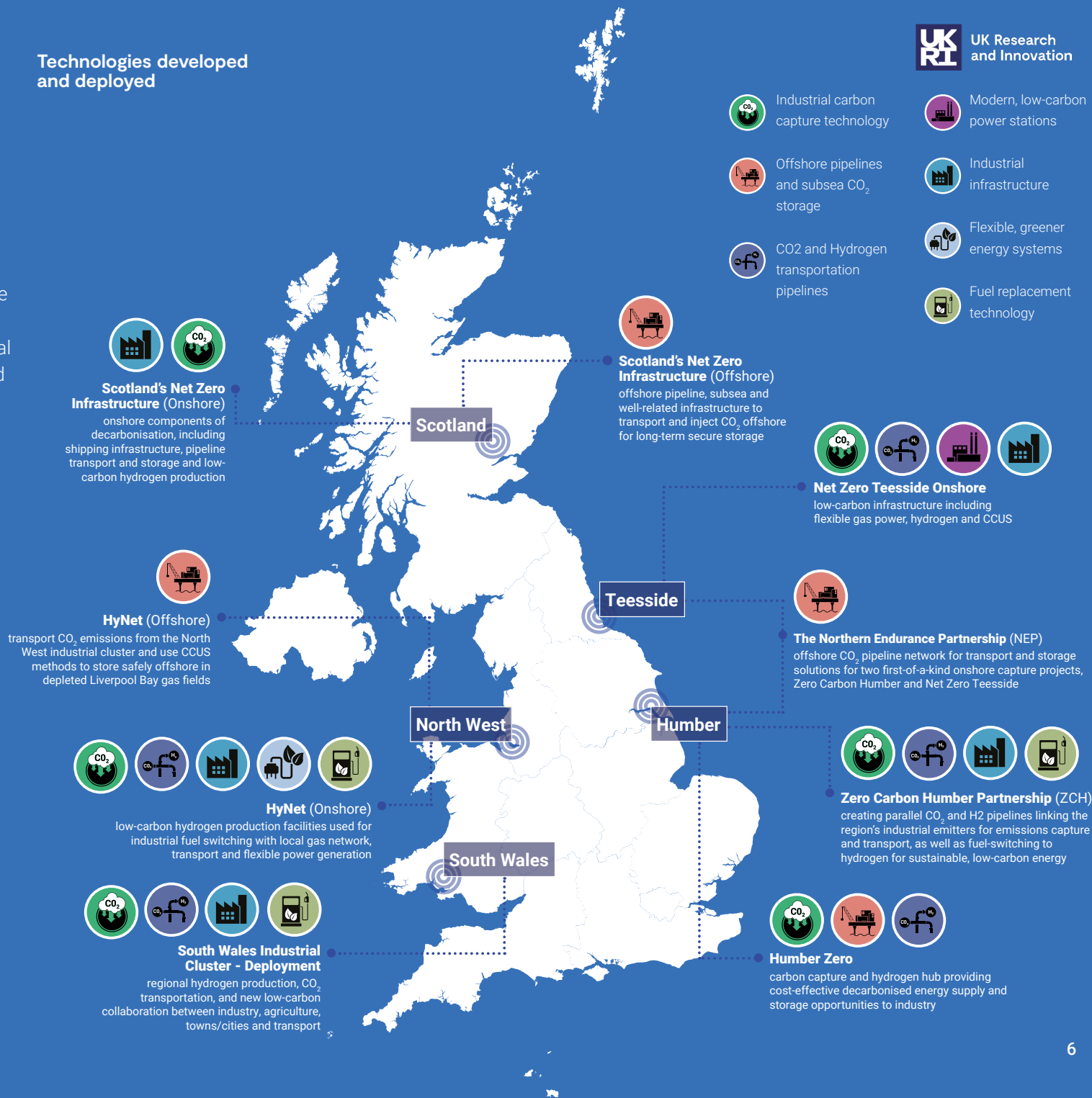
These three inter-related strands of projects were selected following a two-stage competitive process and are as follows:

Deployment projects

The deployment projects are in five of the UK's major industrial regions: South Wales, the North West, Scotland, Teesside, and Humber. They have produced the engineering designs for CCUS and hydrogen production and distribution, commercial arrangements, and impact assessments required to underpin the infrastructure needed to enable the deep decarbonisation of the clusters. The projects comprise a mix of onshore initiatives including pipework, gas compression, hydrogen production, gas storage and carbon capture, and storage of CO_2.

The nine projects that received IDC funding until March 2024 are:

- HyNet (Offshore)
- HyNet (Onshore)
- Scotland's net zero infrastructure (Offshore)
- Scotland's net zero infrastructure (Onshore)
- Net Zero Teesside
- Northern Endurance Partnership
- Zero Carbon Humber
- Humber Zero
- South Wales Industrial Cluster

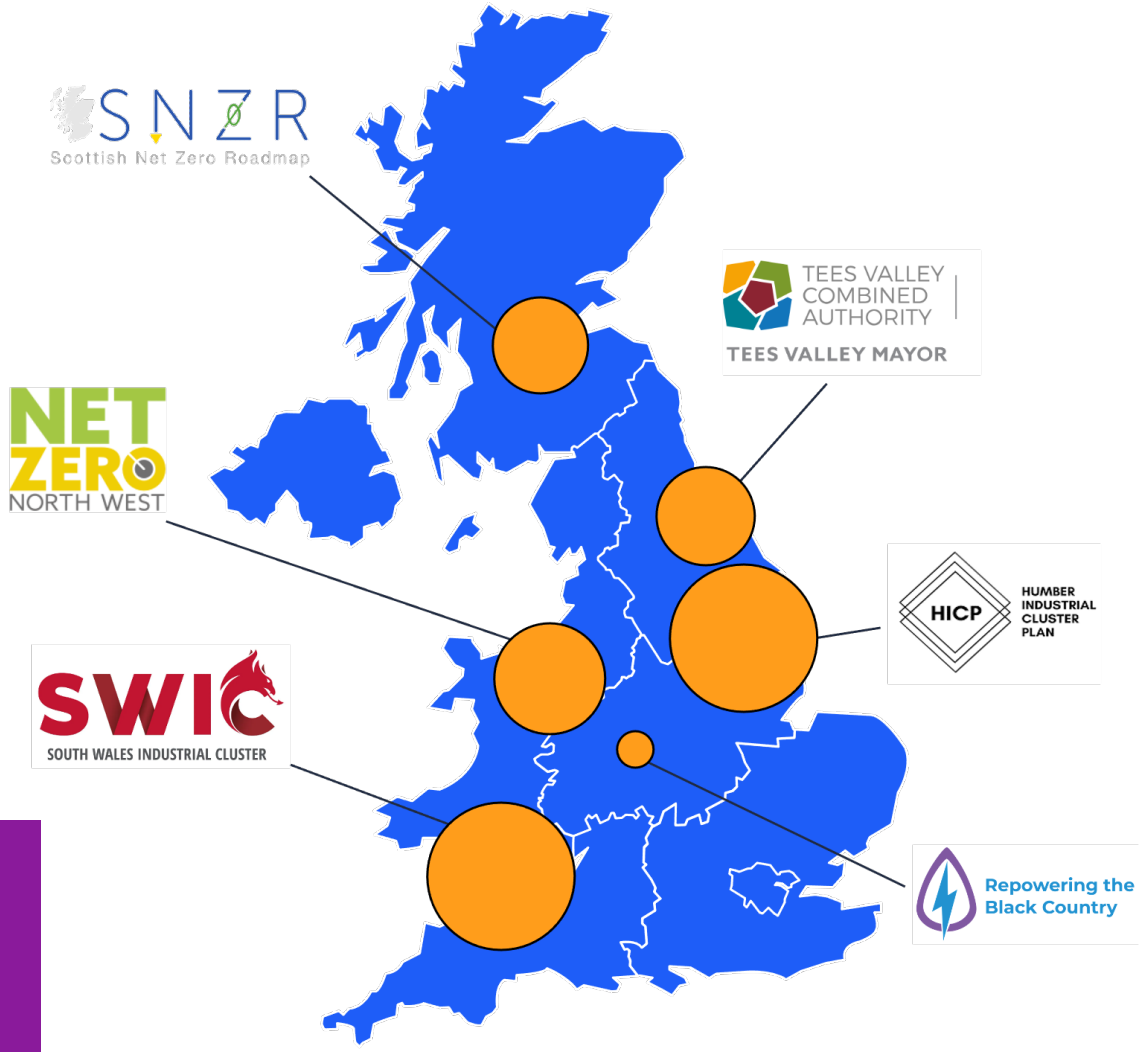


Cluster Plan Projects

Cluster Plans have been developed in the North West, Humber, Teesside, the Black Country, South Wales, and Scotland and provide clear, evidence-based, and attainable plans for decarbonising the cluster, including the deployment of proven low-carbon technologies and processes, while safeguarding jobs and attracting investment to the region. These plans have also contributed to the development of a UK Wide Cluster Plan, titled Enabling Net Zero: A Plan for UK Industrial Cluster Decarbonisation published in October 2023 which sets out how the UK can harness the power of the industrial clusters and drive the next phase of emissions reductions.

The six projects which received funding until March 2023 are:

- Net Zero Tees Valley
- Scotland's Net Zero Roadmap
- Humber Industrial Decarbonisation Roadmap
- Net Zero North West
- South Wales Industrial Cluster
- Repowering the Black Country



Industrial Decarbonisation Research and Innovation Centre (IDRIC)

IDRIC

IDRIC is a virtual research centre which was established with the aim of addressing key challenges / pathways for industrial decarbonisation. It has supported 62 multidisciplinary projects, which are providing evidence to feed into recommendations to policy makers and help overcome the technical barriers to the commercialisation of decarbonisation technologies, maximising the value of UK intellectual property. The centre was designed to support enduring knowledge sharing to go beyond the life of the challenge through new or strengthened partnerships formed between industries, research institutions, investors, and policy makers.

Further detail on all IDC projects can be found in Section 3 of this report.

2.3 UK Policy Development

Following the launch of the IDC, the policy and funding landscape has been transformed and the Government has accelerated the UK's decarbonisation ambition.

Policy/ Announcement	Date	Commitment
BEIS Industrial Clusters Mission	2019	"…establish the world's first net-zero carbon industrial cluster by 2040 and at least one low-carbon by 2030."
UK Ten Point Plan for a Green Industrial Revolution	2020	"…establish CCUS in two industrial clusters by mid 2020s, and aim for four of these sites by 2030, capturing up to 10 Mt of carbon dioxide per year."
The UK Industrial Decarbonisation Strategy	2021	"…four of our major industrial regions linked up to the necessary decarbonisation infrastructure by 2030; around 6 $MtCO_2$ of industry emissions captured each year by 2030" and "low carbon fuels such as hydrogen, electricity and bioenergy replacing fossil fuels, unless combined with carbon capture." "Industrial Decarbonisation will accelerate the cost-effective decarbonisation of industry by developing and deploying low carbon technologies such as carbon capture and storage (CCS) and hydrogen fuel switching, at scale in the UK, across our industrial clusters."
The UK Net Zero Strategy	2021	"…ambition to deliver 6 $MtCO_2$ per year of industrial CCUS by 2030, and 9 $MtCO_2$ per year by 2035."
Spring Budget	2023	"…government will also provide up to £20 billion funding for early development of Carbon Capture, Usage and Storage (CCUS) to help meet the government's climate commitments."

The IDC has been the foundation to the successful delivery of these ambitions, with infrastructure projects funded by the programme now moving into the next stage of development through the Government's Cluster Sequencing initiative.

The IDC programme has harnessed the scale of the UK's major industrial clusters, creating opportunities for them to work together to find cost-effective solutions to decarbonise.

3 The Industrial Decarbonisation Challenge: Projects

3.1 Deployment Projects

The programme was delivered in two stages for all workstreams, an initial scoping stage and a more detailed implementation stage. The funding described focuses on stage two.

HyNet North West

HyNet (Onshore)

Project Lead	Progressive Energy
Partner Organisations	Cadent, Eni, Essar Oil, Heidelberg Materials, INEOS Inovyn, University of Chester
Grant Award	£19,451,381
Pledged Match Funding	£25,672,070
Project length	36 months

Introduction

HyNet is centred in the industrial complex between Ellesmere Port and Runcorn. Bulk low carbon H2 production facilities will be constructed at Stanlow refinery, providing hydrogen for industrial fuel switching, blending into the local gas network, transport, and flexible power generation. A dedicated network will transport H2 from production to demand points and hydrogen storage assets in the Cheshire salt fields to enable supply and demand balancing. The HyNet CCUS network will provide the infrastructure to transport and store the CO_2 produced as a by-product of the hydrogen production process and specific industrial sources that cannot be mitigated by fuel switching. Several of the UK's largest industrial emitters, including Stanlow refinery and Heidelberg's Padeswood Cement plant will connect to the CCUS network.

Project Plan

The UKRI funding will establish a full chain Hydrogen and CCS network in the North West industrial cluster. Hydrogen production centred at the Stanlow refinery would enable 30 TWh capacity by 2030. This will supply hydrogen to industries close to the complex and a repurposed gas distribution network will enable hydrogen transport across the cluster.

The UKRI funding will enable Padeswood cement works and the refinery to develop their decarbonisation plans and connect into a CCS network which will run across the cluster. This part of the project is being developed to connect to the offshore leg which will enable storage of CO_2 in geological rock formation in the Liverpool Bay fields in the Irish Sea.

Achievements and Outputs

The significant milestones include:

- Onshore CO_2 Transport - Front End Engineering Design (FEED) is complete and Development Consent Order (DCO) approval from the Secretary of State has been reached. The onshore pipeline developed signed Heads of Terms with the Government as a world first example of agreement being reached on a regulated asset base business model.
- Hydrogen Distribution – FEED is complete and significant progress has been made on the planning and environmental stages of approval.
- Hydrogen Storage – significant progress has been made to develop the plan for development of regional salt caverns essential for developing a full–scale hydrogen network.
- Cement and Refinery CO_2 Capture – Significant feasibility work completed for CCS installation at Padeswood cement works. Stanlow refinery developed plans for CO_2 capture on their Fluid catalytic cracking (FCC) unit.

HyNet North West

HyNet (Offshore)

Project Lead	Progressive Energy
Partner Organisations	Eni
Grant Award	£13,324,522
Pledged Match Funding	£13,200,241
Project length	34 months

Introduction

The HyNet offshore project will deliver the foundation infrastructure that will transport captured CO_2 emissions from the North West industrial cluster and safely contain these emissions offshore in the depleted gas fields of Liverpool Bay. The primary objective of the offshore project is to finalise all elements necessary to make an application for a CO_2 Storage Permit. The Storage Permit application will include a finalised development plan which will be assessed by the Oil and Gas Authority (OGA) in cooperation with other regulating authorities. The result of the IDC funded project is the delivery of a construction-ready key energy infrastructure scheme that will underpin regional transition to a low carbon economy and make a material contribution to UK emission reduction targets.

Project Plan

The UKRI funding enabled the offshore operator to develop the offshore storage aspect of the project.

For the Transport & Storage (T&S) element, this included FEED, the development of a storage permit application and detailed drilling studies necessary to define well construction and operation. These activities will enable the project to proceed into the post FEED procurement activities.

The initial plan for deployment includes the capture of a combined 2.8 MTPA CO_2 from 5 emitter sites (2 included within the IDC funding for permanent storage in Liverpool Bay).

Achievements and Outputs

The significant milestones include:

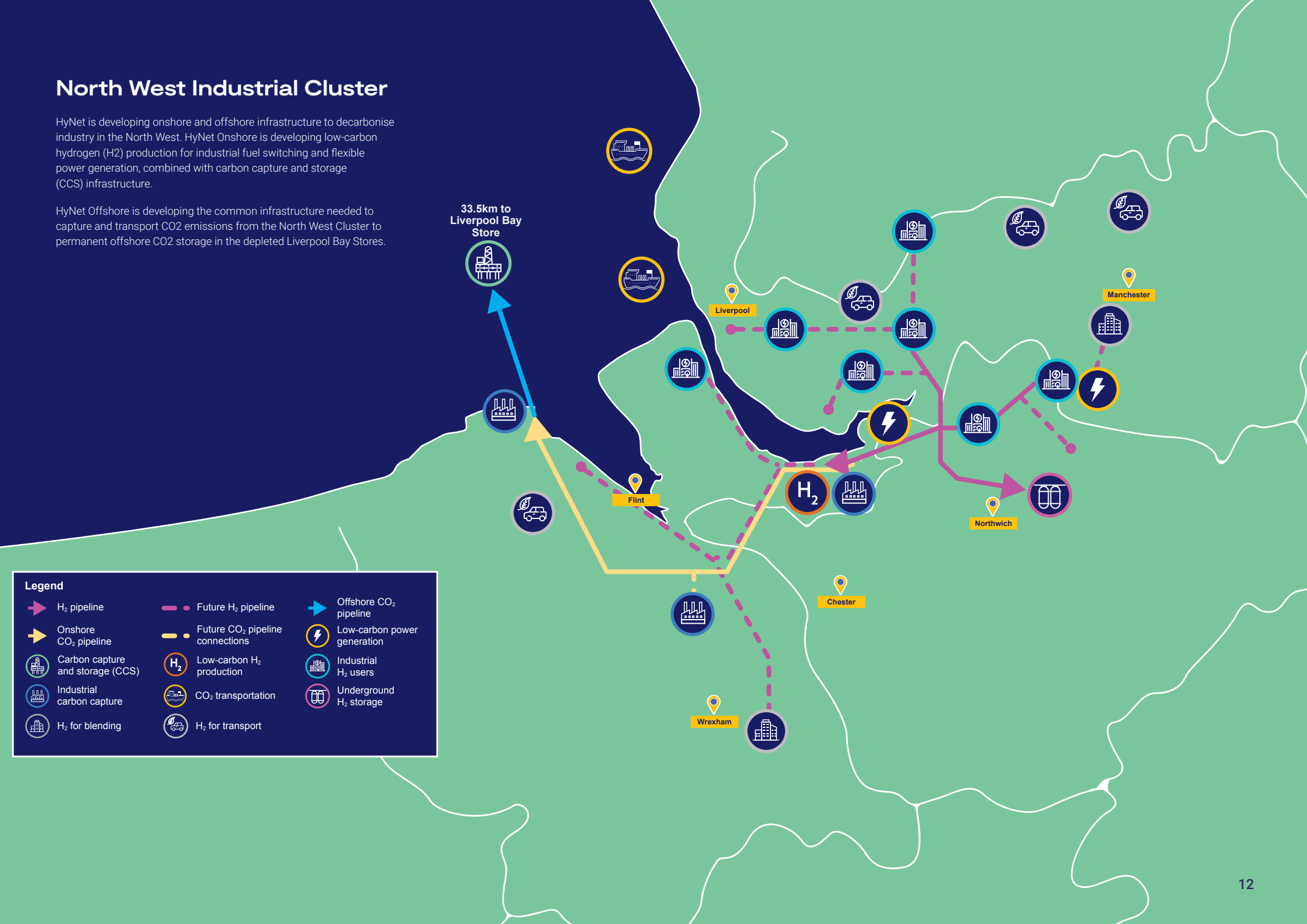
- The completion of FEED studies.
- Planning applications submitted.
- Awarding of contracts for offshore activities and the inspection in preparation for repurposing an onshore CO_2 pipeline from Connah's Quay to Point of Ayr.
- Preparation of vendors and long lead time items ready for construction.

The project is on track to take final investment decision (FID) in Q3 2024.

North West Industrial Cluster

HyNet is developing onshore and offshore infrastructure to decarbonise industry in the North West. HyNet Onshore is developing low-carbon hydrogen (H2) production for industrial fuel switching and flexible power generation, combined with carbon capture and storage (CCS) infrastructure.

HyNet Offshore is developing the common infrastructure needed to capture and transport CO2 emissions from the North West Cluster to permanent offshore CO2 storage in the depleted Liverpool Bay Stores.



Net Zero Teesside Power

Project Lead	BP Exploration Operating Company
Partner Organisations	BOC (non-grant funded), Equinor, NEPIC, Sembcorp (non-grant funded), Tees Valley Combined Authority, Total
Grant Award	£28,052,340
Pledged Match Funding	£35,691,708
Project length	30 months

Introduction

Net Zero Teesside Power's (NZT Power) objective is to deliver technical and commercial solutions required to implement innovative First-of-a-Kind (FOAK) onshore low-carbon CCUS infrastructure in the UK, anchored by a flexible Gas Power and CCUS concept to provide 750MW of low carbon dispatchable power in support of decarbonising the UK grid. The project includes onshore surveys, extensive technical design work (facilities design and cost estimating), supply-chain engagement and commercial development to underpin the relevant business models.

Project Plan

The UKRI funding has enabled NZT Power to develop up to 860 megawatts of flexible, dispatchable low-carbon power, equivalent to the average electricity requirements of around 1.3 million UK homes.

Up to 2 million tonnes of CO_2 per year would be captured at the plant, and then transported and securely stored by the Northern Endurance Partnership (NEP) in subsea storage sites beneath the North Sea. NZT Power is aiming for Final Investment Decision (FID) in September 2024 or earlier. Following FID, the project would be aiming for first commercial operations from 2027.

The IDC funding has enabled NZT Power to progress a first of a kind FEED programme over 30 months. This would also include the significant milestone of a DCO approval during the project duration.

Achievements and Outputs

The significant milestones include:

- The project completed FEED for a CCS enabled combined cycle gas turbine power plant and Onshore Pipeline for transport of CO_2.
- Progression of planning and environmental permitting.
- Successful negotiations on business model support for dispatchable power and regulated asset base for the onshore pipeline.
- The project is ready to take final investment decision.

Northern Endurance Partnership – Integrated Offshore Carbon Storage

Project Lead	BP Exploration Operating Company
Partner Organisations	Equinor, Total
Grant Award	£24,002,130
Pledged Match Funding	£24,713,376
Project length	30 months

Introduction

The Northern Endurance Partnership (NEP) project objective is to deliver technical and commercial solutions required to implement innovative First-of-a-Kind (FOAK) offshore low-carbon CCUS infrastructure in the UK, connecting the Humber and Teesside Industrial Clusters to the Endurance CO_2 storage site in the Southern North Sea. This includes offshore surveys, extensive technical design work (facilities design and cost estimating) and commercial development to underpin relevant business models.

Project Plan

The UKRI funding has enabled the NEP, a joint venture between bp, Equinor and Total Energies to develop the CO_2 transportation and storage infrastructure for the East Coast Cluster (ECC). This includes connecting both the Humber and Teesside industrial clusters to secure offshore storage in the North Sea.

NEP offers access to the Endurance carbon store in the southern North Sea. Endurance is the name of a geological feature – a saline aquifer – which lies approximately 145km offshore from Teesside in the North Sea. Around 4 million tonnes of CO_2 per year would be transported and stored from 2027. The ECC aims to capture and store an average of around 23 million tonnes of CO_2 per year by 2035 across Humber and Teesside.

Achievements and Outputs

The significant milestones include:

- The project completed FEED for the Offshore Transport and Storage of CO_2.
- Progression of planning and environmental permitting. This included the award of a Development Consent Order in 2024.
- Engagement with the Department for Energy Security and Net Zero (DESNZ) on the business models and regulatory framework for CCS as a Track 1 cluster.
- Following FID, the project would be aiming for first commercial operations from 2027.

Teesside Industrial Cluster

Net Zero Teesside Power will be a world-first flexible gas power plant with carbon capture and storage (CCS). It will capture approximately two million tonnes of carbon dioxide (CO_2) annually and decarbonise 750MW of flexible power. CO_2 will be permanently and safely stored in a well-understood, large geological aquifer located in the Southern North Sea.

The Northern Endurance Partnership (NEP) will deliver onshore and offshore infrastructure needed to capture and transport CO_2 from a range of emitters in the Humber and Teesside to secure offshore storage in the North Sea. Endurance, a saline aquifer, has the capacity to store 450m tonnes of CO_2.

Zero Carbon Humber Partnership

Project Lead	Equinor
Partner Organisations	Associated British Ports, British Steel, Centrica Storage, Drax, Mitsubishi Power, PX, SSE Thermal, Triton Power, Uniper, University of Sheffield
Grant Award	£21,496,247
Pledged Match Funding	£40,003,242
Project length	36 months

Introduction

Zero Carbon Humber was established with the aim of delivering first-of-a-kind low-carbon infrastructure, including carbon dioxide (CO_2) and hydrogen (H2) pipelines (with anticipated minimum 17 MTPA and 10GW capacity respectively) linking the region's major emitters, enabling CO_2 emissions to be captured and transported, and fuel switching of end-users to H2 for a long-term sustainable transition to low carbon energy. The infrastructure, which is designed to be anchored by the H2H-Saltend project, will unlock further private sector investment in mature deep decarbonisation projects, enabling the transition to net zero before 2040. This infrastructure enables Hydrogen production/CO_2 capture at Uniper's site in Immingham (c.7 MTPA), clean steel production at British Steel (2-4 MTPA), SSE Keadby-3 CCGT+CCS (c.2 MTPA) and Bioenergy-with-CCUS (BECCS) at Drax (16 MTPA).

Project Plan

The UKRI funding laid out the plans for low carbon infrastructure across the cluster, anchored by the H2H-Saltend project. The low-carbon infrastructure plan includes parallel CO_2 and H2 pipelines with an anticipated minimum 17 MTPA and 10GW capacity, respectively. This will enable CO_2 emissions to be transported and stored whilst also enabling hydrogen fuel-switching, providing a long-term sustainable energy transition. The onshore infrastructure is designed to link to the 'Northern Endurance Partnership (NEP)' offshore project, providing CO_2 transport and storage for Humber and Teesside using the 450 Mt of capacity at the Endurance CO_2 store in the North Sea.

The H2H-Saltend project will develop a 600MW hydrogen production facility, supporting fuel-switching at Saltend Chemicals Park reducing industrial emissions by about 1 MTPA. Additionally, the IDC funding enables H2H-Saltend to develop around 300MW of low-carbon ammonia, positioning the UK at the forefront of an expanding international green products market.

Achievements and Outputs

The significant milestones include:

- Low Carbon Infrastructure - moved from pre-FEED to FEED. This has included significant engineering works and environmental planning. A DCO was submitted to the Planning Inspectorate, November 2022.
- H2H Saltend – significant progress has made including the approval of a planning application and work on securing offtakers for production at site.
- Saltend Fuel Switch - Substantial progress on hydrogen fired turbines including developing a 30% blend and 100% full conversion.
- Supply Chain Development – mobilisation through both the 'Fit4 H2' and 'Fit4 CCUS' programmes. A cohort of 30 supply chain companies worked alongside this.

Humber Zero

Project Lead	VPI Immingham
Partner Organisations	Harbour Energy (non-grant claiming), Phillips 66
Grant Award	£12,692,910
Pledged Match Funding	£12,692,911
Project length	36 months

Introduction

Humber Zero plans to decarbonise the world-scale industrial complex at Immingham, representing a reduction of approximately 8 MTPA of CO_2 emissions by the late 2020's, via a combination of technology pathways. Humber Zero's IDC Phase II focusses on the carbon capture components of this strategy. The IDC-supported scope of work will deliver 3.8 MTPA of abated CO_2 emissions via a post combustion carbon capture (PCC) retrofit to two gas turbines at VPI Immingham CHP, and two auxiliary gas boilers (representing a total of 1052MW) together with a post combustion carbon capture retrofit to the Fluid Catalytic Cracker (FCC) stack at the Phillips 66 Humber Refinery.

Project Plan

The UKRI funding enabled Humber Zero to undertake an extensive FEED programme both at the refinery and the power station. This includes taking a number of key strategic decisions on engineering design and achieving the planning and permitting controls to take the project through to final investment decision.

Humber Zero is also developing interface options to enable CO_2 storage. The project team has engaged with Harbour Energy, the key partner in Viking CCS, which will establish a permanent storage opportunity in the Southern North Sea.

Achievements and Outputs

The project has successfully worked through FEED to develop a credible project which is FID-ready with a date set in 2025. The project has also included development of a storage option, involving connecting with the Viking CCS project which will enable permanent CO_2 sequestration in the Southern North Sea.

The significant milestones include:

- FEED across both the refinery (Phillips 66) and CHP (VPI).
- Mobilisation of the supply chain and key vendors which will deliver the engineering works.
- Selection of key contractors.
- Completion of planning and permitting to enable successful mobilisation of the project post final investment decision.
- Finalised project cost estimates.
- Alignment with the Viking CCS project to enable offshore storage.

The Humber Industrial Cluster

Zero Carbon Humber was established with the aim of delivering a first of a kind low-carbon infrastructure, including carbon dioxide and hydrogen pipelines linking the region's major emitters, enabling both CO2 emissions to be captured and transported, and fuel-switching of end-users to H2 for a long-term sustainable transition to low carbon energy.

Humber Zero aims to deliver one of the UK's largest carbon capture projects, whilst strengthening UK infrastructure and creating local jobs. The project is a collaboration between the Phillips 66 Limited Humber Refinery and VPI Immingham Combined Heat and Power plant. Together they are expected to make a major contribution to the UK Government's Net Zero targets. The project plans to capture up to 3.3 MTPA by 2028 and building to 3.8 MTPA the following year.

Scotland's Net Zero Infrastructure (Onshore)

Project Lead	Storegga
Partner Organisations	National Grid, NECCUS, SSE, University of Strathclyde
Grant Award	£19,956,777
Pledged Match Funding	£19,575,471
Project length	36 months

Introduction

The project will develop the major onshore decarbonisation components of the Scottish industrial cluster, including a viable CO_2 shipping infrastructure to facilitate decarbonisation opportunities for other UK clusters and from abroad. This project will focus on onshore elements of the Acorn CCS and low carbon hydrogen project at St Fergus in north-east Scotland, and the Scottish Industrial Cluster. The project will fund important engineering studies which will develop the executable scopes of key components within the cluster, increasing investor confidence and providing the infrastructure to make a net zero industrial cluster in the UK a reality.

Project Plan

The UKRI funding has enabled the Scotland Net Zero Infrastructure (SNZI) project to develop the major onshore decarbonisation components of the Scottish industrial cluster, including a viable CO_2 shipping infrastructure to facilitate decarbonisation opportunities for other UK clusters and from abroad.

The UKRI funding has supported the development of the core Acorn CCS project, capturing and storing 300,000 tonnes per annum of St Fergus CO_2; the Acorn Hydrogen project, producing 200MW per annum of low carbon hydrogen at St Fergus; a linked CO_2 ship design project to enable large scale shipping of CO_2 from projects at Teesside, Humber and South Wales, and expansion of the onshore pumping capacity to enable these increased CO_2 volumes to be stored offshore.

The project has also developed plans for the low carbon thermal power generation at SSE's Peterhead Power Station site and investigated the potential to repurpose parts of the National Gas Transmission System for CO_2 and H2 transportation.

Achievements and Outputs

The significant milestones include:

- Completion of FEED for a carbon capture module that would help decarbonise St Fergus natural gas processing plant.
- Pre-FEED and an execution study completed for the blue hydrogen plant.
- Design of the highest capacity CO_2 ship studied to date. Novel cargo tank design which has achieved agreement in principle against relevant regulations.
- FEED work commenced for a carbon capture enables power station at Peterhead.
- Modelling of the gas transmission system if a feeder pipeline was re-purposed for CO_2.

Scotland's Net Zero Infrastructure (Offshore)

Project Lead	Storegga
Partner Organisations	Petrofac
Grant Award	£11,347,956
Pledged Match Funding	£11,347,957
Project length	36 months

Introduction

This project will progress the major offshore decarbonisation components of the Scottish industrial cluster, including an offshore pipeline and subsea infrastructure to inject CO_2. The intention is to create a low-carbon, sustainable regional economy that leverages specific attributes such as the plethora of nearby offshore CO_2 stores, skilled engineering and subsurface workforce and existing infrastructure. The project will fund important engineering studies to develop the key offshore components of the cluster, increasing investor confidence and providing the storage capacity to make a net zero industrial cluster in the UK a reality.

Project Plan

The UKRI funding has enabled the (SNZI) offshore project to progress the major offshore decarbonisation components of the Scottish industrial cluster, including an offshore pipeline and subsea infrastructure to inject CO_2. This could store up to 10 MTPA of CO_2 storage by 2030, growing to 20 MTPA.

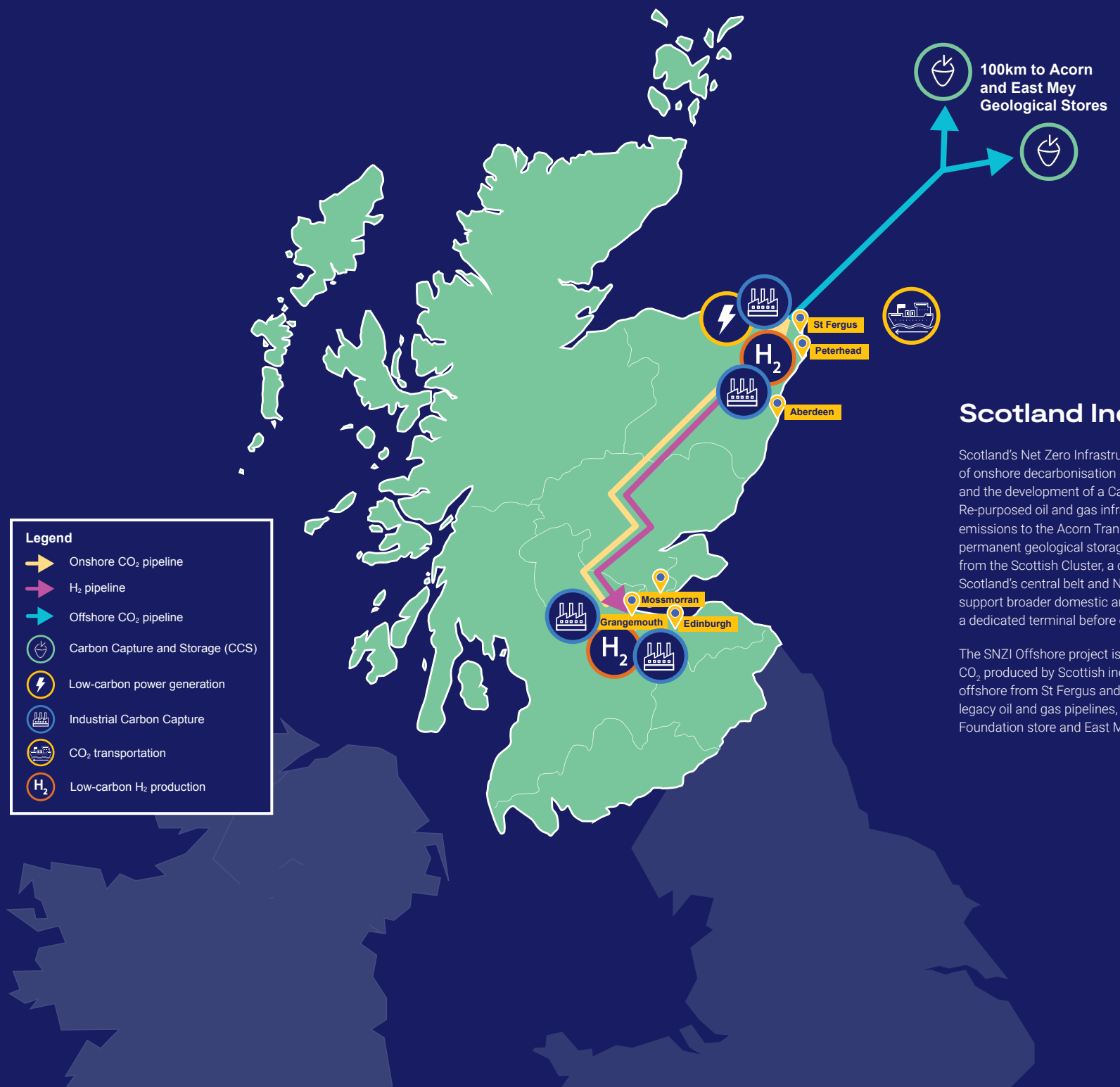
The UKRI funded work sought to develop three offshore elements to progress: one to take the Acorn CCS project to final investment decision; concluding well and associated subsea engineering work in readiness for CO_2 injection into the Acorn South structure; completing the subsurface, well and subsea work required to expand the Acorn South storage facility to develop the capacity required to increase CO_2 volumes to be injected and stored offshore.

In addition, the UKRI funding planned a significant extension to the Acorn store capacity by developing the subsurface understanding for Acorn East, and undertaking concept select engineering activity on the subsea and wells to add a potential 20-30 million tonnes of capacity.

Achievements and Outputs

The significant milestones include:

- FEED completed on the Buzzard platform with respect to using it for control of injection wells.
- Screening of the Captain Fairway and connected hydraulic unit to confirm the best location for future CO_2 injection.
- Successful delivery of Early Risk Assessment for East Mey geological store.
- Award of two new Carbon Storage licenses by the NSTA and extension of an existing license.



Scotland Industrial Cluster

Scotland's Net Zero Infrastructure (SNZI) Onshore project is progressing the development of onshore decarbonisation components including low-carbon hydrogen (H2) production and the development of a Carbon Capture and Storage (CCS) power station at Peterhead. Re-purposed oil and gas infrastructure would be used to transport captured CO2 emissions to the Acorn Transport & Storage (T&S) system, at St Fergus, and onward to permanent geological storage 2.5 kilometres under the North Sea bed.The CO2 will come from the Scottish Cluster, a collection of industrial, power and hydrogen businesses in Scotland's central belt and North East. Acorn T&S's proximity to Peterhead Port could support broader domestic and international decarbonisation,with CO2 being shipped into a dedicated terminal before onward transfer to the Acorn storage facility.

The SNZI Offshore project is focussed on the Acorn Transport and Storage System. CO_2 produced by Scottish industrial emitters will be injected into rock formations 100km offshore from St Fergus and 2.5km below the North Sea bed. The T&S system will reuse legacy oil and gas pipelines, subsea and well-related infrastructure to access the Acorn Foundation store and East Mey expansion store.

South Wales Industrial Cluster – Phase 2 Deployment

Project Lead	RWE
Partner Organisations	Associated British Ports, Capital Law, CR Plus, Dragon LNG, Tata Steel, Lanzatech, Lightsource bp, Milford Haven Port Authority, Progressive Energy, Shell, University of South Wales, Wales and West Utilities
Grant Award	£19,999,997
Pledged Match Funding	£18,380,487
Project length	36 months

Introduction

South Wales Industrial Cluster (SWIC) objectives focus on industrial emissions, producing hydrogen at scale and creating new carbon use industries. It focuses partner projects on aligned strategy - appraising feasibility options, selecting the most techno/economic before launching FEED, and defining sub-projects that encourage investment decisions to advance projects towards construction. SWIC will produce firm plans for the decarbonisation of a significant amount of the emissions from the South Wales industrial and power emitters, reinforced by a comprehensive infrastructure deliverable scheme for; low carbon fuel, hydrogen and ammonia production, CO2 transportation and shipping.

Project Plan

The UKRI funding facilitated the development of SWIC's robust plans around decarbonising the region's largest emitters, in the UK's largest industrial cluster by CO2 emissions output.

The UKRI funding has focused partner projects on an aligned strategy - appraising feasibility options, selecting the best techno-economic options before launching FEED, and defining sub-projects that encourage investment decisions to advance projects towards construction.

Achievements and Outputs

The significant milestones include:

- Viable, end-to-end shipping solution for CO_2 within the region, unlocking further opportunities for Hydrogen and decarbonisation of emitters such as Port Talbot Steelworks and Pembroke Power Station.
- Studies of the viability of MUST (Multi Utility Service Transit), a project to connect the north and south side of Milford Haven Estuary. MUST could make use of the residual process heat, exportation of CO_2 and potential integration of Blue and Green Hydrogen connecting RWE's power station, Dragon LNG's site and support further industry in the region.
- HyLine Cymru: a proposed pipeline that has come about as a direct result of feasibility studies completed as part of the SWIC Deployment Project. HyLine is a proposed 130km hydrogen pipeline running from the Milford Haven Clean Growth Hub to the Port Talbot Clean Growth Hub.
- A planning application to build a pioneering carbon recycling facility in Port Talbot. The facility will be an Alcohol to Jet facility, transforming sustainably sourced ethanol into sustainable aviation fuel.
- The Celtic Freeport Bid was informed by SWIC and the efforts of the Deployment Project.

South Wales Industrial Cluster

The South Wales Industrial Cluster (SWIC) Deployment Project is creating pathways and opportunities to reduce industrial emissions from the region and promote Wales as a leading global player in decarbonised industrial and economic growth.

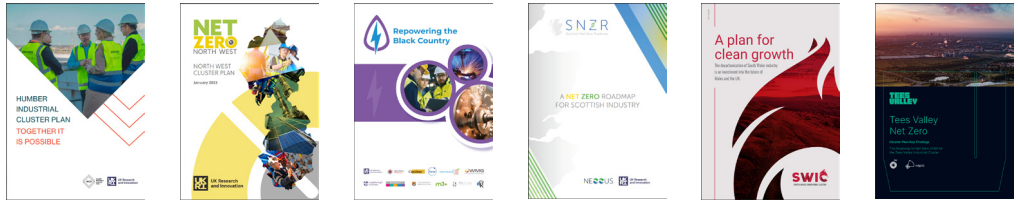
The project is devising options to support regional hydrogen (H_2) production and deployment, develop carbon capture and storage (CCS) projects, and options for transportation of carbon dioxide (CO_2) emissions for shipping and storage. SWIC will also provide the UK with lower carbon steel and reduced carbon cement products that form the backbone of the wider UK Infrastructure Industry.

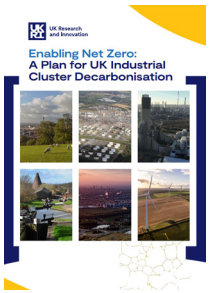
3.2 Enabling Net Zero: A Plan for UK Industrial Cluster Decarbonisation

The IDC has delivered six cluster plan projects and an overview document, "The Plan" which brings the learnings from each of the cluster plans together.

The Plan was published in October 2023 and synthesises the six cluster plans through a national lens. It sets out the next steps for how the UK can harness the power of its industrial clusters and drive the next phase of emissions reductions while contributing to a stronger economy, energy security, greater innovation, and community vitality. In doing so, The Plan creates a platform of shared knowledge and replicable models to support existing and future industrial cluster decarbonisation efforts. The implementation of The Plan will support successful industrial cluster decarbonisation and result in industrial clusters that have competitive advantages attracting investment from and trading with the international market and enable the decarbonisation of UK supply chains, improving the value of products and services sold. Additionally, they will be active hubs of co-operation, technology development, knowledge transfer, and learning that support investment and innovation to drive decarbonisation, and engage meaningfully with local communities to drive environmental, social and economic benefits.

Cluster Plans





The Plan outlines future state ambitions from successful industrial cluster decarbonisation and identifies five key recommendations to achieve this:

Recommendation 1:

Provide clear signals to the market to facilitate the transition from interim deployment targets to net zero across all clusters by 2050.

Recommendation 2:

Rationalise and expedite permitting for common infrastructure.

Recommendation 3:

Formalise an Industrial Cluster Advocate with strong government connections and develop a mechanism for ongoing coordination and communication with industrial clusters.

Recommendation 4:

Develop actionable measures and timings of jobs and skills requirements needed for industrial clusters to decarbonise.

Recommendation 5:

Define and prescribe standardised methodologies for decarbonisation impact estimating.

3.3 Cluster Plan Projects

Scotland's Net Zero Roadmap

Project Lead	NECCUS
Partner Organisations	Optimat, Storegga, University of Strathclyde, University of Edinburgh, Net Zero Technology Centre, Wood, Halliburton, Energy Systems Catapult, Doosan Babcock, Costain, Aker
Grant Award	£868,949
Pledged Match Funding	£365,976
Project length	27 months

The Scottish Net Zero Roadmap focuses on industrial activity on the east coast of Scotland, which covers many of the largest industrial sites across a range of sectors and 75% of Scotland's industrial CO_2 emissions. This includes the petrochemical site at Grangemouth, a natural gas terminal handling 30% of the UK's natural gas volumes and a gas-fired power station, the largest whisky and alcohol distillery in the world, as well as glass and cement manufacturing.

The Scottish Net Zero Roadmap comprises different technology deployment scenarios derived from an analysis of industrial decarbonisation technologies and the policy landscape. Its plan to decarbonise by 2045 (in line with current Scottish Government targets) is dominated by emission reductions in the chemicals, power, and refining sectors. It also accounts for the projected increase in baseline emissions from the waste management and mineral wool manufacturing sectors.

The expectation is that the large Grangemouth emitters will implement CCUS first as they are best positioned to develop common infrastructure at reasonable cost. The development of this infrastructure will drive change in other areas as costs decrease and financing improves. While electrification is an option for sites with small energy consumption, many of the high emitters will require hydrogen to decarbonise. Due to the dispersed nature of the industrial sites (28 within 14 local authority areas), the roadmap proposes that hydrogen plants with carbon capture could form the basis of a regional or national hydrogen network. The benefits associated with these interventions include an average of 5,000 jobs per year between 2023-2045, which translates to an economic impact of £21 billion.

The Scottish Net Zero Roadmap identified social acceptance as a key component in delivering the challenge of industrial decarbonisation and commissioned research from academics to identify key messages and narratives that would support the development of the decarbonisation plans for CCUS.

Impact & Benefits

Net Zero target date:	2045
Current emissions from NAEI large point source sites	4.2 Mt CO_2 e/yr
Industrial Profile	Power, oil and gas and chemicals
Investment levels required	£6–9 billion+
Jobs	5,000 per year between 2023 - 2045

South Wales Industry – A Plan for Clean Growth

Project Lead	CR Plus
Partner Organisations	Associated British Ports, Capital Law, Carbon8 Systems, Celsa Manufacturing, Confederation of Paper Industries, Connect and Convey, Costain, Dragon LNG, Energy Systems Catapult, ERM, Front Door Communications, Milford Haven Port Authority, National Grid, Neath Port Talbot Council, Offshore Renewable Energy Catapult, Pembrokeshire Country Council, Progressive Energy, Rockwool, RWE, Sector Development Wales, Siemens, Tarmac, University of South Wales, Vale, Valero, Wales & West Utilities, Western Bio-energy
Grant Award	£1,451,425
Pledged Match Funding	£756,456
Project length	26 months

The South Wales Industrial Cluster stretches from Milford Haven in the West to Newport in the East. The cluster is home to high-emitting and economically important businesses across the steel, nickel refining, cement, glass, mineral wool, food, and chemicals sectors. The cluster also includes a large and diverse energy supply sector, including a gas power station, onshore wind generation, and two liquefied natural gas terminals.

Fuel switching, including electrification, the use of hydrogen and alternative low-carbon fuels, is the main lever for the cluster's decarbonisation. Because of this, the cluster has explored how the electricity and gas distribution grids must be developed to support the cluster's decarbonisation targets. South Wales Industrial Cluster also envisages using CCS to address a third of its emissions. However, South Wales does not have ready access to geological CO_2 storage and must instead rely on shipping the captured CO_2 to sites elsewhere. As a result of this, the cluster plan includes developing shipping capabilities and exploring technologies and measures to utilise the CO_2 locally.

The cluster plan is also aligned with Wales' sustainable development legislation, the Well-being of Future Generations (Wales) Act 2015, which sets out how public bodies must have the well-being of future generations at the heart of their policy decisions. Linked to this, the cluster carried out a skills gap study on the Milford Haven Waterway energy sector and has been working with academic institutions to develop a related future skills blueprint. Overall, the SWIC Cluster Plan notes that guiding Welsh industry through the net zero transition can help retain 113,000 industrial and manufacturing jobs in the region.

Impact & Benefits

Net Zero target date:	2040
Current emissions from NAEI large point source sites	9.1 Mt CO_2 e/yr
Industrial Profile	Steel, oil and gas, paper and cement
Investment levels required	£30 billion
Jobs	Retention of 113,000 jobs and a net positive increase in jobs overall

Net Zero Tees Valley Cluster Plan

Project Lead	Tees Valley Combined Authority
Partner Organisations	bp, North East of England Process Industry Cluster (NEPIC)
Grant Award	£887,569
Pledged Match Funding	£246,054
Project length	26 months

The Tees Valley Net Zero Cluster Plan covers the region covered by the Tees Valley Combined Authority in the North East of England. Tees Valley Industrial Cluster is a concentration of 60 industrial sites within a five-mile radius. It has a deep-water port, access to CO_2 geological storage nearby, and contains the Teesside freeport, a tax and secure customs zone.

The Tees Valley Industrial Cluster is made up of a small number of large CO_2 emitters (i.e., chemical works, power, and heat (steam) generation, and waste processing and recovery) and many small emitters. A third of the cluster's planned decarbonisation is directly related to CCS, while up to another third is indirectly reliant on CCS (i.e., capturing the CO_2 associated with the production of blue hydrogen and use of the electricity generated by power stations with pre- and post-combustion CCS).

The cluster plan also outlines how the cluster intends to scale up green and blue hydrogen production to become a net-exporter to other UK regions and European countries. To support this growth area, as well as the broader cluster objectives, the plan highlights the challenge of reversing the decline in skilled metal, electrical and electronic trade.

The cluster aims to achieve net zero aligned decarbonisation without de-industrialisation, a historic issue in the region. A successful transition to net zero in the region could translate to some £34 billion in cumulative additional Gross Value Added (GVA) by 2040, which is associated with up to 30,000 new jobs. The required investments for the net zero projects are partially being addressed by leveraging funding for the redevelopment of the old Teesside Integrated Iron and Steel works site.

Impact & Benefits

Net Zero target date:	2040
Current emissions from NAEI large point source sites	3.8 Mt CO_2 e/yr
Industrial Profile	Process industry and energy
Investment levels required	£10 billion
Jobs	Up to 30,000 jobs

Repowering the Black Country

Project Lead	Black Country Consortium
Partner Organisations	Camirus, CR Plus, Pro Enviro, M3MAS, Kew Projects, District Eating, University of Warwick, University of Birmingham
Grant Award	£1,498,970
Pledged Match Funding	£454,068
Project length	26 months

The Black Country Industrial Cluster covers an inland area in the West Midlands encompassing Dudley, Sandwell, Walsall, and Wolverhampton. The cluster is made up of diverse manufacturing supply chain companies, including small and medium sized enterprises that typically have modest emissions per site but are collectively significant. Manufacturing sectors covered in the cluster include aerospace, automotive, minerals processing, paper, chemicals, and food and drink. The manufacturing focus of this cluster makes it more representative of the majority of UK industry than the high-emitting heavy-industries that dominate the other IDC industrial clusters. 95% of UK's industrial GVA and 98% of industrial employment comes from manufacturing businesses like those in the Black Country Industrial Cluster.

Although energy from waste plants are the largest point source emitters in the cluster, they are not the focus of the Black Country Industrial Cluster's Plan. The cluster plan outlines that decarbonisation of energy from waste plants relies on networked CCS infrastructure, which is unlikely to be available in the Black Country region until after 2045. The cluster plan therefore focuses on developing a replicable decarbonisation model for manufacturing companies. In addition, the National Centre for Manufacturing Transition was established as a vehicle to scale decarbonisation solutions for dispersed sites.

Another feature of this cluster is the dispersed nature of the industrial sites. It is likely to be more expensive to decarbonise dispersed sites through large infrastructure investments such as CCS. As a result, the cluster plan focuses on the development of Zero Carbon Hubs, i.e., collaborations between co-located industries to share energy and material vectors. Zero Carbon Hubs offer manufacturing companies a decarbonisation method which involves a combination of resource and energy efficiency measures, increased electrification, and a modest deployment of hydrogen. The hubs are projected to generate smaller economic benefits individually, with each hub requiring in the tens of millions of pounds in capital expenditure to secure 50-500+ jobs. However, with 60 hubs expected to be required to deliver net zero in the cluster, the corresponding impacts have the potential to scale.

Impact & Benefits

Net Zero target date:	2040
Current emissions from NAEI large point source sites	0.5 Mt CO_2 e/yr
Industrial Profile	Aerospace, automotive, minerals, paper, chemicals and food and drink
Investment levels required	£3 billion
Jobs	Securing jobs across an industry base of more than 3,000 energy-intensive businesses

Humber Industrial Cluster Plan

Project Lead	Humber and East Yorkshire Local Enterprise Partnership
Partner Organisations	HEY LEP, CATCH, British Steel, Equinor, Keadby Generation, National Grid Carbon, Centrica, VPI Immingham, Drax, Phillips 66
Grant Award	£1,657,844
Pledged Match Funding	£996,269
Project length	27 months

The Humber Industrial Cluster is located around the Humber estuary and includes the UK's main steel production centre, its largest port complex and enterprise zone, a third of national fuel refining capacity, the second largest chemical cluster, one of the nation's largest concentrations of food manufacturing and cold storage, along with biofuel, lime, and glass manufacturers. The region also supplies a sixth of the UK's electricity, including from the Drax biomass power station and extensive offshore wind farms.

The cluster's plan to reduce emissions focuses on CCS with smaller contributions from resource and energy efficiency measures, electrification, and fuel-switching to hydrogen. Bioenergy with carbon capture and storage (BECCS) applied to the Drax power plant is also a potential lever for carbon removal. To support the implementation of these interventions, the Humber Industrial Cluster conducted community workshops to understand societal expectations and concerns related to decarbonisation.

The cluster benefits from proximity to CO_2 storage reservoirs and from its relative compactness, which should allow for more cost-effective networks for transporting CO_2 and hydrogen. If these planned interventions are successful, the cluster plan anticipates that net zero by 2040 in the region could bring £3-5 billion per year in National GVA (with ~20% of this increase retained in the Humber region) and the creation of up to 22,800 direct jobs.

The cluster is also in a prime position to develop a scalable and integrated hydrogen network with plans for multiple new projects covering hydrogen production, transmission, and use to decarbonise industry. It already houses important hydrogen storage capacity at two sites, which helps balance energy supply and demand and improve energy system resilience. The cluster plan includes an assessment of the likely impact of water availability on decarbonisation plans. The cluster also took steps to better understand public perception of, and to build public acceptance for, decarbonising the regions' industries.

Impact & Benefits

Net Zero target date:	2040
Current emissions from NAEI large point source sites	8.8 Mt CO_2 e/yr
Industrial Profile	Steel, oil and gas, refining, cement, chemicals, glass, lime
Investment levels required	£4-5 billion
Jobs	22,800

The Net Zero North West Cluster Plan

Project Lead	Peel NRE
Partner Organisations	Cadent, Progressive Energy, University of Chester, Equans, Liverpool City Region LEP, Cheshire & Warrington LEP, North West Business Leadership Team, Uniper, Net Zero North West, SP Manweb
Grant Award	£364,879
Pledged Match Funding	£244,497
Project length	27 months

The Net Zero North West industrial cluster stretches from Cheshire in the South to Manchester in the East to Cumbria in the North, covering the entirety of North West England and parts of Wales. The region, notably the area around the Dee Estuary, boasts the largest concentration of advanced manufacturing and chemical production in the UK. Significant emitters include major power producers, cement manufacturers, an oil refinery, chemicals and ammonia producers, the food and drink sector, and waste management.

The cluster plan sets out a roadmap to a multi-vector energy system, including renewables, hydrogen, CCUS, nuclear and smart grids, to drive clean growth in the region. Approximately half of the cluster's planned emission reductions stem from energy efficiency, on site renewable electricity generation and decarbonising the power sector. The cluster focused on the decarbonisation of dispatchable power (i.e., not wind and solar which are subject to weather conditions) using hydrogen turbines or natural gas turbines with CCUS and also considers the potential for adoption of less developed technologies. The other main decarbonisation lever in the clusters plan is the roll out of both the production and use of green, and blue hydrogen.

The HyNet project is deploying hydrogen infrastructure across North West England and North Wales, covering the production, transport, and storage of low-carbon hydrogen. The cluster also explored its options for distributing electrolytic hydrogen: either through connections to the HyNet hydrogen network or supplying industry directly. A focus for Net Zero North West, the industry-led consortium that developed the cluster plan, was accelerating public and private sector investment for industrial decarbonisation. The Net Zero North West Investment Case puts the pipeline of investible projects in the region at £30 billion, spread across a strategically diverse mix of net zero intervention types. The cluster plan further indicates that 34,500 jobs and £36.5 billion GVA would be associated with these projects, if realised.

Impact & Benefits

Net Zero target date:	2040
Current emissions from NAEI large point source sites	5.2 Mt CO_2 e/yr
Industrial Profile	Glass, chemicals, paper and pulp, refining, chemicals, cement, food and drink
Investment levels required	£30 billion
Jobs	34,500

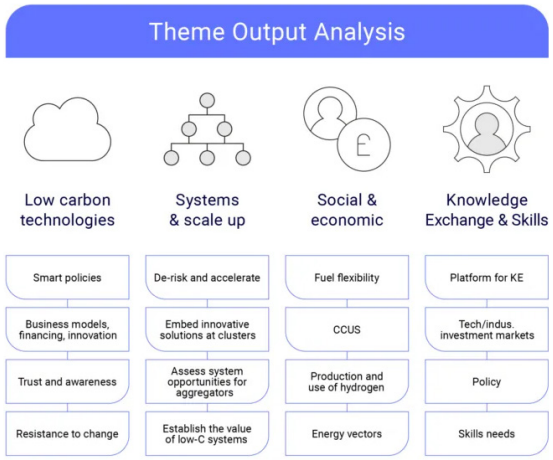
3.4 Research Centre

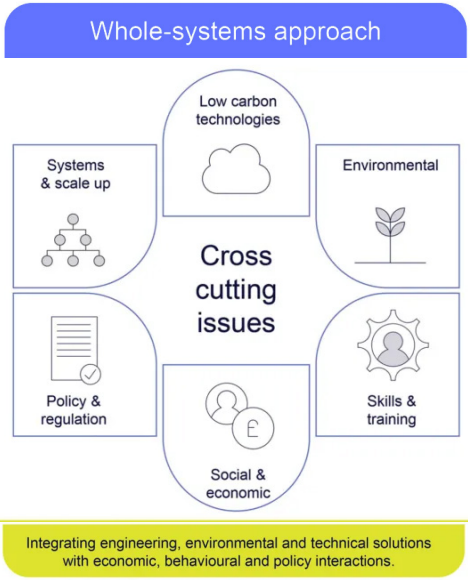
Industrial Decarbonisation Research and Innovation Centre (IDRIC)

Project Lead	Herriot Watt University
Grant Award	£20,000,000*
Project length	36 months
Projects Funded	100

*Represents 80% Full Economic Costs (fEC)

IDRIC was established to work with academia, industry, government, and other stakeholders to deliver the multidisciplinary research and innovation needed to support decarbonisation of the UK's industrial clusters. The programme was delivered through a range of multidisciplinary research projects in cross-cutting areas of technology, policy, economics, and regulation. Its work supported knowledge exchange, regulation, policy, and key skills, benefitting industry sectors and clusters across the UK.





IDRIC takes a whole-systems approach to support the development and deployment of low carbon technologies in areas such as fuel switching, energy storage, hydrogen, CCUS and negative emissions technologies. It focuses on systems and scale up by developing innovative planning and decision-making tools for infrastructure and supply chains, as well as informing the design of business models and regulatory frameworks. IDRIC research also addresses key social, economic and policy aspects of industrial decarbonisation including skills pathways for low carbon industry and roadmaps to support a just transition.

IDRIC has provided £16.9 million of funding to 65 research projects. These projects were split into two waves with 45 projects in wave one, launched in 2021 and 20 further projects in wave two, launched in 2022.

In addition, 'Flexible Funding' of £2.1 million for 29 emerging research areas was provided (including six 'Impact Accelerator' funding to accelerate the impact of existing IDRIC projects) and an additional £512,500 'Secondment' funding to support skills development and knowledge exchange in industrial decarbonisation stakeholders.

IDRIC's research is grouped into nine Multidisciplinary Integrated Programmes (MIPs), each addressing a key challenge or pathway for industrial decarbonisation.

Achievements and Outputs

- Training courses on the safe use of zero carbon fuels being rolled out at universities and colleges, nationally and internationally.
- Maps to illustrate where hydrogen storage in porous rocks might be possible in the UK, providing industry with information on potential sites for storage.
- Beta-version of a Smart Decision Modelling tool for industrial cluster decarbonisation which uses Artificial Intelligence (AI) and machine learning to assess different decarbonisation scenarios in clusters ready for testing.
- Online platform identifying optimal carbon capture solutions.
- Improved CO_2 storage capacity data (collected from data owners) for 200 oil and gas fields not previously included in the UK's national CO_2 storage database to support UK clusters carbon capture and storage strategies.
- Patent filed for a "mobile energy stored as heat' system which can transport waste heat from industrial sites to domestic heat users.

IDRIC has made submissions to policy consultations and Parliamentary engagement and delivered a programme of forums and thematic roundtables that brought together expertise and shared understanding needed to drive action on key policy issues. Skills impacts supported by the Centre include the development of the 'Enabling Skills for the Industrial Decarbonisation Supply Chain' report which quantifies the workforce needed to meet the demands of industry and has been used by the clusters, Engineering Construction Industry Training Board, Cogent, EU Skills and the Carbon Capture and Storage Association to inform future workforce strategies.

> **In the three years since its inception, IDRIC has laid strong foundations to empower the decarbonisation of the UK's industrial clusters by cementing its position as a mission-driven research and innovation centre. The funding from the IDC has allowed us to engage with our network of academic, industry and government partners to realise the full benefits of industrial decarbonisation to unlock long-lasting economic growth and societal benefits.**
>
> **Professor Mercedes Maroto-Valer**
> Director
> IDRIC

IDC funded projects

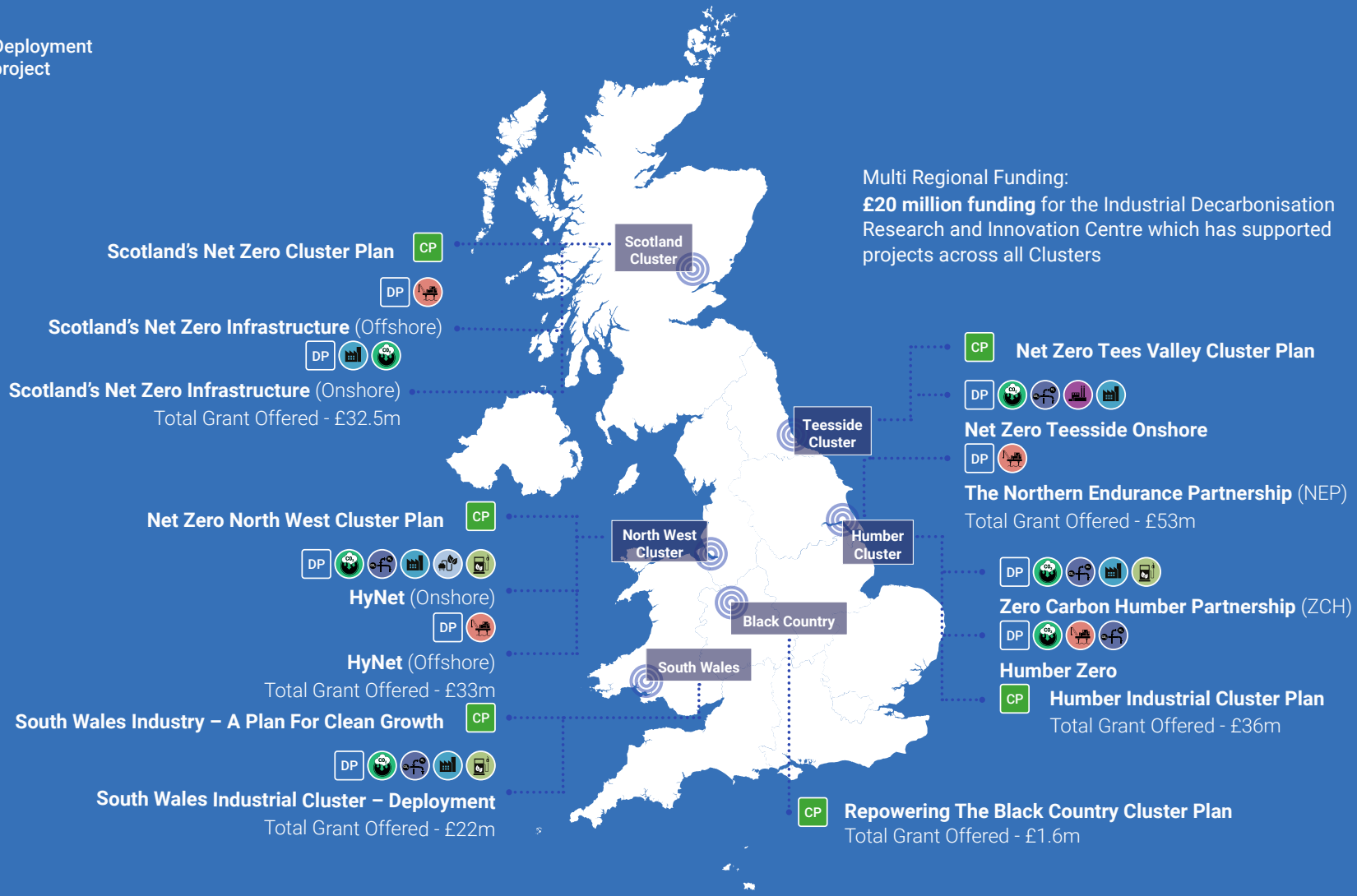
Project key

CP Cluster plan project

DP Deployment project

Deployment project technologies key

- Industrial carbon capture technology
- Offshore piapelines and subsea CO_2 storage
- CO_2 and Hydrogen transportation pipelines
- Modern, low-carbon power stations
- Industrial infrastructure
- Flexible, greener energy systems
- Fuel replacement technology



Multi Regional Funding:
£20 million funding for the Industrial Decarbonisation Research and Innovation Centre which has supported projects across all Clusters

4 Challenge Impact

4.1 Project Impacts and Benefits

The outputs of the IDC will support the UK to:

- Meet net zero targets
- Drive clean growth and inward investment
- Protect jobs and develop skills
- Enhance energy security
- Nurture innovation and supply chains
- Grow international trade and exports

Some of the world's most impressive industrial decarbonisation projects are being delivered in the UK's industrial clusters. The IDC deployment portfolio features nine first of a kind decarbonisation projects, six onshore and three offshore, that have completed their detailed engineering plans for infrastructure deployment. They are complex configurations of industry coming together with a common goal to decarbonise on a scale not seen anywhere before in the world. The deployment projects in the IDC portfolio are set to take final investment decisions from late 2024 in preparation for construction and operation in the mid-late 2020s.

The IDC has demonstrated that the most cost-effective ways of decarbonising are within an industrial cluster rather than an industry or sector on its own. This cross-sector-focused approach enables knowledge sharing and learning and throughout the programme there have been many examples of the projects embracing this culture.

Industrial clusters are important industrial hubs, large employers and major contributors to the national economy and export market. They secure 1.5 million jobs and export goods from chemicals, steel, ceramics, food and drink, cement, paper, glass, and refined oil worth around £320 billion. The Industrial Decarbonisation Challenge has demonstrated how to boost the industrial productivity of these regions whilst also cutting carbon emissions, boosting the competitiveness of key industrial regions and driving inward investment, whilst also creating and protecting jobs for a low carbon industrial sector.

IDC projects are world leading examples of industry decarbonisation, including, for example:

Humber Zero – this project will decarbonise the UK's largest combined heat and power plant through post combustion capture and develop a world first application of CCS at the Humber Refinery's fluid catalytic cracking (FCC) stack. There are 200 refineries in Europe, this is UK expertise which can be exported around the globe.

HyNet - this project will be the world's first commercial scale hydrogen and CCUS project which will provide a replicable model of an integrated decarbonisation programme.

The Cluster Plans have connected multiple stakeholders across industrial clusters providing industrial decarbonisation leadership. These projects have identified the near-term deliverable options to achieve low carbon clusters by 2030 and longer-term robust strategies to create the world's first net zero industrial clusters by 2040.

The importance of CCS for the UK's net zero ambitions is clear, with the IDC projects generating tremendous global momentum and driving ambitious plans towards decarbonising their clusters.

> **The Phillips 66 Humber refinery would be the first refinery in the world to use carbon capture and storage for capture of emissions. It presents new challenges from a technical point of view, from a regulatory point of view, from a societal and policy development point of view. It is a flagship first of a kind project. The UKRI funding has been essential in enabling us to do this, to progress and dedicate resources to the development of the project which otherwise just would not happen. This project is really a world leading initiative to be able to decarbonise complex world scale industrial sites across both Phillips 66 and VPI Immingham together as the Humber Zero project.**
>
> **Jenny Sutcliffe, Principal Consultant**
> Regulatory Affairs
> Phillips 66

4.2 Final Impact Evaluation Findings

Evaluation is a systematic assessment of the design, implementation, and outcomes of an intervention. The Final Impact Evaluation of the Industrial Decarbonisation Challenge (IDC) looks to understand the difference the programme implementation has made in terms of what effects it had, for whom, how and why. The independent Final Impact Evaluation indicates the following observed effects and outcomes in the preliminary findings:

4.2.1 Contribution towards industrial decarbonisation

There are positive indications that the IDC is on track to support progress towards deploying CCUS in at least one cluster by the mid-2020s and establishing at least four low-carbon clusters by 2030, which would exceed the original objectives of the IDC. There is evidence to show that the intervention of the IDC has sped up progress towards industrial decarbonisation. Track 2 of the UK Government's CCUS Cluster Sequencing process has provided greater confidence and positive signals for some of the IDC clusters. Progress after the end of IDC will depend on the continued momentum of projects.

4.2.2 Addressing barriers and creating opportunities for decarbonisation

The IDC has been instrumental in increasing confidence in the UK Government's direction towards industrial decarbonisation. The IDC's whole-systems approach and the cluster model were noted as being particularly beneficial by project stakeholders. These stakeholders identified key barriers to be future funding, the direction of UK Government (e.g., policy, business models), speed of licensing and regulatory approval, and maintaining the current momentum beyond the IDC.

4.2.3 Economic impacts

Although economic impacts are still developing and not fully realised, there are early indications of positive economic impacts. Low carbon industries have generally grown in the UK and overseas, with the IDC contributing through building knowledge foundations and confidence. The IDC projects are relevant to a variety of stakeholders from industrial, technological, regional, and national contexts. Some evidence shows the IDC contributing towards understanding of skills shortages and supply chains (e.g., major expansion of the CATCH training facilities in the Humber), but practical outcomes of this are currently unclear. There is the potential for replicability of the IDC, and benefits from economies of scale.

4.2.4 Unintended outcomes from the Challenge

There is limited evidence of any unintended outcomes such as increased competitiveness of overseas markets through knowledge transfer. Projects have submitted environmental impact assessments and completed public consultations, which may contribute towards reducing negative environmental or societal impacts. The CCUS Cluster Sequencing Competition was seen as a key factor impacting outcomes, especially regarding collaboration and knowledge sharing and the continued momentum of projects. Although some individual projects have experienced challenges, such as the withdrawal of key emitting project partners, these projects have managed to adapt and continue.

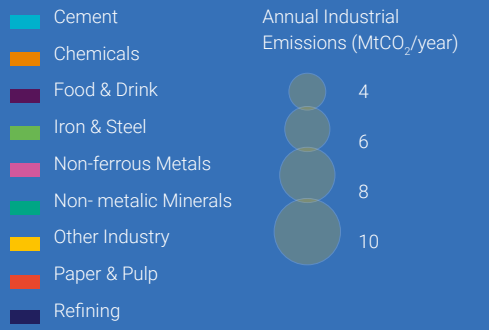
4.2.5 Knowledge sharing and collaboration

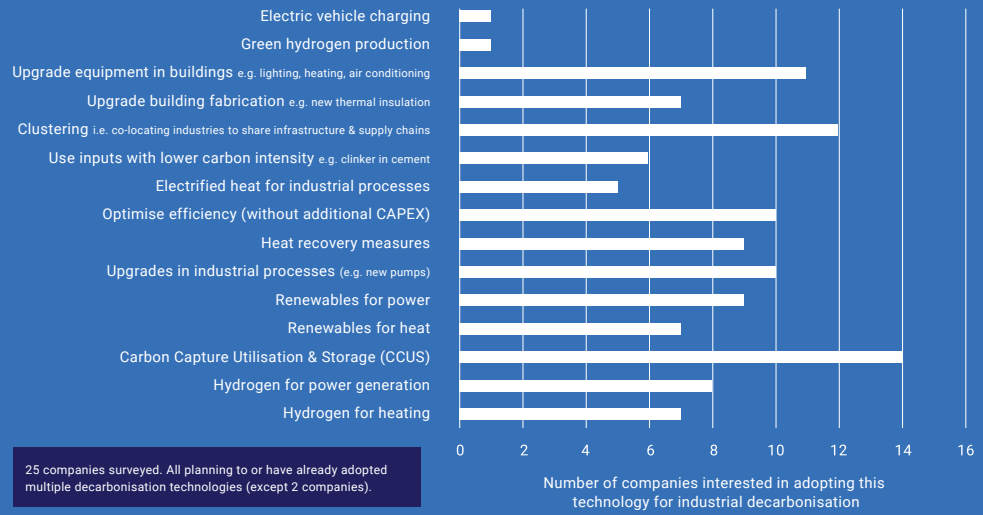
All three strands of the IDC (deployment projects, cluster plans and IDRIC) have facilitated and contributed towards knowledge generation, knowledge sharing and collaboration. There is evidence of knowledge sharing between and beyond the clusters, with biggest examples being UKRI IDC events, the Cluster Plan launch events and the IDRIC Annual Conferences.

Benefits and Impacts

IDC Objectives

1. Design, demonstration or deployment of decarbonisation technologies and shared infrastructure at industry-scale in at least one cluster by 2023/2024.
2. Develop by 2022/2023, credible evidence and investable plans for decarbonising up to five industrial clusters in line with Cluster Mission for net zero operation by 2040.
3. Ensure opportunities to decarbonise across all clusters are socialised, enabled and optimised for maximum take-up by 2024.

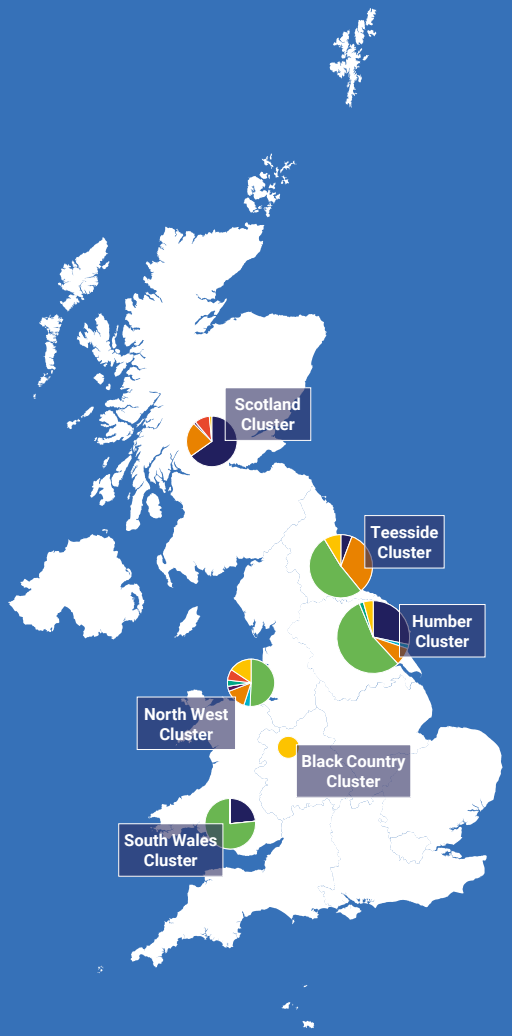




25 companies surveyed. All planning to or have already adopted multiple decarbonisation technologies (except 2 companies).

Socio-economic benefits if net zero is realised

Jobs	Gross Value Added (GVA)
Scotland Cluster	
Average of 5,000 jobs per year between 2023-2045	The GVA generated in 2020 in this region is over £740 million GVA per year. Net zero will deliver £21 billion of economic impact.
Teesside Cluster	
Net zero by 2040 creates up to 30,000 new jobs	£34 billion in cumulative additional GVA by 2040
Humber Cluster	
Net zero can create up to 22,800 direct jobs	Net zero by 2040 in Humber could add £3-5 billion per year to national GVA
North West Cluster	
Net zero by 2040 could create 34,500 jobs	£36.5 billion GVA associated with the projects for net zero by 2040
South Wales Cluster	
Retains 113,000 industrial and manufacturing jobs	Growing the current £6bn Gross Value Added benefit from South Wales industry
Black Country Cluster	
Supports the retention of 57,355 jobs in manufacturing	Total GVA associated with manufacturing in the Black Country is £3.4 billion



Electrification of heat

CO_2 capture & storage (CCS)

Hydrogen as fuel or feedstock

Knowledge sharing and collaboration

- Evidence of knowledge sharing across all three strands of the IDC, including cluster plans, deployment projects and IDRIC.
- Knowledge sharing webinars hosted by UKRI with an average of 40 attendees at each event, including project partners, wider industry, academia and relevant stakeholders from the public sector.
- Social media presence on the IDC LinkedIn page which currently has 5007 followers (as of 23 May 2024).
- Written material for knowledge sharing includes thought leadership articles, blogs and articles produced over the course of the IDC.
- Engagement and communications activities include presentations at events, both in the UK and internationally, videos and blogs.

IDRIC - Research Impacts

- IDRIC's Knowledge Hub hosts over 147 resources, including academic journal articles, reports, blogs, webinars, policy briefs, policy updates, guidance/ toolkits, database and podcasts. There has been direct engagement with partners through activities such as IDRIC Annual Conferences and networking events.
- IDRIC has supported 100 research projects through Wave 1 (2021) and Wave 2 (2022) and Flexible Funding (start dates over 2023).
- Skills & training: Courses provided on advanced carbon accounting, carbon management and reporting. Funded a total of 10 secondments. The Early Career Research Academy provides training on good grant writing, career coaching and organised site visits to local industry in the clusters.

4.3 Co-investment

The funding from UKRI's Industrial Decarbonisation Challenge and the funding from the organisations involved in each of the projects only tells a small part of the story of the financial stimulus that this programme has generated. The IDC has enabled significant additional investment from the organisations involved, which has been tracked throughout the delivery of the programme. This co-investment falls into 4 categories[2];

Pledged Matched Funding – the additional investment in the project made by funded organisations which is required as a condition of the grant funding.

Accompanying – the additional public, private or third sector funding received or invested which contributed to the achievement of activities within the IDC grant funding.

Aligned – the investment in a technology/research area aligned thematically to, but not directly on, IDC-funded activity.

Follow-on – the investment to take to market, or exploit, outcomes from IDC-funded activity.

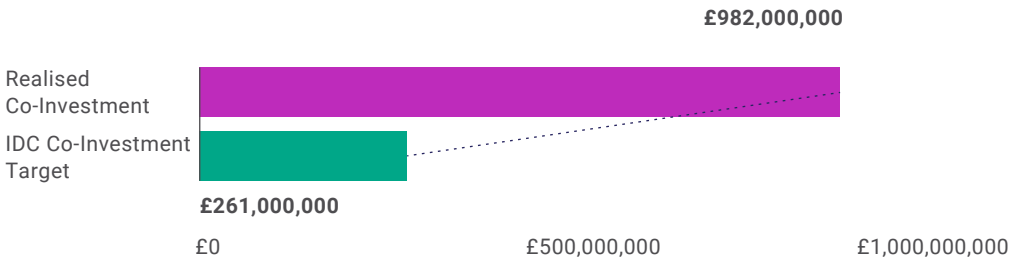
> We are incredibly grateful for the funding provided by UKRI over the past two years as the project has progressed through several stages of Government assessment, culminating in its selection to enter negotiations for business model support. The UKRI funding has been crucial, allowing us to design and develop the world's first commercial scale gas-fired power station with carbon capture. Upon completion, NZT Power will provide enough low carbon electricity to power up to 1.3 million homes per year with up to two million tonnes of CO_2 a year being captured and stored in the process.
>
> **Ian Hunter, Managing Director**
> Net Zero Teesside Power

To date, the IDC has nearly quadrupled its co-investment target of £261 million and generated £982 million of realised co-investment, across of all four areas of co-investment. Realised co-investment represents the actual value of investment made to March 2024.

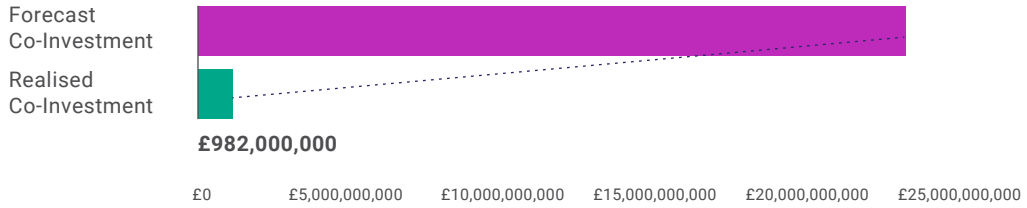
In addition, the projects are forecasting £21.5 billion co-investment that will be realised this decade as the work to build the deployment project infrastructure gets underway. Due to commercial sensitivities, not all forecast co-investment has been shared by the projects therefore the total co-investment generated by the programme is expected to be significantly larger than the reported total.

IDC co-investment target against the realised co-investment to date:

IDC Target and Realised Co-Investment



IDC Realised and Forecast Co-Investment



[2] For further explanation of each area of co-investment please see the Glossary

4.4 Knowledge Sharing

Successful innovation and deployment of carbon capture technology is dependent on industry working together. The IDC programme has demonstrated that the most cost effective and efficient process of decarbonisation is within industrial clusters, in part because this enables collective learnings and knowledge being disseminated widely amongst partners.

From the start of the programme, IDC has worked to ensure that industry works together, sharing knowledge and their experience as they go through this journey together. There should not be a competitive advantage from withholding knowledge: in the same way as good health and safety practices are shared widely and rapidly, lessons learnt as projects are developed and implemented must be shared widely and rapidly, and it is essential to effective deployment that we see sharing of knowledge and learnings right across the industry.

From the start of the IDC, including the bidding stage, IDC projects were made aware that knowledge dissemination throughout the programme and beyond was a key expectation. The legacy of the programme will be the move towards a culture of seamless knowledge exchange across an industry working together to deploy CCS and enabling an effective energy transition and decarbonised industrial base, which underpins the UK economy's journey towards net zero.

An IDC programme of 18 Knowledge Sharing Forums has seen a range of presentations and topics discussed and facilitated knowledge exchange across the UK industrial clusters. Subjects discussed have included Equality Diversity & Inclusion, lessons learnt from the Northern Lights project in Norway, non-amine carbon capture technology and lessons learnt from pilot projects in Canada and North America.

As an example, Humber Zero, an early mover, produced a Technology Selection Report and disseminated their selection process and learnings at events, including the IDC's webinar series. As a result of this event, a non-disclosure agreement was signed by two of the UK's largest emitters Phillips 66 Refinery from the Humber Zero project and Essar's Stanlow Refinery a participant in the HyNet project. Shared learnings within the boundaries of commercial confidentiality and Competition Law have enabled two major industrial players to work together. This is a notable example of innovation funding working, allowing industry to take on risk, and then sharing the lessons learnt to others who will go through this process later. Knowledge sharing enables a more cost effective and efficient decarbonisation decision process.

The IDC has continued to bring the Cluster Plan partners together to continue to collaborate and foster an ongoing culture of knowledge exchange, as well as generating opportunities to bring our deployment projects together with key stakeholders, such as the Health and Safety Executive.

Knowledge sharing is key to enabling successful industry decarbonisation and it remains vital that those in this sector embrace this culture as the market develops over the coming years.

> **The IDC funding has allowed us to conduct process design studies and ground investigations. These have enabled us to de-risk our delivery schedule and ensure that we are in a prime position to deliver for Track 2 of the government's cluster sequencing programme. The funding has really increased our organisational learning and cross industry collaboration to enable us to understand what is important for the individual contributors to the cluster.**
>
> **Andy Underwood, Project Director**
> SSE

5 Beyond the Industrial Decarbonisation Challenge

Of course, the conclusion of the IDC does not signal the end for the IDC funded projects which are all moving towards their next stages of development. The Cluster Plan projects are moving forward in various forms, the deployment projects are progressing into the next phase of development with most forming key projects within the governments' Cluster Sequencing process and IDRIC has secured additional funding from the Engineering and Physical Sciences Research Council (EPSRC) until March 2025.

For the clusters to implement the activities outlined in their plans, entities to manage and monitor progress have been identified and in some cases, new organisations have been established. These entities are continuing to collaborate, sharing knowledge within and between clusters. They are also continuing to engage with government to coordinate and advocate for industrial cluster decarbonisation. Learnings from the cluster plans are also supporting wider development of decarbonisation with the Black Country, as the only in-land cluster in the IDC project portfolio, now sharing learnings with the DESNZ local industrial decarbonisation plans programme (LIDP).

> **The ISCF funding has been critical in enabling the Northern Endurance Partnership (NEP) to move forward at pace. During the two-year funding cycle, the East Coast Cluster was selected as one of the first low-carbon industrial clusters in the UK, three projects have moved into business model negotiations and our Front-End Engineering Design has been completed through multiple UK-based contractors in several separate locations simultaneously. Thank you to UKRI for their confidence in the project and the crucial role the funding has played in its development.**
>
> **Andy Lane, VP H2/CCS**
> UK - bp

The next step for the deployment projects is taking final investment decisions to begin building the infrastructure for the projects. The success of these projects mean that they are the cornerstone of the governments' Cluster Sequencing process[3], with the HyNet and Teesside projects pivotal to Track 1 and the Scotland and Humber projects central to Track 2. The projects within Track 1 aim to be operational by the mid-late 2020's and by 2030 plan to capture a combined 20 million tonnes of CO_2 per annum.

To support the achievement of the UK's industrial decarbonisation objectives, the IDC has also commissioned several reports which are currently in development. These reports focus on important areas that will further support the growing industrial decarbonisation effort post IDC and include: a current state assessment of the Deployment projects, Carbon Capture and Storage Supply Chain, CO_2 Shipping and Non-Pipeline Transport and Carbon Capture as a Service and will be published throughout 2024. Work on Network Models is also underway, which will contribute to the understanding of what is needed to enable a cost-effective and efficient roll-out of CCS for the UK beyond the core emitters on within Industrial cluster networks is also underway to support government strategy development.

The full impacts and outcomes of the IDC will not be seen until industrial decarbonisation infrastructure and technologies are deployed. The earliest final investment decisions (FIDs) are anticipated to occur in Q3 2024. If the most advanced clusters can achieve their industrial decarbonisation goals by the intended dates, the ambition of four low-carbon clusters by 2030 is on-track to be achieved. The IDC has significantly de-risked industrial decarbonisation, however some challenges remain, such as a lack of certainty in ongoing investment which has impacted project confidence, particularly if they were not selected as Track-1 under Cluster Sequencing.

Other challenges include: (i) planning permission and permits; (ii) jobs, skills, and supply chains being ready to meet the demand of industrial decarbonisation; and (iii) the scaling up of low carbon technologies. Whilst the IDC has contributed towards addressing these challenges, further work is needed beyond the IDC to overcome these barriers and allow continued progress towards the UK's 2050 targets.

Beyond providing the funding for these projects, the work of the IDC has supported the overall development of CCUS in the UK by providing a model of collaboration that has brought together organisations, sectors, academic institutions, and Government to work together to de-risk and scale CCUS technology to the brink of deployment. The IDC has provided the foundation for the UK's industrial clusters to decarbonise at scale and to meet the government ambition of four low carbon clusters by 2030 and a net zero cluster by 2040. The key to the next phase of establishing CCUS in the UK will be building on this firm foundation to develop the infrastructure, building the infrastructure, supply chains and knowledge and skills base that will create a globally competitive CCUS market to create jobs, economic growth and forge the path to net zero.

[3] The Ten Point Plan for a Green Industrial Revolution, published in November 2020, included a commitment to deploy carbon capture, use and storage (CCUS) in two industrial clusters by the mid-2020s, then in a further two clusters by 2030. The Track-1 Cluster Sequencing process is the model that was used to select the first two priority clusters and shortlist the CCUS projects (emitters) that would potentially connect to the transport and storage (T&S) infrastructure in the clusters. The process did not award funding; rather it identified the clusters and projects that government would then enter a process of due diligence and a bilateral negotiation with, to develop and agree a package of measures to support the deployment of CCUS. This latter stage is still ongoing at the time of this evaluation and falls outside the scope of this piece of work. Track-1 was split into two, sequential phases: Phase 1 to select the two priority clusters, and Phase 2 to select shortlisted emitter projects. Source; Evaluation of the Track-1 Cluster Sequencing Processes (publishing.service.gov.uk) Evaluation of the Track-1 Cluster Sequencing Processes (publishing.service.gov.uk)The Track-2 process aims to establish two new clusters as part of the further development of CCUS. Source; Cluster sequencing for carbon capture, usage and storage (CCUS): Track-2 - GOV.UK (www.gov.uk)

Benefits of UK Industrial Decarbonisation

Meeting Net Zero Targets

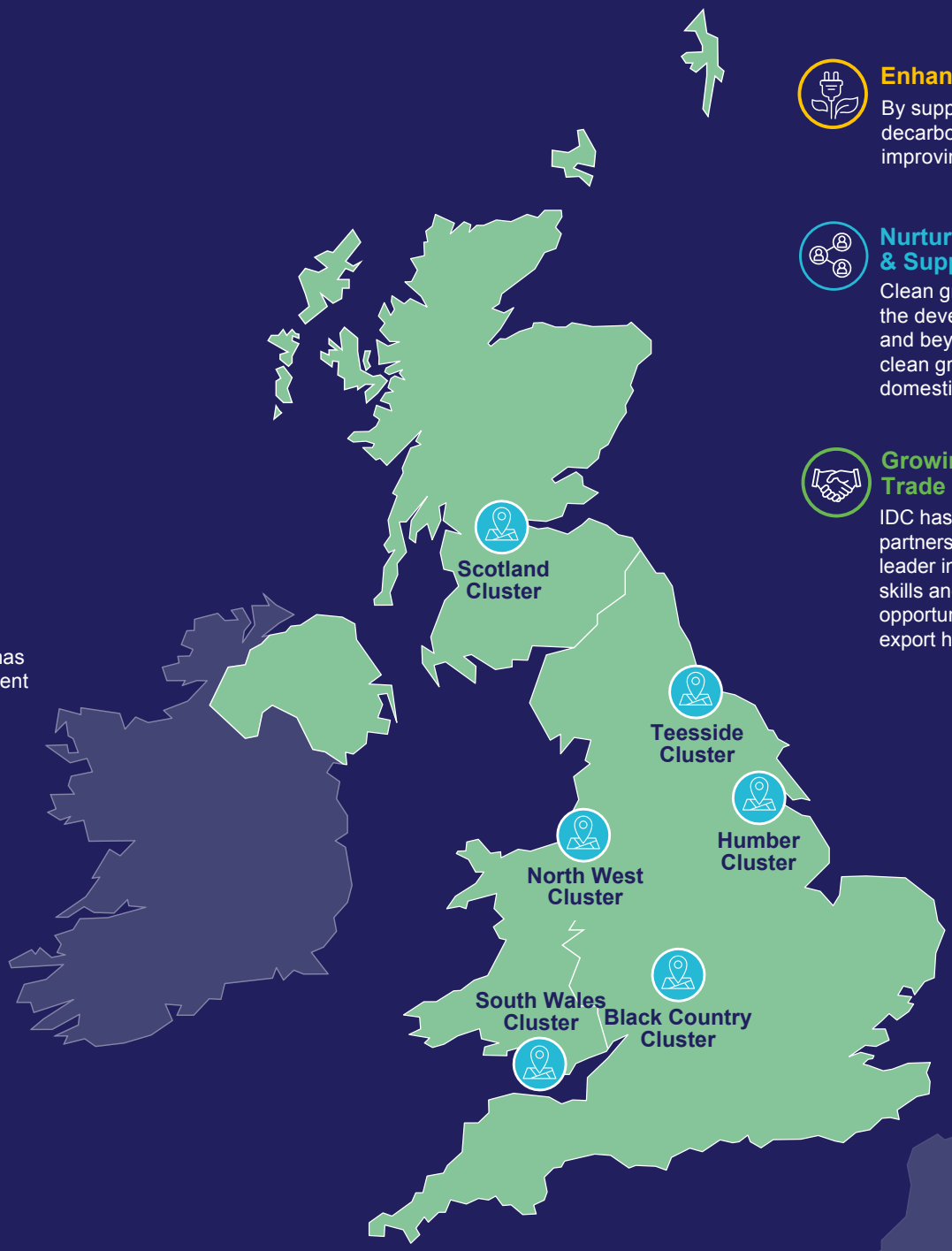
The Industrial Decarbonisation Challenge(IDC) is supporting the UK's six largest industrial clusters to decarbonise at scale, reducing their emissions to meet world-leading net zero targets.

Driving Clean Growth & Inward Investment

Funding of cluster decarbonisation is drawing inward investment to the regions and can provide established British manufacturers with new, clean growth opportunities.

Protecting Jobs & Developing Skills

Without industrial decarbonisation, a growing number of jobs in industry will be at risk. IDC has stimulated retraining and green skill development to underpin a revitalised UK industry.



Enhancing Energy Security

By supporting the development of decarbonised power facilities, the IDC is improving the UK's future energy security.

Nurturing Innovation & Supply Chains

Clean growth within the clusters is stimulating the development of innovative technologies in and beyond the clusters. These provide early, clean growth supply chain opportunities domestically and internationally.

Growing International Trade & Exports

IDC has fostered sharing between industrial partners to enable the UK to become a world leader in industrial decarbonisation to export skills and expertise, alongside longer-term opportunities to import CO_2 for storage or to export hydrogen to Europe.

6 Acknowledgements

The Industrial Decarbonisation Challenge team would like to thank our colleagues in Innovate UK, EPSRC, UKRI and the Department for Energy Security and Net Zero for their support in the delivery of this transformative programme. Additionally, our thanks to all of the businesses and organisations involved in the projects that have contributed to the impact and success of the IDC.

We would also like to thank the Industrial Decarbonisation Challenge Advisory Group for providing invaluable guidance and insights throughout.

7 Abbreviations/Glossary

Accompanying Co-investment	The additional public, private or third sector funding received or invested which contributed to the achievement of activities within the IDC grant funding. This is investment over and above the pledged co-investment which is a condition of grant funding. Examples of accompanying co-investment include funding from a Local Enterprise Partnerships, the Department of Energy Security and Net Zero, other government departments and investment that could not be included in eligible costs for the project
Aligned Co-investment	The investment in a technology/research area aligned thematically to, but not directly on, IDC-funded activity, this could be because of increased confidence in the area created by the policy focus and IDC challenge. For instance, as a result of the IDC, an organisation may have commenced related or supplementary projects of work that have been funded through other private, public or third sector investments
BECCS	Bioenergy with Carbon Capture and Storage
Bioenergy	Energy produced from recently living organisms and typically referring to electricity and gas that is generated from organic matter, known as biomass
Bioenergy with carbon capture and storage (BECCS)	Refers to the process of extracting bioenergy from biomass and capturing and storing the carbon, thereby removing it from the atmosphere
Biomass	Any material of biological origin used as a feedstock for products or as a fuel for bioenergy or biofuels (transport fuels)
Blue hydrogen	Hydrogen produced from natural gas with use of carbon capture and storage
Carbon capture and storage (CCS)	The process of capturing CO_2 from industrial processes, power generation and other sources of CO_2. The captured CO_2 is then stored permanently in disused oil and gas fields or naturally occurring geological storage sites
Carbon capture, utilisation, and storage (CCUS)	The process of capturing CO_2 from industrial processes, power generation, and other sources of CO_2. The captured CO_2 is then either used, for example in chemical processes, or stored permanently in disused oil and gas fields or naturally occurring geological storage sites
CCGT	Combined Cycle Gas Turbines
CCUS	Carbon Capture, Utilisation and Storage
CHP	Combined Heat and Power Plant
Climate Change Committee (CCC)	An independent, statutory body established to advise the UK and devolved governments on emission targets and to report to Parliament on progress made in reducing GHG emissions and preparing for and adapting to the impacts of climate change
Combined cycle gas turbine	Refers to a type of combined cycle power plant commonly used for high efficiency, fast responding electricity generators, typically fuelled with natural gas
Common infrastructure	Infrastructure whose use and benefits are shared amongst more than one user, and which may, or may not, have shared ownership. This includes pipelines for CO_2 transport, hydrogen networks, and power transmission and distribution infrastructure, among others
Decarbonisation	The process of reducing the amount of greenhouse gases, primarily CO_2, released into the atmosphere by a system, asset, or organisation
Dispatchable power	Refers to an electrical power system, such as a power plant, which can adjust its power output to the electrical grid on demand
Dispersed sites	Industrial sites located outside of industrial clusters
East Coast Cluster	Two industrial regions of the UK – Teesside and Humber – situated adjacent to suitable carbon dioxide storage sites in the North Sea
Economies of scale	Economies of scale are cost advantages reaped by companies when production becomes efficient, typically due to large volumes of production
Electrification	Switching from using fuels, such as gas or petroleum, to using electricity

Emitter	Producer of CO_2
Energy from waste	Refers to taking waste and turning it into a useable form of energy, typically electricity
fEC	Full economic cost
FEED	Front End Engineering Design
FID	Final Investment Decision
Follow On Co-investment	The investment to take to market, or exploit, outcomes from IDC-funded activity. This often involves combining the outcomes with other intellectual property and technology to achieve commercial products or services. For instance, following the funding received from the IDC, a company could have taken any industrial decarbonisation related investment decisions that extend beyond the end of the IDC funding that would not otherwise have occurred
Fuel Switching	Transitioning from carbon intensive fuels to low or zero carbon alternatives
Green hydrogen	Hydrogen produced from electrolysis with renewable electricity
Greenhouse gas emissions (GHG)	Addition to the atmosphere of gases that are a cause of global warming, including CO_2, methane, and others as set out in the Kyoto Protocoliv
Gross Value Added (GVA)	Value generated by any unit engaged in the production of goods and services
Industrial Cluster	Places where related industries are co-located. Clustered industrial sectors tend to be those that require energy-intensive manufacturing processes, specifically: chemicals, glass, oil refining, paper and pulp, and iron and steel
LIDP	Local Industrial Decarbonisation Plans: an approximately £6 million in Department for Energy Security and Net Zero (DESNZ) funding towards development of plans to decarbonise local cluster
MTPA	Million tonnes per year
Mt	Megatonne (1 million tonnes)
National Atmospheric Emissions Inventory-UK (NAEI)	The NAEI estimates annual pollution emissions for most pollutants, from 1970 to the most current publication, for the UK
Negative emissions	Achieved by removing more GHGs from the atmosphere, for example, through direct air capture or bio-energy production with carbon capture
Net zero	Refers to the balance between the amount of GHG that is produced and the amount that is removed from the atmosphere within a given boundary
Offtakers	Party that will buy the product produced
Pledged Matched Funding	The additional investment in the project made by funded organisations which is required as a condition of the grant funding
Post-combustion CCS	A method of collecting CO_2 emissions that are produced from the burning of fossil fuels
Renewable energy	Energy that is collected from resources which are naturally replaced in human timescales such as sunlight, wind, rain, tides, and waves
Track 1	The DESNZ Track-1 Cluster Sequencing process is the model that was used to select the first two priority clusters in which to deploy carbon capture and storage, including shortlisting CCUS projects that would potentially connect to the transport and storage infrastructure in the clusters
Track 2	The Track-2 Cluster Sequencing process aims to establish 2 new clusters as part of the further development of CCUS
TWh	Terawatt Hour

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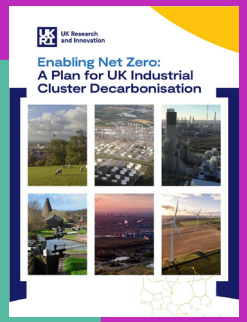
Find out more: **Industrial Decarbonisation – UKRI**

Enabling Net Zero Report: A Plan for UK Industrial Cluster Decarbonisation



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Enabling net zero: a plan for UK industrial cluster decarbonisation