



**TEES
VALLEY**

Tees Valley Net Zero

Cluster Plan Key Findings

The Roadmap to Net Zero 2040 for
the Tees Valley Industrial Cluster



INTRODUCTION



The Tees Valley Net Zero Cluster Plan sets out how we will deliver the world's first Net Zero industrial cluster by 2040, securing economic growth and tens of thousands of new green jobs.

This is the cumulation of the Stage 1 and 2 projects funded since 2019 by the UK government's Industrial Decarbonisation Challenge. It builds on the Tees Valley's 2022 Net Zero Strategy by providing a roadmap to industrial decarbonisation.

The Tees Valley industrial cluster is the best placed industrial region in the UK to deliver deep decarbonisation due to its concentration of industry, location, North Sea access, legacy of the integrated chemical works and the infrastructure that provides, and Teesworks – the site of the former Redcar steelworks which is being redeveloped for the new decarbonised industries.

The Tees Valley industrial Cluster currently emits up to 4.6 Mt of CO₂ each year. This is the 'Scope 1' CO₂ that is passed directly to the atmosphere by burning fossil fuels to generate heat, power and in other industrial processes.

The Cluster Plan demonstrates how this can be reduced to Net Zero by 2040. It also shows how industrial decarbonisation will be a catalyst for growth in the region and, with the new industries coming to the region – decarbonised power, hydrogen production and circular economy fuels – the CO₂ abated will be much higher.

The anchor project for decarbonisation in the Tees Valley industrial cluster will be the Net Zero Teesside (NZT) carbon capture and storage scheme. Part of the East Coast Cluster and enabled by the Northern Endurance Partnership CO₂ Transportation and Storage network, this will enable the transport of up to 10 MtCO₂/yr of CO₂ to be captured and stored in saline aquifers and depleted reservoirs deep below the North Sea.

The Cluster Plan demonstrates how low carbon technologies deployed in the Tees Valley can achieve Net Zero in our industrial cluster by 2040 and support decarbonisation across the rest of the UK economy, with new fuels such as hydrogen, Sustainable Aviation Fuel (SAF) and rDME (a low-carbon LPG replacement).

FOREWORD

The Tees Valley Net Zero cluster plan project team has worked with over 40 industrial emitters in the region to create an impressive vision to achieve Net Zero by 2040.

The project has worked over the past two years to deliver a route for decarbonisation and identify the associated infrastructure requirements.

This is one of six projects receiving funding from UKRI's Industrial Decarbonisation Challenge to deliver a regional plan for decarbonisation. The Tees Valley industrial cluster represents a number of carbon-intensive industries over a compact geographical area with a strong industrial heritage, and the region includes the Net Zero Teesside project and the Northern Endurance Partnership (for geological storage of CO₂). The plan highlights future opportunities to expand upon the decarbonisation efforts of these major infrastructure projects in the wider region.

It is a pleasure to see the hard work of all those involved in the Tees Valley Net Zero Cluster Plan recognised in this report. The project team has taken a wide-ranging view of industrial decarbonisation whilst remaining focused on the societal and regional benefits which could be delivered in the Tees Valley.

The Cluster Plan report highlights the scale of the opportunity and the importance of decarbonisation in the Tees Valley, and is a significant step in the region's progress toward Net Zero.



**Bryony Livesey, UKRI
Challenge Director,
Industrial Decarbonisation**

The Cluster Plan - At a Glance

The Cluster Plan has been informed by and developed from 17 separate studies carried out by the project partners – bp, NEPIC and Tees Valley Combined Authority – and supporting organisations.

Much of this work has been developed from data provided by the 46 Tees Valley industrial companies included in the study. These are the key industries that have an impact on industrial decarbonisation and they include:

- Net Zero Teesside project, a single development comprising Northern Endurance Partnership (NEP) CO₂ transportation and storage system and NZT Power – gas-fired power plant with carbon capture capabilities
- The current and future CO₂ emitting industries
- Infrastructure companies
- Technology providers
- Future decarbonised power stations with pre-and post-combustion carbon capture
- Future low-carbon hydrogen producers
- Future Energy from Waste plants
- Future circular economy industries making renewable fuels and chemicals
- The existing and new industries that will provide the demand-side economy for renewable electricity, hydrogen and other products in the industrial cluster

Key Findings

The Key Findings for the Tees Valley Net Zero Cluster Plan presented in this report are:

- **2030:** The Cluster will store 100% of the 2020 baseline emissions becoming a **low-Carbon Cluster**
- **2040:** The Cluster will be the first **Net Zero industrial cluster** storing up to 10 MtCO₂/yr equivalent to 180% of the 2020 baseline emissions
- More than **£10 billion invested in industrial decarbonisation**. This is the baseline – not the projected maximum
- More than **£34 billion in cumulative additional GVA** by 2040
- Up to **30,000 new jobs** if all plans are realised

Our Roadmap to Decarbonisation – The Cluster Plan Actions at a Glance

A United Voice for the Cluster – 2023

We have set up a new industry group for the Tees Valley industrial cluster with the specific aim of ensuring that Net Zero will be achieved in the cluster.

Carbon Accounting – 2023-2025 & onwards

We will use the Carbon Accounting methodology that we have developed in the Cluster Plan to provide a definitive measure of Net Zero in the Cluster.

Carbon Capture Utilisation and Storage – Online 2027-2030

We will continue to work with and support the Net Zero Teesside, Northern Endurance Partnership and East Coast Cluster CCS projects.

Low Carbon Hydrogen – Industrial Scale Production – 2027-2030

We will work with, support and promote all sectors of the hydrogen economy, building on the existing hydrogen production and infrastructure in the Tees Valley, enabling the new hydrogen supply/demand economy and creating a centre for industrial scale low-carbon hydrogen production.

Infrastructure & Planning – 2023-2030

We will work with key infrastructure partners including Northern Powergrid and Northern Gas Networks to maximise the benefits of cluster decarbonisation and tackle systemic barriers.

Renewable & Sustainable Fuels – Energy from Waste & Circular Economy 2023-2027

We develop a Tees Valley green fuels sector, helping create the right conditions for investment in technologies including Sustainable Aviation Fuel, rDME (LPG replacement), and others.

National Coordination – 2023 onwards

We will continue to work with key national partners including government Departments, the Carbon Capture and Storage Association, the Multi-Cluster Forum to drive decarbonisation in the Tees Valley cluster and share best practice.

The Cluster Plan is Presented in Four Thematic Lines

The full report for the Cluster Plan that accompanies this Key Findings document describes how we have used the data provided by the industrial cluster companies to develop the Cluster Plan on four thematic lines.

1 Decarbonisation in the Tees Valley industrial cluster

- Introduction
- Tees Valley Industrials Case Studies
- National Policy Overview
- Net Zero Teesside – CCS and the CO₂ gas gathering network
- Mapping the Cluster Plan to UN Sustainable Development Goals

2 Net Zero Planning

- The Cluster Model – Scope 1 CO₂ emissions reduction and the Net Zero balance
- Tees Valley Industrial Cluster Systems Model – a tool for maximising the benefit of the Tees Valley cluster's inherent integration
- Carbon Accounting – GHG Protocol with Life Cycle Analysis showing the wider value of Scope 1/2/3 emissions reduction

3 Societal & Regional Benefit

- Economic impact assessments
- The “Policy Off” scenario” what happens if we do not adopt industrial decarbonisation
- The “Limited Policy On” and “Full Policy On” scenarios - the benefits of adopting different degrees of industrial decarbonisation
- Barriers to decarbonisation
- Jobs & GVA
- Skills and workforce planning

4 Enablers & Future Opportunities

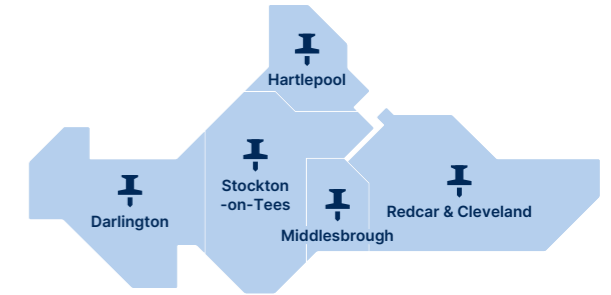
- Infrastructure requirements I - electricity
- Infrastructure requirements II - hydrogen
- The future opportunity for CCS and CO₂ storage
- Shipping Industrial Gases I - importing CO₂ by sea
- Shipping Industrial Gases II - exporting hydrogen
- Circular economy fuels and Energy from Waste



Key Project Names & Glossary

What we mean when we talk about the Tees Valley and Teesside:

- **Tees Valley** – This is a political boundary which refers to the area covered by the Tees Valley Combined Authority, which covers the Local Authority areas of Darlington, Hartlepool, Middlesbrough, Redcar & Cleveland and Stockton-on-Tees
- **Teesside** – This is the name in general use for the areas which border the River Tees: Middlesbrough, Redcar & Cleveland, and Stockton-on-Tees.



This is the Cluster Plan project that we are reporting on in this document. It is the work to develop the roadmap to Net Zero 2040 in the Tees Valley industrial cluster.



The Tees Valley Net Zero project has been completed by bp, NEPIC and TVCA.



This is the project to develop the carbon capture and storage system for the Tees Valley industrial cluster. It will comprise a power station with carbon capture, the CO₂ gas gathering network and pipeline to the Northern Endurance Partnership store.



This will be the world's first commercial scale gas-fired power station with carbon capture capabilities, and will serve as the anchor project in Teesside that will connect into the CO₂ transportation and storage infrastructure being developed by the Northern Endurance Partnership.



This is the CO₂ transportation and storage company which will deliver the onshore and offshore infrastructure needed to transport CO₂ from a range of emitters across Teesside and the Humber to offshore storage, starting with the Endurance store under the southern North Sea.



Net Zero Teesside and Zero Carbon Humber (ZCH) together form the East Coast Cluster, enabled by the Northern Endurance Partnership CO₂ transportation and storage infrastructure. It is the CO₂ Transportation and Storage company for the Tees Valley and Humber industrial clusters. Now selected as one of the first two carbon capture, usage and storage clusters to be taken forward by the UK government.

The Tees Valley Industrial Cluster

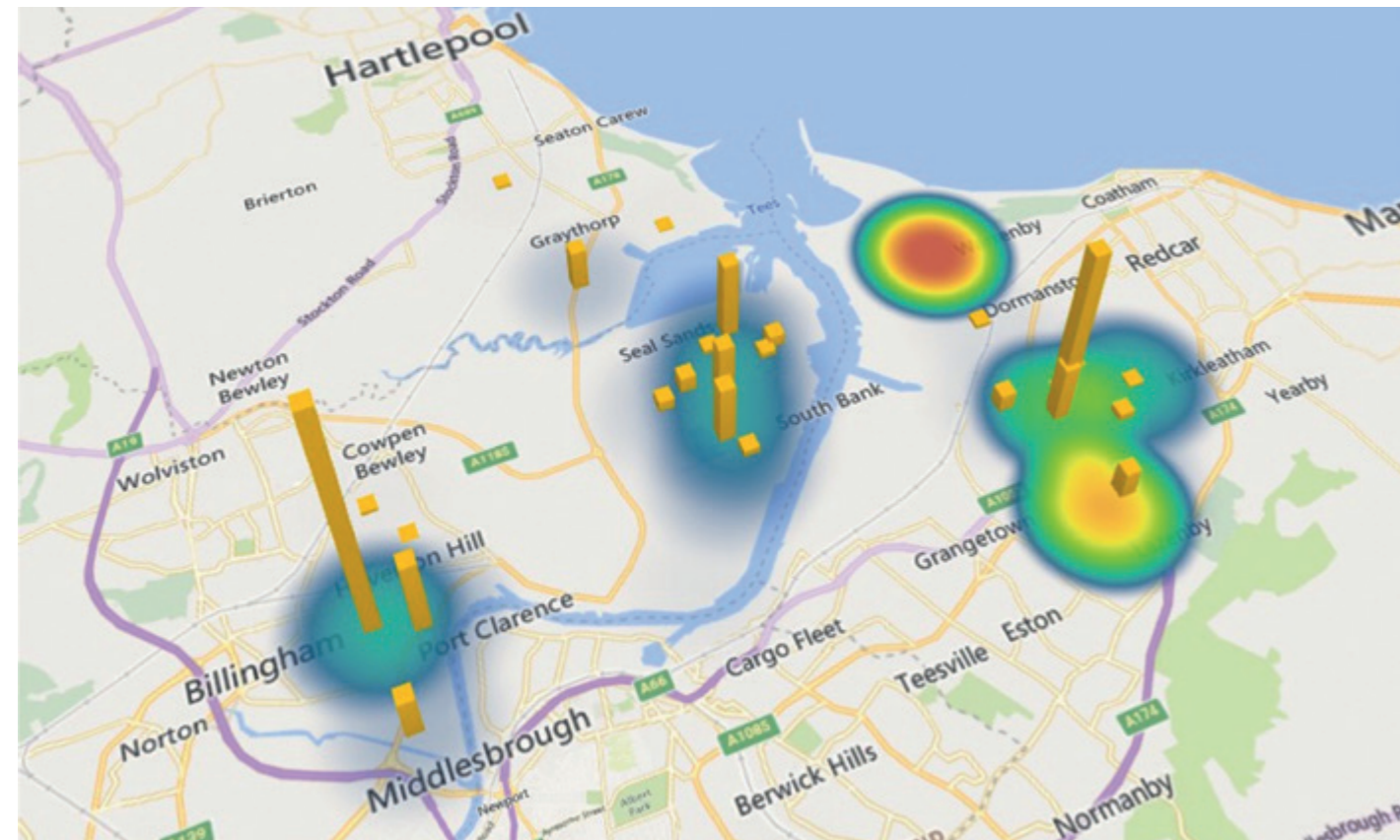
The Tees Valley industrial cluster is the most concentrated pocket of industry in the UK – there are more than 60 industries all within a five-mile radius of the centre. Around 46 of these are existing businesses, or new industries in planning, that have an impact on deep decarbonisation. They include:

- **The Net Zero Teesside (NZT) carbon capture and storage system, currently under development**
- **Industrial CO₂ emitters – chemical industries and manufacturing**
- **Power stations – including bio-energy and nuclear**
- **Renewables – wind and solar**
- **E-fuels – bio-ethanol and bio-diesel**
- **Energy from Waste**
- **Circular economy fuels**

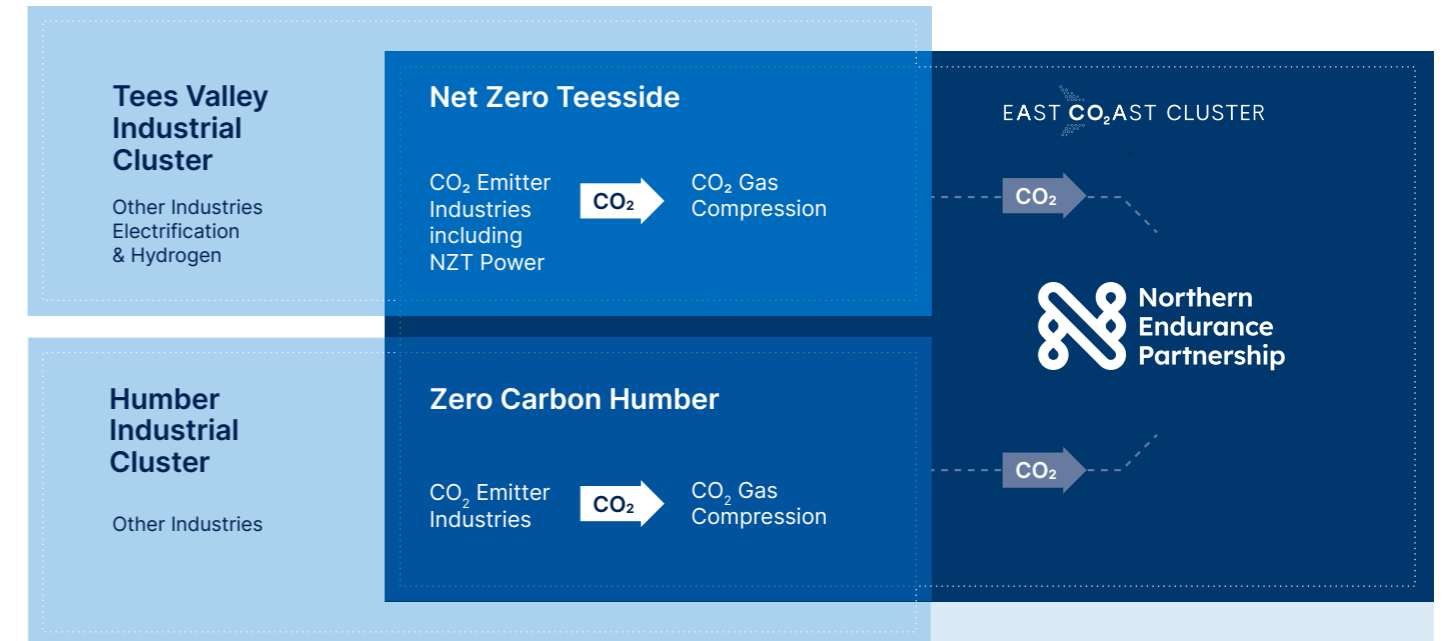
The plot shows CO₂ emissions taken from the UK National Atmospheric Emissions Inventory 2020 data. The contours show maximum historic emissions and highlight the impact of the Teesside Integrated Iron and Steelworks at Redcar. The columns show 2020 emissions - the Steelworks is no longer present and the industrial cluster's emissions are centred on Wilton, North Tees and Billingham.

The Tees Valley is uniquely placed in the UK to achieve deep decarbonisation.

- We are located at the centre of the UK with road, rail, airport and sea access
- We are perfectly positioned to access CO₂ geological storage such as the Northern Endurance Partnership CO₂ store
- Deep water port access provides access to national and international trade – it enables the chemical industry in the cluster. In the future it will enable the import and export of industrial gases such as CO₂ (potential future import for long-term storage helping to decarbonise other regions) and hydrogen (which in the future will be exported as a fuel to decarbonise industry, transport and domestic heating across the UK)
- The Teesside Freeport provides investment incentives and tax-efficient import of goods for manufacture on Teesside and export of finished products
- The legacy of the UK's first modern integrated chemical works provides the infrastructure and interconnectedness for industries to thrive
- The Teesworks site provides the brownfield site, services and opportunity for a host of new businesses – led by the flagship Net Zero Teesside project



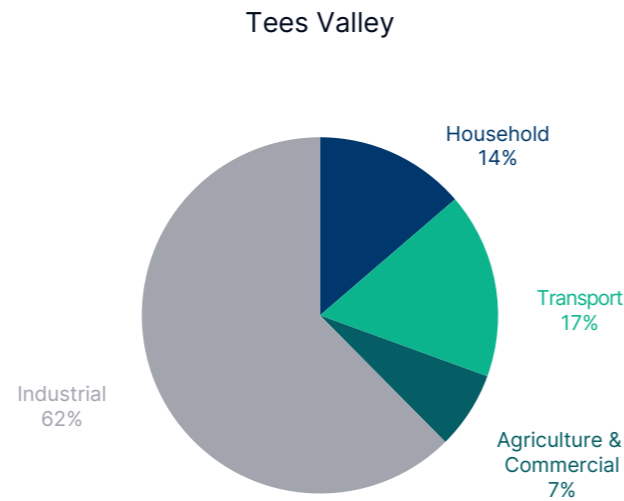
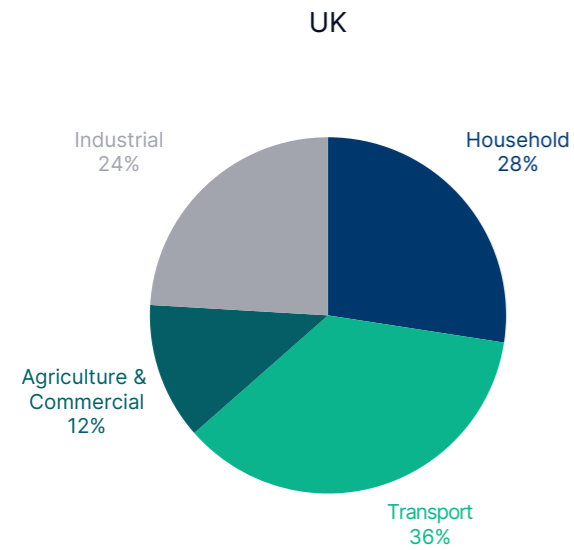
Net Zero Teesside is the anchor project for decarbonisation in the Tees Valley industrial cluster. The Tees Valley industrial cluster, and our cluster plan, also include non-CO₂ emitter industries, and companies fuel switching to hydrogen or electrification. The Humber industrial cluster is a separate grouping that is also served by the NEP CO₂ transportation and storage project.



The Cluster Plan recognises that deep decarbonisation is not just the remit of a select few companies. Many industries in the Tees Valley will have an impact on decarbonisation and we worked with 46 separate industrials to develop the plan. Of these, 31 were able to provide detailed data on their operations, emissions and decarbonisation planning. Together these have provided a highly detailed data set for the cluster which we have leveraged for our decarbonisation planning.

This shows a high level of engagement across the industries in our cluster, which recognises the cluster's widely held commitment to Net Zero and the sense of community in the cluster.

In the journey to Net Zero, decarbonising industry is key to decarbonising the Tees Valley as a whole. Across the UK, 24% of total CO₂ emissions are due to industry. Locally industry accounts for 64% of the total CO₂ emissions. There are 6.40 tCO₂/yr emitted per person compared with the national average of 1.24 tCO₂/yr. This demonstrates the importance of industrial decarbonisation here.



The Challenge

The UK

In the Climate Change Act (2008) the UK has set into law that the country must reach Net Zero by 2050. Industrial clusters around the UK are relatively easy to abate due to their concentration of CO₂ emitters. They also provide much of the power, fuels and goods that will help the rest of the UK meet the Net Zero 2050 target. The Industrial Decarbonisation Challenge* is the enabler for the Tees Valley Cluster Plan and through this the Tees Valley is set to become a low-carbon industrial cluster by 2030 and world's first Net Zero cluster by 2040.

Removing the CO₂ Scope 1 Emissions

Up to 4.6 MtCO₂/yr is currently emitted by the Tees Valley industrial cluster. These are Scope 1 Greenhouse Gas (GHG) emissions – i.e. CO₂ released from the direct burning of fossil fuels. In the Tees Valley most of these CO₂ emissions are from chemical processes, and electricity and heat generation to power chemical processes.

In the recent past, our CO₂ emissions were substantially higher at around 15 MtCO₂/yr. The closure of the Teesside power station and the loss of the steelworks resulted in large drops in CO₂ emissions. However, this deindustrialisation, is not decarbonisation, and has a negative impact on the local economy. The CO₂ emissions from these industries still exist – the steel and power are produced elsewhere, and the CO₂ is still released to atmosphere. The greatest challenge in deep decarbonisation is to ensure economically viable decarbonised industries remain and there is a positive impact on the local economy.

CO₂ produced as a by-product in chemical processes is a commodity – it is used in the nuclear industry as a coolant; in food production and packaging; and in carbonated drinks. Much of the CO₂ produced in the Tees Valley as by-products from industrial processes is already captured and utilised in this way – this is Carbon Capture and Utilisation, or CCU.

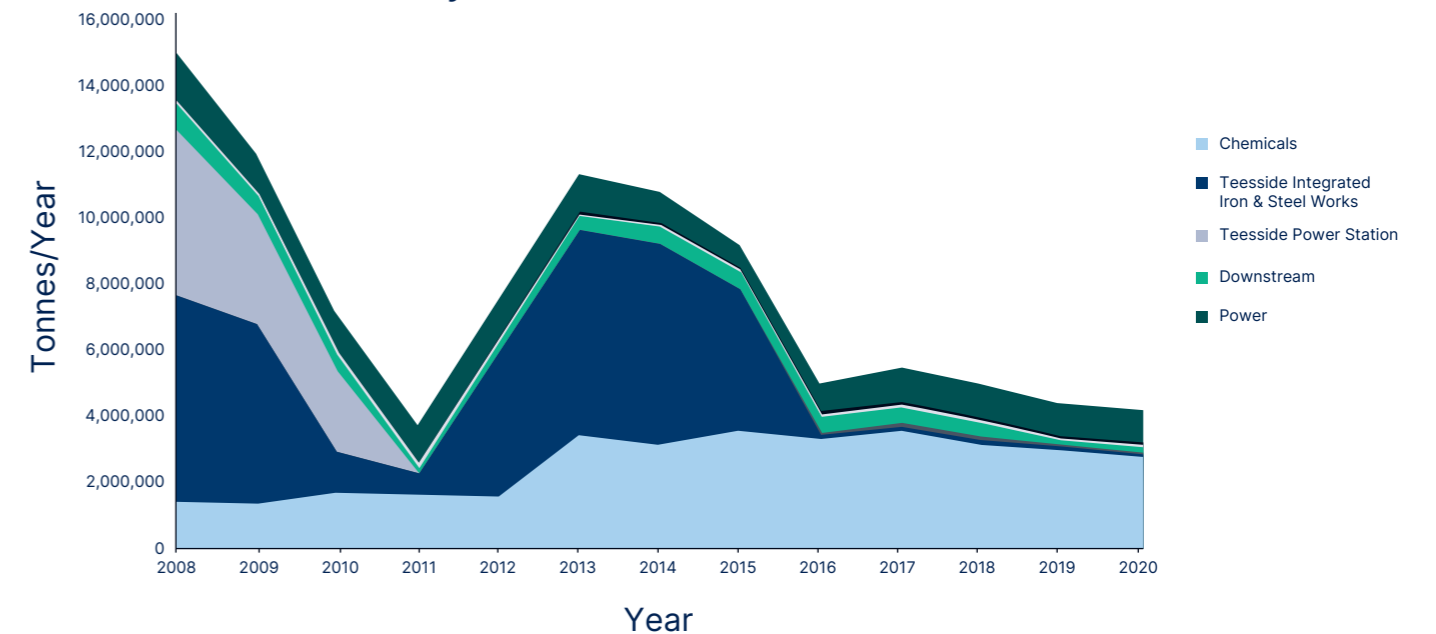
Net Zero Teesside - Carbon Capture and Storage (CCS)

Net Zero Teesside is the anchor project in the Tees Valley for deep decarbonisation. This is comprised of the NZT Power project and the NEP CO₂ transportation and storage system.

- The NZT Power project is a Combined-Cycle Gas Turbine (CCGT) power station with carbon capture, producing up to 860MW of flexible low carbon electricity.
- The Northern Endurance Partnership system will gather CO₂ in a gas network stretching across Teesside. The CO₂ will be compressed and transported in a subsea pipeline over 145km to the Endurance CO₂ store in the southern North Sea. There, CO₂ will be injected into a saline aquifer 1km below the seabed for permanent storage.

Collectively, the NEP system and emitters across the Tees Valley and the Humber make up the East Coast Cluster, one of the first two clusters in the UK to be selected by the government to develop carbon capture and storage. Together, the Tees Valley and Humber industrial clusters represent around 50% of the UK's industrial cluster emissions. NEP will receive up to 10 MtCO₂/yr from the Tees Valley and 17 MtCO₂/yr from the Humber.

Tees Valley industrial cluster - historic emissions



The Challenge (Cont'd)

Scenario Planning – The Cluster Model

The Tees Valley industrial cluster is made up of a small number of large CO₂ emitters and a large number of small emitters. Currently the large emitters include chemical works, power and heat (steam) generation and waste processing and recovery. Bio-energy also generates large CO₂ emissions but this is not included in the Scope 1 total as these emissions are not due to combustion of fossil fuels. Capturing the emissions from bio-energy can provide “negative emissions” which are vital in establishing Net Zero in the industrial cluster to offset residual CO₂ emissions which cannot be captured and stored.

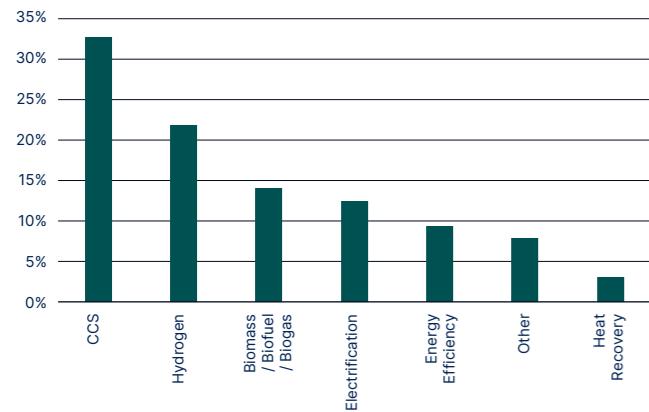
The data provided by the industries in the cluster show that 32% of the potential decarbonisation pathways will require CCS – this includes both capture of biogenic and non-biogenic emissions.

Fuel switching to hydrogen, biomass/biofuel/biogas, and electricity are the next three largest fractions of technology options. Though it's important to remember that the bulk of the hydrogen available will be “blue” hydrogen – i.e. steam methane reformed hydrogen produced from natural gas with CCS to remove the CO₂ by-product. Also, much of the electricity available in the cluster will be provided by new power stations with pre- and post-combustion CCS.

This means that 53 – 65% of the decarbonisation pathways in the Tees Valley industrial cluster will be reliant on CCS in some way.

Our cluster decarbonisation model looks at both the technological opportunity for decarbonisation and the probability that the decarbonisation technologies will be implemented. The probabilities have been assigned by the industrials themselves based on their current understanding of the drivers affecting their business: carbon taxes; markets; corporate policy; and technology availability. This allows us to look at and plan for many pathways to deep decarbonisation.

Percentage of pathways of particular technology



The modelling shows that by 2040 the cluster could be capturing 8.4 MtCO₂/yr of Scope 1 CO₂ emissions for storage in the Net Zero Teesside CCS system. These are the CO₂ emissions from burning fossil fuels for power and heat and those released from chemical processes.

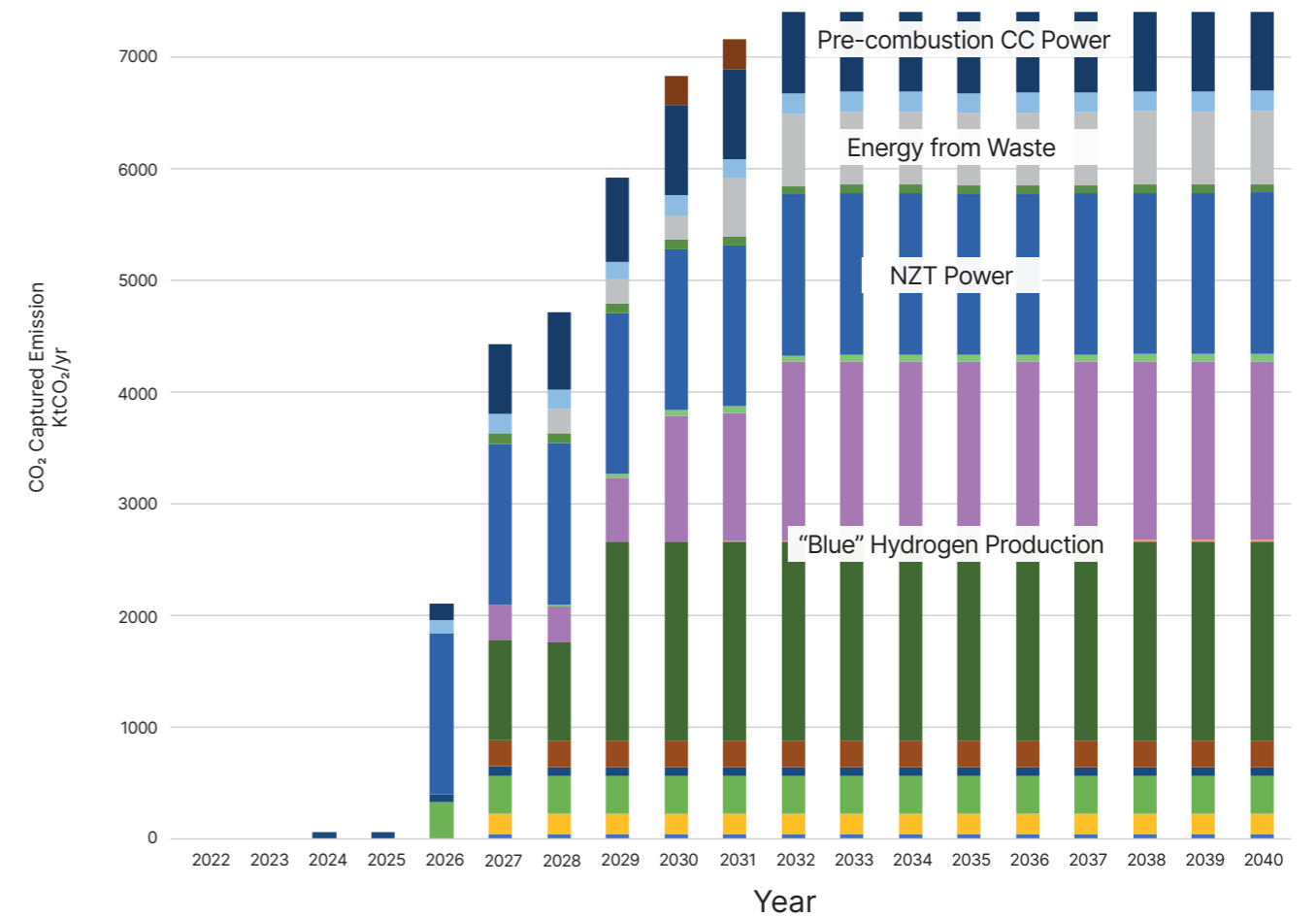
Comparing the captured Scope 1 emissions with the current baseline of 4.6 MtCO₂/yr shows that by 2040 the industrial cluster will capture over 180% of the baseline emissions.

Plot shows the industries with the major contributions to Scope 1 CO₂ emissions that can be captured and stored in the Net Zero Teesside system. The different colour bands indicate different industrials.

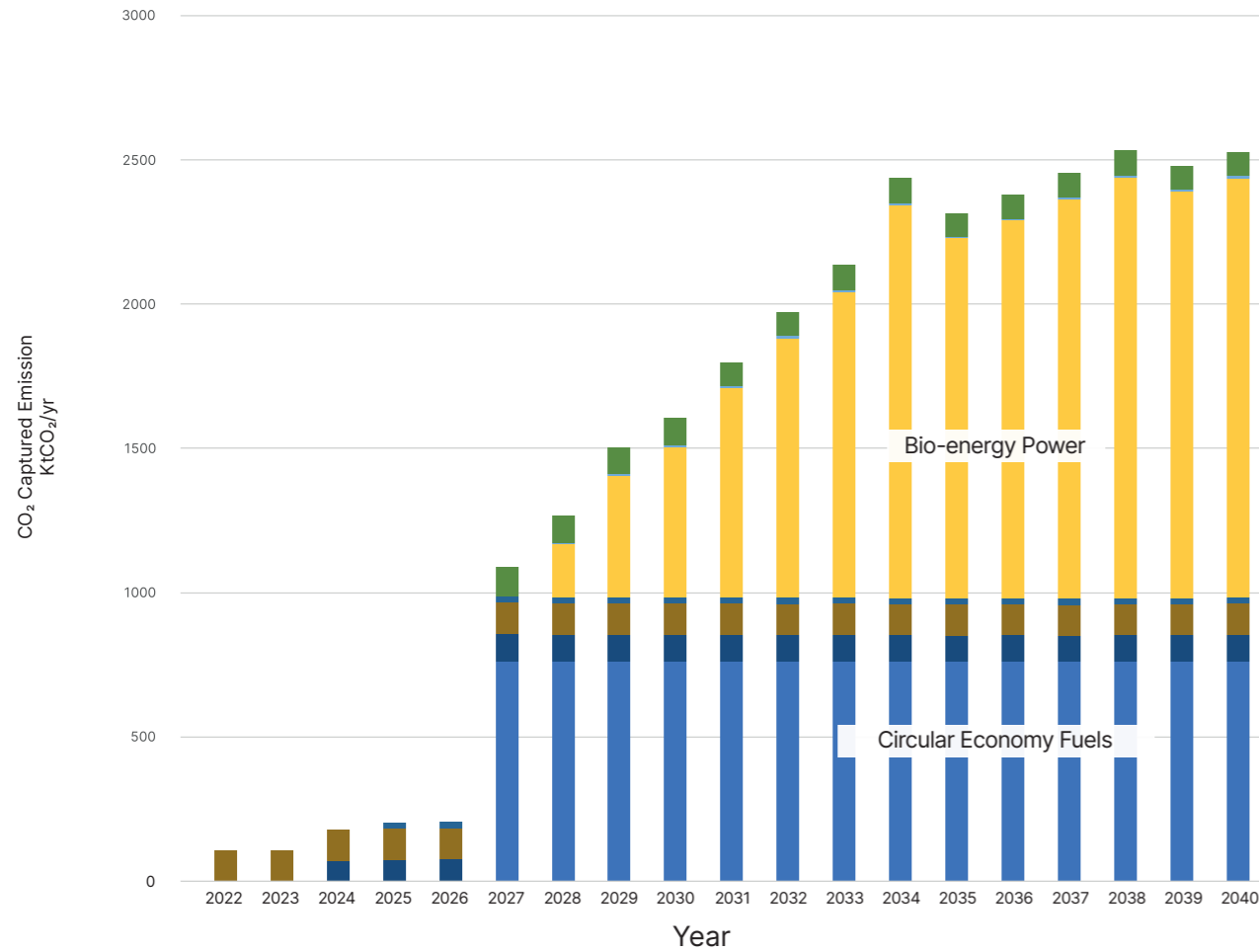
Between then, the two blue hydrogen projects account for nearly 50% of these emissions. This demonstrates how the Net Zero Teesside CCS enables new decarbonised industries in the Tees Valley.



Fossil Fuel Derived (Scope 1) CO₂ Captured



Biogenic Derived (non-Scope 1) CO₂ Captured



Decarbonisation technologies are not 100% efficient and other industries will not be able to decarbonise. The residual CO₂ emissions from these industries could be up to 1.5 MtCO₂/yr.

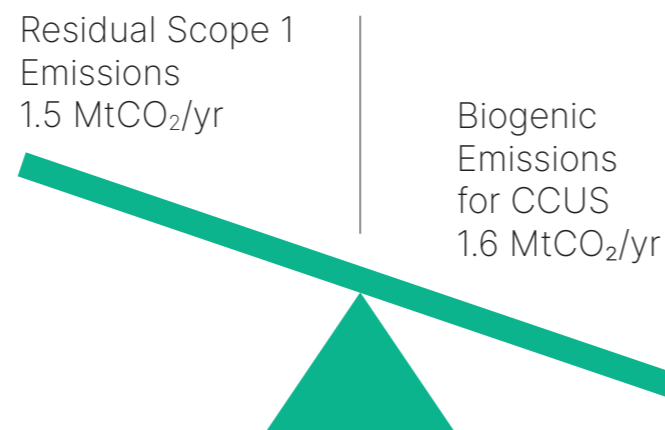
However, the cluster also has bio-energy power and circular economy chemical and fuels production. CO₂ emissions from these have a high biogenic content and a large potential for negative emissions. Up to 2.7 MtCO₂/yr of CO₂ from these biogenic sources will be available for capture and storage. Storing CO₂ with biogenic origin effectively removes CO₂ from the atmosphere creating the “negative emissions” and can potentially more than offset the residual Scope 1 CO₂ emissions.

The Net Zero Teesside CO₂ pipeline is being designed to transport and store 10 MtCO₂/yr. Our analysis shows that if 8.4 MtCO₂/yr of the capacity is from Scope 1 CO₂ emissions, then the remaining 1.6 MtCO₂/yr capacity can be taken by captured CO₂ of biogenic origin.

This balances the 1.5 MtCO₂/yr residual Scope 1 CO₂ emissions and ensures the industrial cluster meets Net Zero.

Headlines - The Tees Valley industrial cluster will:

- 2030 – Capture and store CO₂ volumes equivalent to our current industrial cluster’s emissions
- 2030 – Become a low-carbon cluster by 2030
- 2040 – Become the world’s first Net Zero integrated industrial cluster
- 2040 – Capture and store 180% of the 2020 baseline CO₂ emissions



The Opportunity

The Case for Growth

Decarbonisation is an opportunity for economic growth – supporting the government’s policies on Net Zero, levelling up and energy security.

The “green” chemicals, steel and fuels made in the Tees Valley will be exported outside of the region to help decarbonise the rest of the country in the drive for the whole UK economy to reach Net Zero by 2050.

The Tees Valley provides all the conditions needed to maximise the opportunity presented by decarbonised industry. The three principal components for a decarbonised industrial cluster – CCS, hydrogen and decarbonised electricity generation – will soon be in place. The infrastructure to integrate these facilities is present and being enhanced.

CCS – Driving Inward Investment

The success of Net Zero Teesside is driving inward investment to the region. The storage capacity it will provide – 10 MtCO₂/yr – is more than double the current CO₂ emissions of the Tees Valley industrial cluster.

This has created the opportunity for new industries to come to the region, where their ambition is to capture and store CO₂ emissions. These include CCGT power stations with pre- and post-combustion carbon capture; Energy from Waste; and circular economy fuels from waste.

Fuelling the Future

Energy from Waste: Waste is an important commodity with waste incineration combined with CCS providing clean electricity. CO₂ captured from waste that contains biogenic materials will provide negative CO₂ emissions. The Tees Valley Cluster plan includes three new Energy from Waste plants and there are additional opportunities to apply CCS to existing EfW, increasing our generation of clean electricity.

Biofuels: The Tees Valley is a leader in bio-fuel production – industrials in the cluster already produce bio-ethanol and bio-diesel which provide the E10 and B7 green fuel content to forecourt petrol and diesel mandated by the government

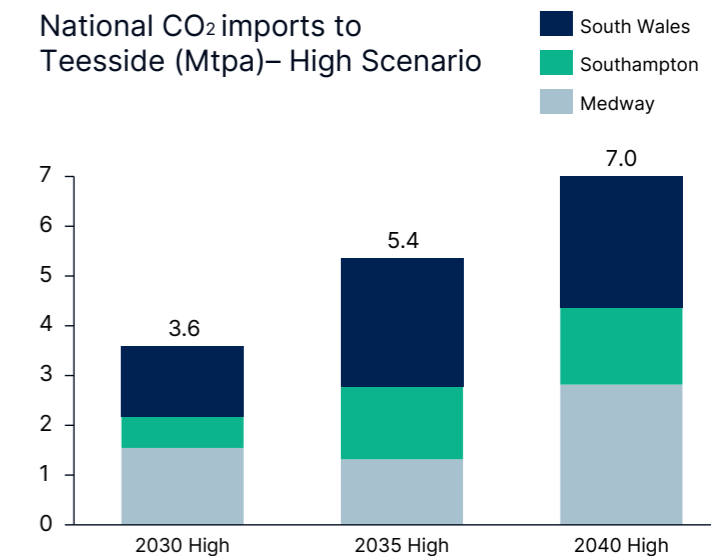
Fuels from Waste: The Tees Valley industrial cluster provides the infrastructure to attract new industries using waste to produce green fuels. Alfanar is developing its Lighthouse Green Fuels project which will produce 2200 bbl/day of Sustainable Aviation Fuel and 1000 bbl/day of green naphtha. Circular Fuels Ltd is developing its rDME production plant – rDME is a drop-in replacement fuel for cylinder gas and LPG and will enable decarbonisation of off-grid properties.

Enabling Net Zero Across the UK

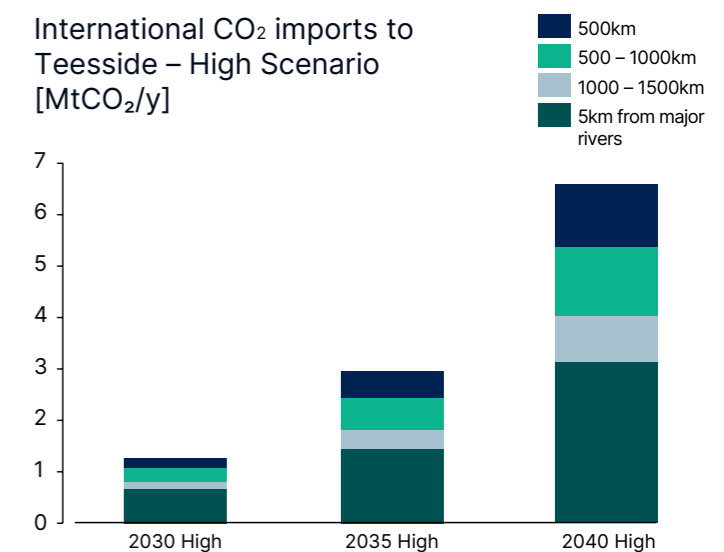
Our Cluster Plan has looked at the wider benefit that the Tees Valley can provide in helping to decarbonise industrial regions outside the region. We have carried out feasibility studies looking at the potential for importing CO₂ from outside the cluster for storage and which industrial regions in the UK may need the Tees Valley to export low-carbon hydrogen to them.

By 2040, up to 7 MtCO₂/yr could be shipped to the Tees Valley from industrial and power sector emitters, with potential contributions from the Solent, South Wales and the Medway. Imports of CO₂ from Europe could reach up to 6.6 MtCO₂/year by 2040. The highest share of these potential imports is from industrial clusters in Germany, located within 5km of the Rhine. Although there is some uncertainty on the scale of uptake of CCS in the UK and Europe due to development of alternative decarbonisation options, the analysis highlights areas for future potential development. Focusing on these now and planning for these imports will help to unlock these opportunities.

National CO₂ imports to Teesside (Mtpa)– High Scenario



International CO₂ imports to Teesside – High Scenario [MtCO₂/y]



Hydrogen

The Tees Valley will be a centre for industrial scale low-carbon hydrogen production. Industrials in the Tees Valley already produce 50% of the UK's commercially available hydrogen. To enable the new low-carbon hydrogen economy it will be important to move rapidly to producing hydrogen at scale.

- This will be enabled by the two Steam Methane Reformed (SMR) or Autothermal Reformed (ATR) "blue" hydrogen projects – bp's H2 Teesside and Kellas Midstream's H2 Northeast – each capable of delivering 1 GW volumes of hydrogen.
- Electrolytic – or "green" hydrogen is also under development by bp, EDF and Protium. These are currently planned combined output of 200 MWe, with the potential for expansion between them to over 1 GW of hydrogen production.
- As the availability of renewable electricity increases, green hydrogen production will increase.

Together, the proposed hydrogen production projects in the Tees Valley could see up to 2.5 GW of hydrogen production capacity by 2030. This represents a quarter of the government's ambition for 10 GW.

Deploying the New Hydrogen Economy

The analysis we have carried out in the Cluster Plan has provided a range of insights which are valuable for deploying the new hydrogen economy – some selected points of this taken from the full report include:

Social

- The Tees Valley supports many workers in carbon intensive sectors providing opportunities for education, training and employment. This should be matched or surpassed by employment opportunities in Hydrogen. Highly trained individuals will seek equivalent employment and a premium salary to re-train

Technological

- Whole system integration between technology components is a key consideration to enable reliable and efficient technology
- Accessible and scalable hydrogen infrastructure is key to attracting new industry to Tees Valley and securing future industrial demand
- The interactions between groups of different energy consumers – industry, transport, domestic heating – is key to driving technology investment decisions

Economic

- The degree to which hydrogen price is coupled with the price of gas and electricity is critical to leveraging economic advantages of green hydrogen
- The learning rates and supply chain of new technologies may present a substantial risk to the economic viability of a future hydrogen capability

The Race to Scale scenario sees a significantly higher proportion of blue hydrogen demand in 2040. In this scenario, Blue Hydrogen is used to quickly scale up overall UK hydrogen production in the UK, before electrolysis capacity is expanded.



Hydrogen use grows in industrial clusters initially from the mid-2020s before spreading out from these locations in 2030s. 53% of total industrial demand is met by hydrogen.



Electrification is considered the most cost-effective method for decarbonising heating. Hydrogen demand increases as the network is converted and by 2050, hydrogen meets 27% of demand, primarily for heating and hot water.



From the mid-2030s, hydrogen-fuelled HGVs and HFCVs increase in-line with local and national hydrogen infrastructure. By 2050, there are over 3million hydrogen vehicles in total and hydrogen vehicles make up nearly all heavy-duty freight.



Hydrogen for residential heating is initially built around hydrogen clusters before spreading nationwide, as the hydrogen network is built out. Hydrogen-ready boilers are installed from 2025 and by 2040, more homes are heated by hydrogen than natural gas.



All hydrogen production comes from a combination of methane reformation with CCUS and renewable energy powered electrolysis. A national hydrogen distribution and transmission network exists by 2050 with hydrogen blending into the gas network between 2030 and 2043. Electrolysers begin to produce more hydrogen than required to meet demand, resulting in the development of a hydrogen export market. The UK meets 10GW of hydrogen capacity by 2032, and by 2050 has 83GW hydrogen production capacity.



There is still demand for natural gas in the UK due to the reliance on methane reformation for hydrogen production.



The growth in renewable energy generation is rapid. Gas-fired power stations abated with CCS and hydrogen power stations provide dispatchable electricity generation and play an important role in meeting Security of Supply.

Hydrogen Export Opportunities

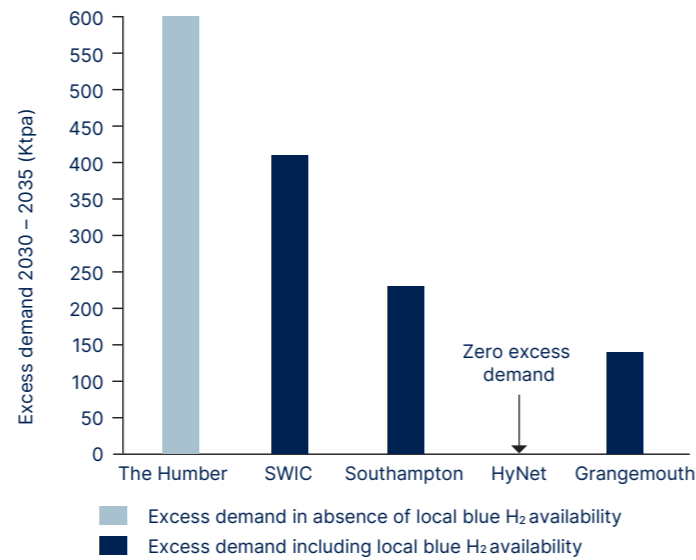
As the scale of the regional hydrogen economy increases, the Tees Valley will have increasing opportunities to export hydrogen to other domestic and overseas regions. Early adoption of policies to support these opportunities will increase the potential for success in these markets.

Domestic Demand

Analysis that we have undertaken in the Cluster Plan shows that the South Wales industrial cluster (SWIC), Southampton and Grangemouth industrial regions may have demand for hydrogen in excess of what they can produce locally. The Humber has similar scale plans to produce hydrogen as the Tees Valley, but its region has significant stresses on water demand and availability. If sufficient water is not available for the Humber to produce hydrogen at scale, this may create additional export demand from the Tees Valley.

The highest demand scenarios show that there may be up to 750 ktpa excess hydrogen demand at industrial clusters in the UK. This would require an additional 8 GW of hydrogen production which could be supplied by the Tees Valley. Pipeline infrastructure projects such as the National Grid's "Project Union" will be vital connect the clusters and stimulate hydrogen market development. Where pipelines are not viable, shipping can be utilised.

Hydrogen transport as liquid hydrogen or ammonia is well suited to applications with long distribution distances and significant demand, such as SWIC and Southampton. This is because liquefaction, ammonia cracking, and liquid hydrogen ships benefit strongly from economies of scale, and liquid hydrogen and ammonia ships have high volumetric energy densities, allowing large amounts of hydrogen to be transported per delivery.



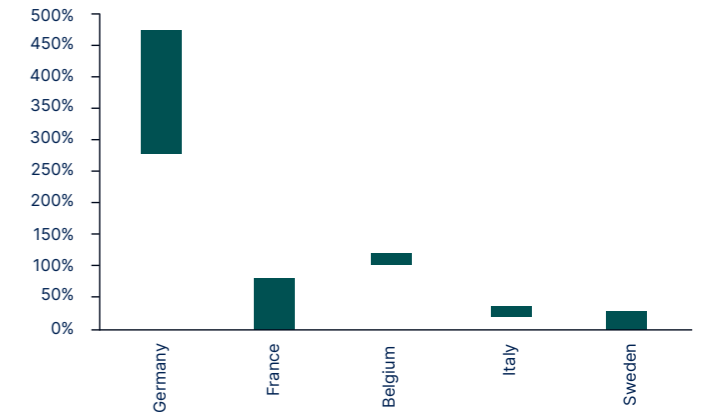
International Demand

The Tees Valley's location on the North Sea and its resources for low-carbon hydrogen production provide the opportunity for international hydrogen export.

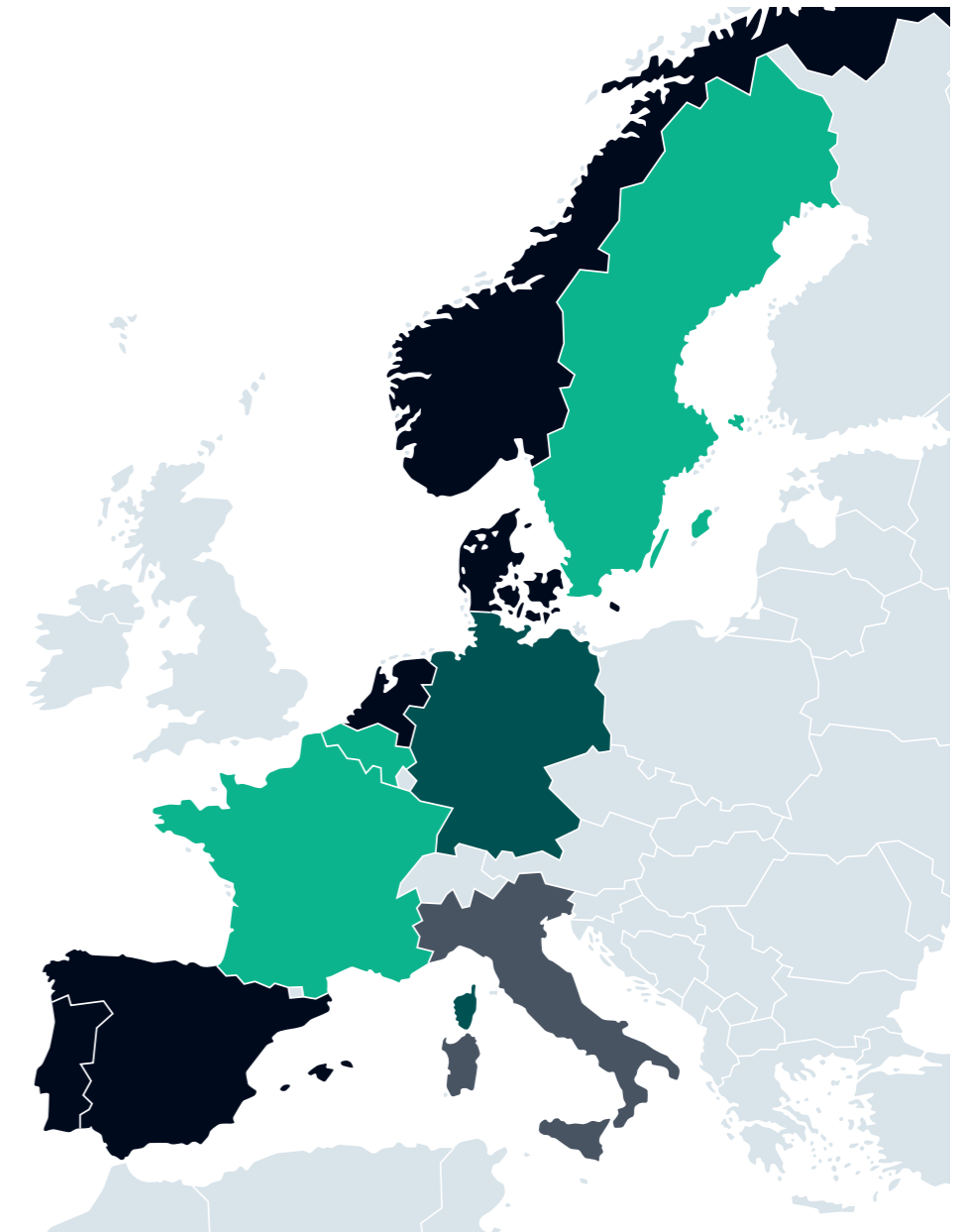
The most promising countries for hydrogen export are Germany, Belgium, France and Sweden. These are countries which have stated import targets for hydrogen (such as Germany) or where national targets of hydrogen usage outstrip announced hydrogen production projects.

In a high scenario, the Tees Valley could supply up to 600 ktpa hydrogen to European neighbours – equivalent to around 6.5 GW additional hydrogen production.

Level of excess demand (ktpa)



- Countries with limited import demand
- Countries with some import demand, however, in close proximity to other major exporters (e.g. Morocco)
- Countries with some import demand
- Countries with very high import demand



Economic Case

Net Zero and deep decarbonisation in the industrial cluster provide a significant opportunity for economic growth. Before decarbonisation technologies were available, there was a link between CO₂ emissions – the by-product of industrial output – and our economic performance measured through jobs and GVA.

The closure of large industries – such as the Teesside Integrated Iron & Steelworks – has led to reductions in both CO₂ emissions and the regional economic performance. But this is not decarbonisation. The global demand for iron and steel is still present and these products are made elsewhere, in economies where carbon taxes and decarbonisation policies have not been enacted. This just means that the CO₂ emissions have been “offshored”.

Through the data gathering that we have carried out with the industrials in the Tees Valley cluster, and econometric modelling based on that data, we are able to determine the potential for growth that Net Zero and deep decarbonisation will bring to the Tees Valley.

We have looked at a “Policy Off Scenario” which considers the impact on the regional economy if we do not adopt any decarbonised industries. This includes losing the ability to attract new industries, and a reduction in the existing industrial base as carbon taxes increase and impact economic viability.

We have looked at two scenarios for different levels of uptake of industrial decarbonisation and compared these with a baseline of no decarbonisation projects being developed in the Tees Valley.

- **“Limited Policy On Scenario”** – in this we have looked at just the group of projects in the Tees Valley that are currently shortlisted in the government’s Cluster Sequencing competition

These will generate

- 8,500 additional jobs
- £14.7bn additional cumulative GVA over the 2022-2040 period

- **“Full Policy On Scenario”** – here we have included all the potential decarbonisation projects that we currently know about – these are the projects for the 46 industrial companies we have gathered data from and that we have included in the Cluster Plan.

These will generate

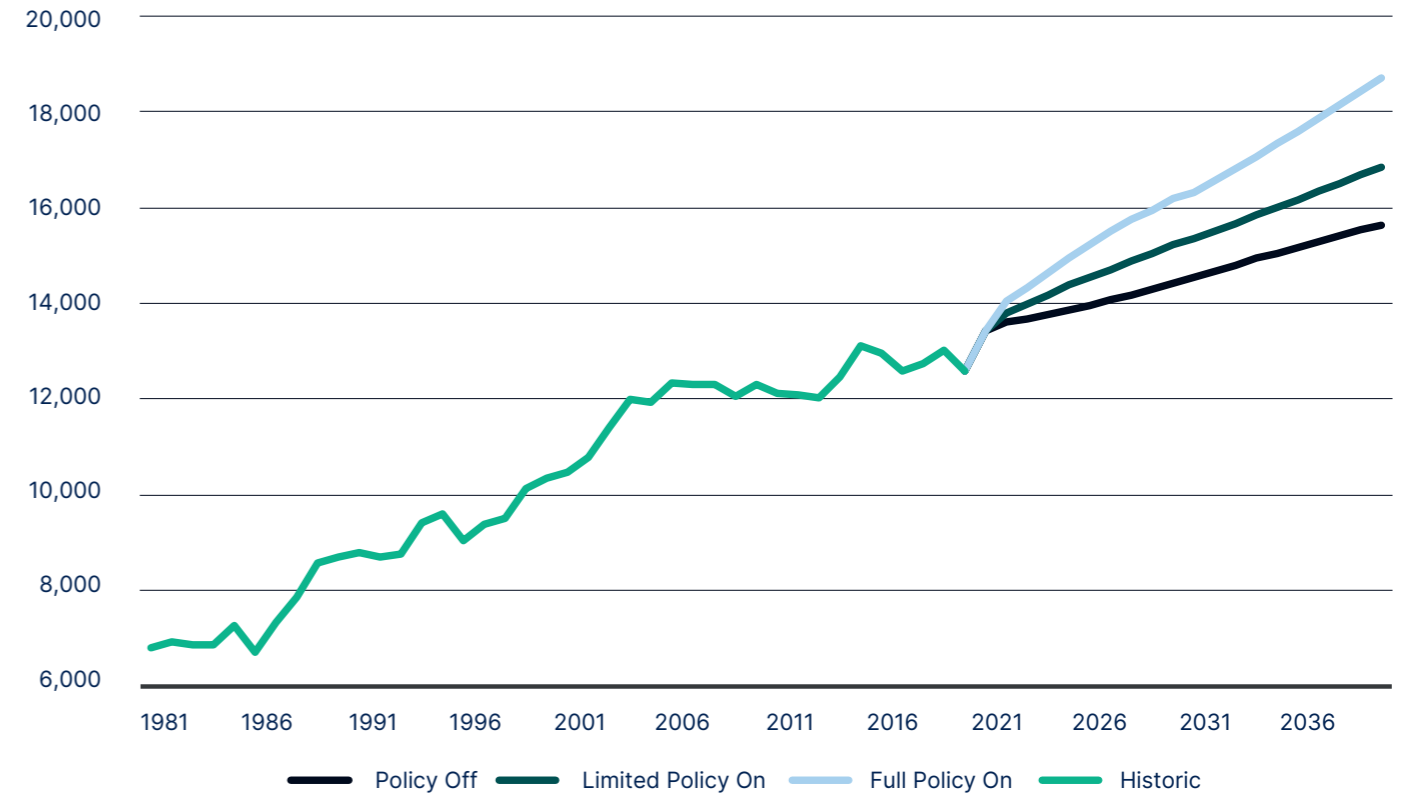
- Over 30,000 new jobs in the region
- £34.6bn additional cumulative GVA by 2040

The financial investment that this will bring to the Tees Valley will be at over £10bn.

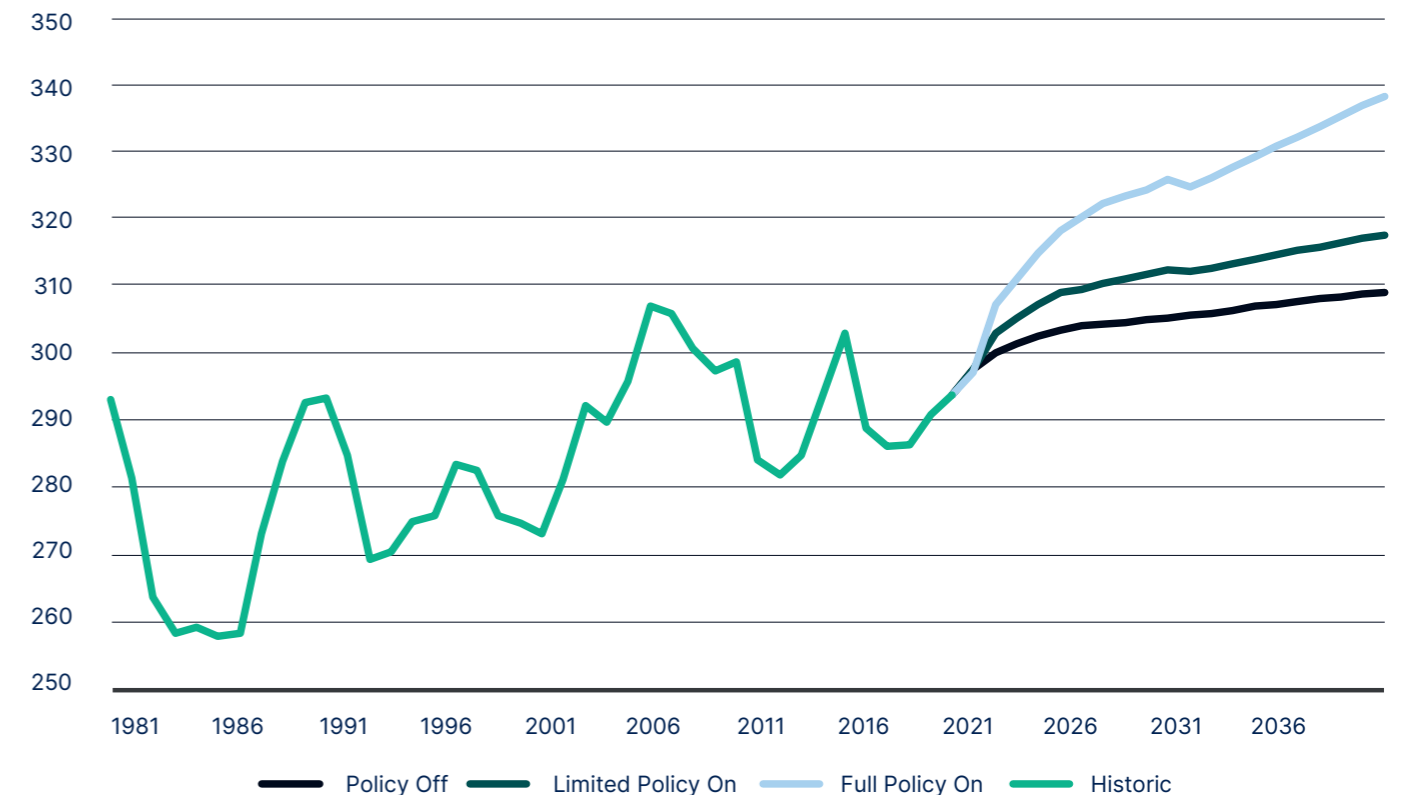
- **Many of the projects and investments contributing to this £10bn are being unlocked by the £200m invested in the re-development of the Teesworks site since 2015; and the forward plan to invest a further £393m in the Teesworks through 2023**
- **This shows the impact and leverage that the Teesworks redevelopment is providing to the Tees Valley**

These are just the projects that were under development during the time that we developed the Cluster Plan. The opportunity that the Tees Valley provides for new decarbonised industries is attracting more and more attention for new developments which will further increase these levels of investment.

Total GVA Projections (£m)



Employment Projections (000s jobs)



Skills

Plans for Growth & Skills Impact

Central to our growth plans is our ambition to become the national capital of clean growth and green energy, delivering a Net Zero industrial cluster by 2040, providing good jobs with long term prospects that local people can access.

This supports government's ambition for two million green jobs in the UK by 2030. The Green Jobs Taskforce 'Report to government, Industry and the Skills Sector' (July 2021) states: "Achieving Net Zero by 2050 will require a system-wide transformation of the economy; most occupations, to varying extents, will become green."

The **Net Zero Strategy for the Tees Valley*** sets out our Ten Point Plan and our top priorities include 'delivering training and employment opportunities aligned to the new green economy'.

The **Tees Valley Employment and Skills Strategy – 2022**** and beyond, sets out our future skills priorities and is aligned to the significant economic opportunities across the whole of the Tees Valley over the coming years. In developing this strategy, it was important to recognise that every job of the future will be directly or indirectly shaped by the transition to Net Zero as all sectors will go through a transformation on this journey.

Delivering industrial decarbonisation projects will depend on businesses having access to the skills they need to grow, as well as residents having the opportunity to develop and acquire the required skills and experience, at the required levels, to secure these roles.

The data that we have gathered on the economic benefits due to Net Zero and decarbonisation policies complements the Employment and Skills Strategy and help us to identify the skills needed to enable the new decarbonised industries and to plan accordingly.

A key focus of this strategy will be to ensure that capital investment decisions create opportunities for all our residents through new jobs that will become available and to support the retraining and upskilling of workers.

Our vision for employment and skills in Tees Valley includes:

Every business has access to a readily available skilled workforce and know where to go to find the workforce they need

Every business has access to workforce development and skills support, to sustain and grow their business

Every Tees Valley resident can access a good and progressive job

In developing the strategy, it was important to recognise that every job of the future will be directly or indirectly shaped by the transition to Net Zero as all sectors will go through a transformation on the journey to Net Zero.

The **Skills for Jobs White Paper***** set out an ambitious plan to put employers more firmly at the heart of the skills system to help ensure businesses and people have the skills they need to thrive and progress. Local Skills Improvement Plans (LSIPs) are a key part of achieving this aim.

LSIPs should set out the key priorities and changes needed in a local area to make post-16 technical education or training more responsive and closely aligned to local labour market needs, identifying where skills needs are converging across different sectors, as well as within sectors, including the transition to carbon Net Zero.

The Statutory Guidance for the Development of a Local Skills Improvement Plan states that, 'LSIPs need to go beyond simple statements about the need for more engineers or digital skills. This means understanding the actual skills employers need in the workplace but are struggling to find.'

The economic benefits and occupational data that we have gathered in the Cluster Plan will help inform the programme of skills activity to be delivered under the Tees Valley Employment & Skills Strategy and the recommendations for the Tees Valley LSIP. The data will help us better understand and identify the current and future skills needed to enable and mobilise the new decarbonised industries in the Tees Valley industrial cluster.

Comparing with the 2019 baseline – the new decarbonisation projects will:

Drive the growth of skills required categories such as science, research, engineering, technology professionals and associate professionals.

Provide a boost in construction and building trades

The Tees Valley Job Vacancies Report (January 2023) is already showing an increase in demand for these skills over the last year – and this is yet to include any serious activity in the "Policy On" scenarios.

Tees Valley Job Vacancies by Occupational Groups (2-digit SOC)

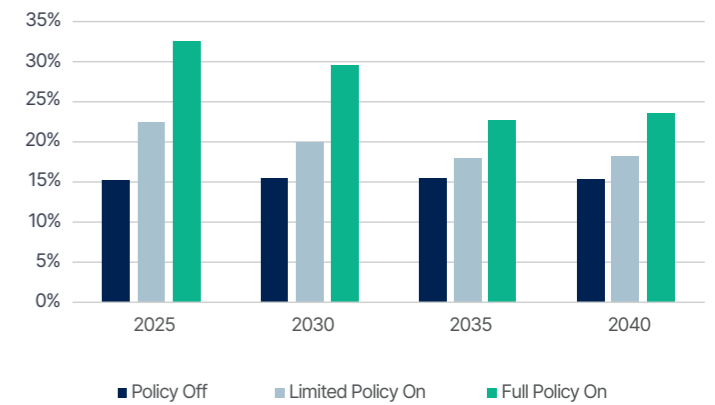
Occupational Group	Vacancies	
	Dec 2021	Jan 2023
Science, Research, Engineering and Technology Professionals	219	325
Science, Research, Engineering and Technology Associates	116	291
Skilled Construction and Building Trades	38	120

Skills Projections

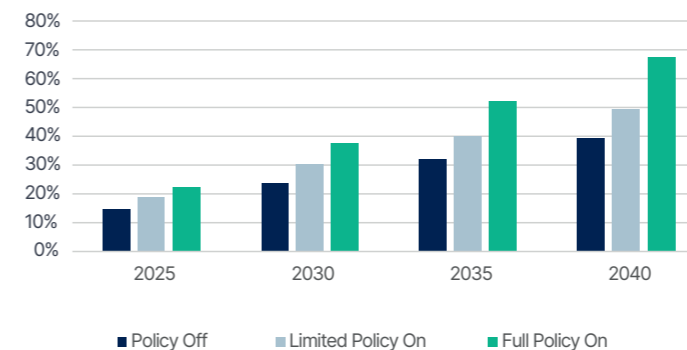
In the Economic Case, we describe the "Limited" and "Full Policy-On" Scenarios and the resulting economic impacts. We have used these same scenarios for our skills planning and this has allowed us to forecast required numbers of skills needs by occupational groups to implement the Net Zero policies:

- Reverse the decline in the "skilled metal, electrical and electronic trades" and "process plant and machine operatives"

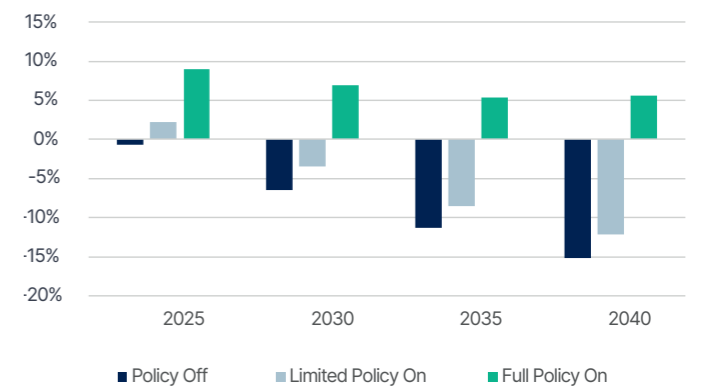
Skilled construction and building trades



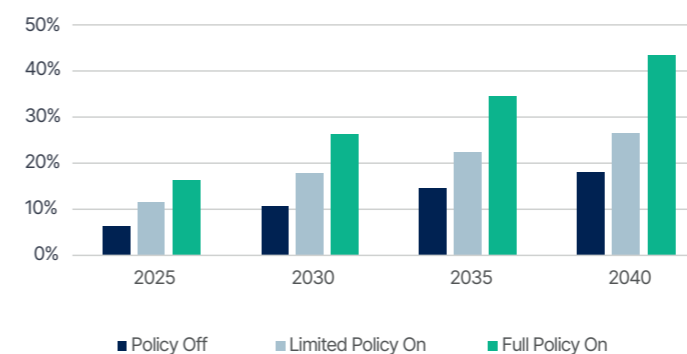
Science, research, engineering and technology professionals



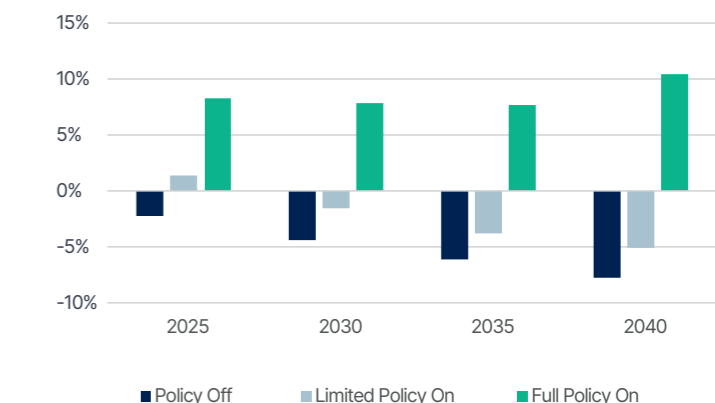
Process plant and machine operatives



Science, research, engineering and technology associate professionals



Skilled metal, electrical and electronic trades



*<https://tvca.wpenginpowered.com/wp-content/uploads/2023/02/Net-Zero-strategy-Digital.pdf>
 **<https://teesvalley-ca.gov.uk/wp-content/uploads/2022/07/9-Tees-Valley-Employment-Skills-Strategy.pdf>
 ***<https://www.gov.uk/government/publications/skills-for-jobs-lifelong-learning-for-opportunity-and-growth>

The Tees Valley Job Vacancies Report (January 2023)

also shows an increase in demand for these skills over the last year.

Tees Valley Job Vacancies by Occupational Groups (2-digit SOC)

Skilled metal, electrical and electronic trades had 185 vacancies in January 2023 compared to 159 in January 2022.

Process, Plant and Machine Operatives vacancies increased by 116% from the January 2022 figures (37 to 80), there was also a rise of 63% from December 2022 (49 to 80). But delivering this will depend on businesses having access to the people and skills they need to grow, as well as residents having the opportunity to develop and acquire the required skills and experience, at the required levels, to secure these roles.

Our strategic approach to achieve this is underpinned by three pillars of support – Retention, Preparation and Intervention.

Retention – support for those in employment and accessing work (our new and existing workforce and their employers)

Enhancing the skillset of those in employment and ensuring

that employers are able to clearly articulate their existing and future skills gaps whilst achieving change in the skills offer to address these gaps.

Preparation – support for those still in education and training (our pipeline future workforce)

Ensuring that those still in education and training are equipped to make the right education and career decisions, and that education and training providers and employers regularly engage to ensure emerging training opportunities address current and future businesses skills demands.

Intervention – support for those seeking work (our potential future workforce)

Enhancing the employability of those who are close to employment and addressing the constraints faced by those more distant from the labour market as well as fulfilling that the training and support system meets the needs of local businesses.

Devolution provides us with the opportunity to make this happen. We are able to engage with government departments and secure investment in new ways that enable us to better align and maximise our employment and skills programmes and funding streams. This ensures a more effective and joined-up system that addresses local challenges and seizes opportunities to improve outcomes for our businesses, young people and adults.

Policy Barriers & Enablers

The Tees Valley will be a significant beneficiary from deep decarbonisation projects in the industrial cluster.

These will support the government's agendas for growth, levelling up and energy security – as well as providing significant reductions in CO₂ within the region, and the fuels to help meet the wider UK's Net Zero 2050 goal: hydrogen, biofuels, circular-economy fuels from waste & renewables.

To ensure that we meet the Net Zero 2040 target, and optimise the regional economic growth from decarbonisation projects, it is important to ensure that as many of the potential projects go forward. Many of these will need appropriate government policy to be enacted – via the legislation and business models for CO₂ Transport & Storage, and Hydrogen. While the adoption of decarbonisation in existing industries risks additional costs being passed to consumers, the growth and jobs opportunities from Net Zero transition in Tees Valley may mitigate this to some extent.

Barriers

In the Cluster Plan we have carried out research to identify barriers and their impact on decarbonising the cluster. These are largely based around three main categories – investment, policy and regulatory – which are influenced by infrastructure availability, technology readiness and market conditions.

To provide a more detailed review of barriers, we interviewed the industrial cluster members and they share many common themes in their assessment of the barriers to decarbonising their separate businesses.

Understanding their barriers is key to the decarbonisation strategy in the Tees Valley and our work to ensure we maximise the potential for Net Zero industries and growth. We are using the information gathered in the cluster plan on barriers and enablers to inform our policy and following conversations with stakeholders from industry, trade bodies and government.



Clarity and Consistency from Government

Some industrials highlighted the need for increased clarity, action, and commitment from government, with improvements in these areas being perceived as beneficial in overcoming barriers. One particular issue that was highlighted was the inconsistencies in end-user market support. For example – decarbonising the transport sector is heavily supported by government but off-grid and industrial fuels are not. It was emphasised that the government departments needed to be joined up to ensure that waste streams are not unfairly allocated and the Department for Energy Security and Net Zero and Department for Transport do not compete with each other for residual waste.

As industrial decarbonisation is still a relatively new area, there is a rapidly developing policy landscape which creates uncertainty for investors. Many of their concerns were related to the business case and incentivising the move to decarbonisation.

Stranded Asset Concern

One of the specific risks that was highlighted by the industrial cluster is the reliance on the CO₂ Transport and Storage system:

- **The biggest risk to decarbonisation is if the Net Zero Teesside project does not go ahead.**

If this project does not progress, then there will be no way of storing the CO₂ that is emitted. Any new industries built, or additional CO₂ capture plant specifically for integration with Net Zero Teesside risk becoming stranded assets if this were to happen.

For the majority of the Tees Valley's industrial decarbonisation projects to work there will need to be deployment of the CO₂ storage system. Some of the Tees Valley industrials will not spend any significant funds unless there was certainty that they would have the opportunity to connect to the Net Zero Teesside CCS network. Others require future certainty that the CCUS infrastructure and policies proposed would be maintained.

Fuel Switching & Infrastructure

Some industrials have emphasised that to implement fuel switching to hydrogen, there needs to be clarity over the infrastructure availability, timelines and volumes of supply.

Other industrials are planning fuel-switching to electricity and this generates similar concerns. The National Grid has a number of infrastructure restrictions to the north and south of the Tees Valley, and this has knock-on impacts to the programme for allowing updated and new electrical connections to industrials in the Tees Valley. TVCA is currently working with Northern Powergrid to identify these blockages and develop policies to overcome the restrictions.

The Cluster Plan includes work on the needs for hydrogen and electricity infrastructure planning, and we will be taking these forward as actions to implement then Cluster Plan

Innovation and Technical Challenges

Technical challenges are also a potential barrier. Decarbonisation is still a developing technology with a range of implementation strategies and there are difficulties in decarbonising certain plants. There are innovation challenges in decarbonising production processes – this could be a long-term issue and is dependent on technological advances. Linked to this is the risk of technology lock-in and stranded assets. Some industrials have long replacement cycles, (up to 50 years) and new machinery would need to be hydrogen ready to avoid missing the window of opportunity for decarbonisation.

Investment & Financial Challenges

The financial costs of decarbonisation is a common concern amongst the Tees Valley industrial cluster. For companies operating on a global marketplace – the cost of decarbonised energy has impacts on competitiveness. The high cost of decarbonised electricity means that price rises could be passed onto the customer, losing competitiveness on the global market with other countries which do not have deep decarbonisation policies. The high UK industrial energy prices were also stressed by a number of industrials as a major barrier as decarbonised solutions were likely to require more electricity. There is a clear need for decarbonisation plans to be cost effective.

Pricing Structures

Pricing structures were repeatedly highlighted as a concern and issues with the UK Emissions Trading Scheme (UK ETS) were quoted by more than a quarter of the industrial cluster companies. Although the system is intended as a driver for decarbonisation, it is not universally applied and therefore there is not a level playing field and the sector risks losing competitiveness. Without a universal application of the ETS, it becomes a taxation on industry and production volumes, which leads to the potential for “offshoring” industries.

- Renewable fuels industrials in the cluster highlighted the lack of carbon caps in the UK ETS. They can be charged for CO₂ emissions under UK ETS even though their product decarbonises another sector in the UK economy.
- An overhaul of carbon accounting was also “desperately needed” changing direct emission accounting to complete supply chain accounting.
- There are concerns for competitiveness in regard to the EU Carbon Border Adjustment Mechanism (CBAM) as it is unclear if the UK will be a part of this.

In specific sectors such as hydrogen, there was much uncertainty surrounding the pricing structure. Industrials highlighted the lack of government direction in relation to this and also emphasised their concerns over government strategy when moving to business models.

Business Models for BECCS

Other organisations are currently awaiting business models for power BECCS (Bio-Energy with Carbon Capture and Storage) and are not willing to invest until the model is published. The longer it takes for business models to be confirmed and published, the slower the progress to decarbonisation.

Competitiveness

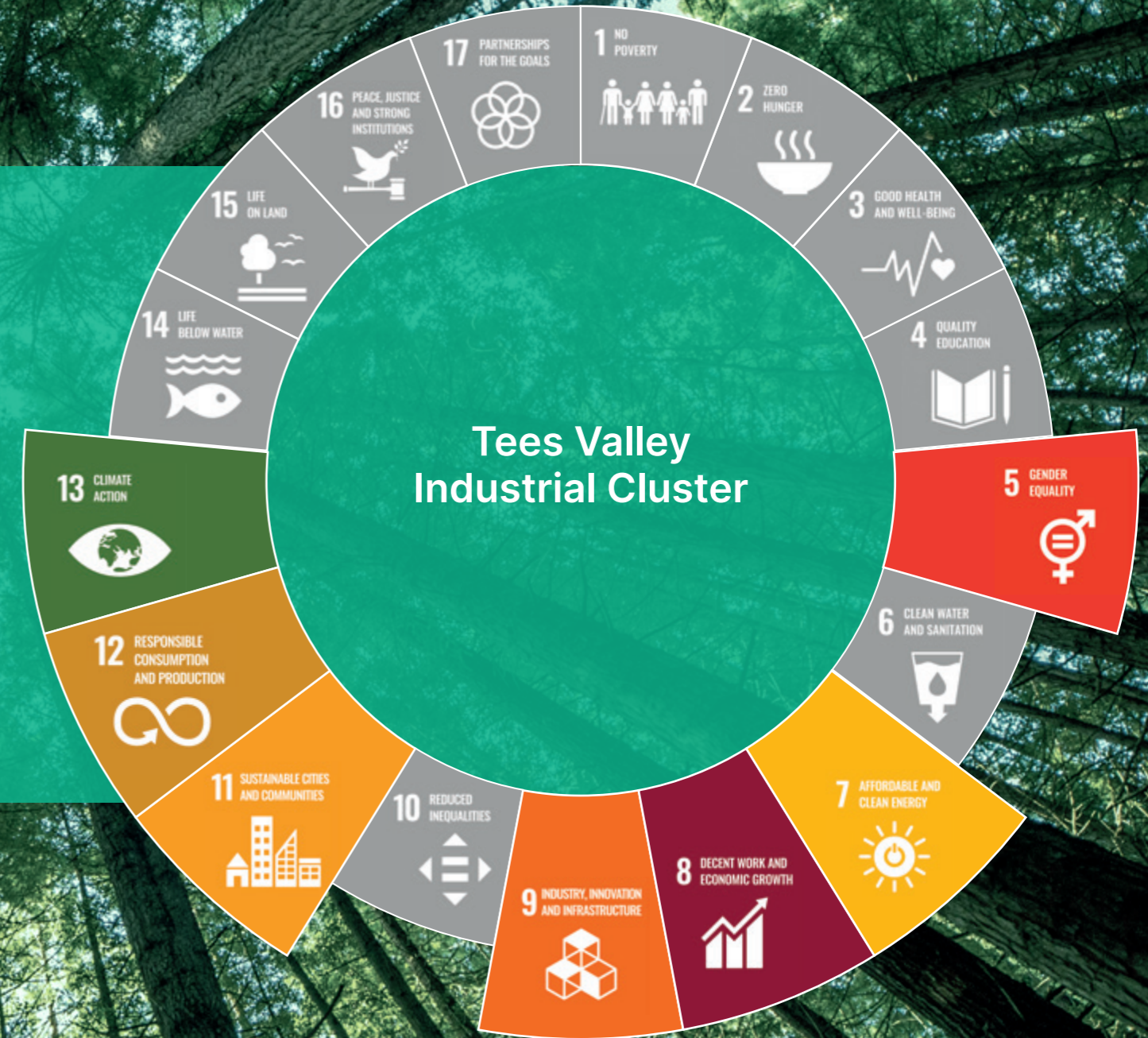
Competitiveness was also linked to carbon prices and taxes. Although this was seen as a driver of progress to Net Zero, there were multiple concerns. Carbon taxes are not seen to be optimal and even though the carbon impacts of projects are considered in some cases, this is purely on an economic basis. This will impact progress to Net Zero unless there is a suitable incentive and driver to get there.

This emphasises the importance of creating business incentives to move towards Net Zero. Businesses wanted more economic drivers to help support the move, requiring these before any decisions were made. Particular support is needed for the steel sector with emphasis on the need for government intervention to support the cost of carbon reduction.



UN Sustainable Development Goals

Industrial decarbonisation is an essential contribution to tackling climate change. We have mapped the Tees Valley industrial decarbonisation Cluster Plan to the UN Sustainable Development Goals to demonstrate how it fits within the wider global context for sustainable development.



The Cluster Plan Roadmap

The studies that we have undertaken during the Cluster Plan project provide a wealth of information and data on the potential for decarbonisation in the Tees Valley industrial cluster. These are the keystones of our roadmap for realising Net Zero 2040.

A United Voice for the Cluster – 2023

We have set up a new industry group for the Tees Valley industrial cluster with the specific aim of ensuring that Net Zero will be achieved in the cluster. This will be a focal point for coordination between the many industrials within it. It will allow us to address common themes and provide a unified voice for delivering Net Zero 2040. It will allow us to address infrastructure and resources needs together. It will provide a platform for the needs of new decarbonised industries coming to the cluster to integrate Net Zero planning with the existing industries.

Carbon Accounting – 2023-2025 & onwards

We will use the Carbon Accounting methodology that we have developed in the Cluster Plan to provide a definitive measure of Net Zero in the cluster. We will work directly with the industrials in the cluster, and their data provided during the Cluster Plan project, to determine the Scope 1 and Scope 2 CO₂ emissions in a uniformly assessed account. We will work to extend this to cover Scope 3 emissions also. An important part of this work will be to quantify the “avoided carbon” emissions provided by renewable and circular economy fuels and chemicals produced in the cluster. These will demonstrate and quantify the positive effect that Tees Valley industries have in displacing carbon emissions from the wider UK economy.

Carbon Capture, Utilisation and Storage – 2027-2030

We will continue to work with and support the Net Zero Teesside, Northern Endurance Partnership and East Coast Cluster CCS projects. These will:

- Provide up to 10 Mt per year of CO₂ storage capacity
- Enable the Tees Valley to be a world-leading low-carbon industrial cluster by 2030 and achieve Net Zero by 2040
- Reduce Scope 1 CO₂ emissions from the Tees Valley industrial cluster by at least 180%

- Enable the new hydrogen economy in the Tees Valley by storing the CO₂ by-product of 2 GW blue hydrogen production.

We will continue to promote all CO₂ emitters who are able capture their carbon for transport and storage to the NZT / ECC project. This will include projects who do not necessarily need funding or Contracts for Difference (CfDs) through the Cluster Sequencing competition.

We will continue to work with the industrials in the cluster who capture CO₂ for utilisation – this is already a feature with CO₂ captured and supplied to nuclear, food and drink processing and other markets. We will work with the industrials in the cluster to find appropriate and new markets for CO₂ – e.g. in the manufacture of Sustainable Available Fuels.

Low Carbon Hydrogen – Industrial Scale Production – 2027-2030

We will work with, support and promote all sectors of the hydrogen economy, building on the existing hydrogen production and infrastructure in the Tees Valley, enabling the new hydrogen supply/demand economy and creating a centre for industrial scale low-carbon hydrogen production. This will include:

- 2 GW blue hydrogen production being planned by bp and Kellas Midstream for development by 2030
- 200 MWe green hydrogen production in planning with the vision to upscale this to 1 GW
- Industrial CCS being implemented on BOC’s existing hydrogen production
- Following opportunities for hydrogen production from nuclear power derived electricity and heat

Infrastructure & Planning – 2023-2030

The decarbonised industries in the Tees Valley will provide electrical supply and demands on the national and local distribution network. We will work with Northern Powergrid to understand these new needs within grid supply points, support electrical infrastructure planning, and to ensure that electrical infrastructure does not bottleneck the development of new decarbonised industries.

The Tees Valley hydrogen industrial scale production will need the means to transport hydrogen between producers and users within and outside the industrial cluster. We will work with Northern Gas Networks, including the Hydrogen Village Community, National Grid, Project Union, and the East Coast Hydrogen project to make these a reality.

Renewable & Sustainable Fuels: Energy from Waste & Circular Economy – 2023 onwards

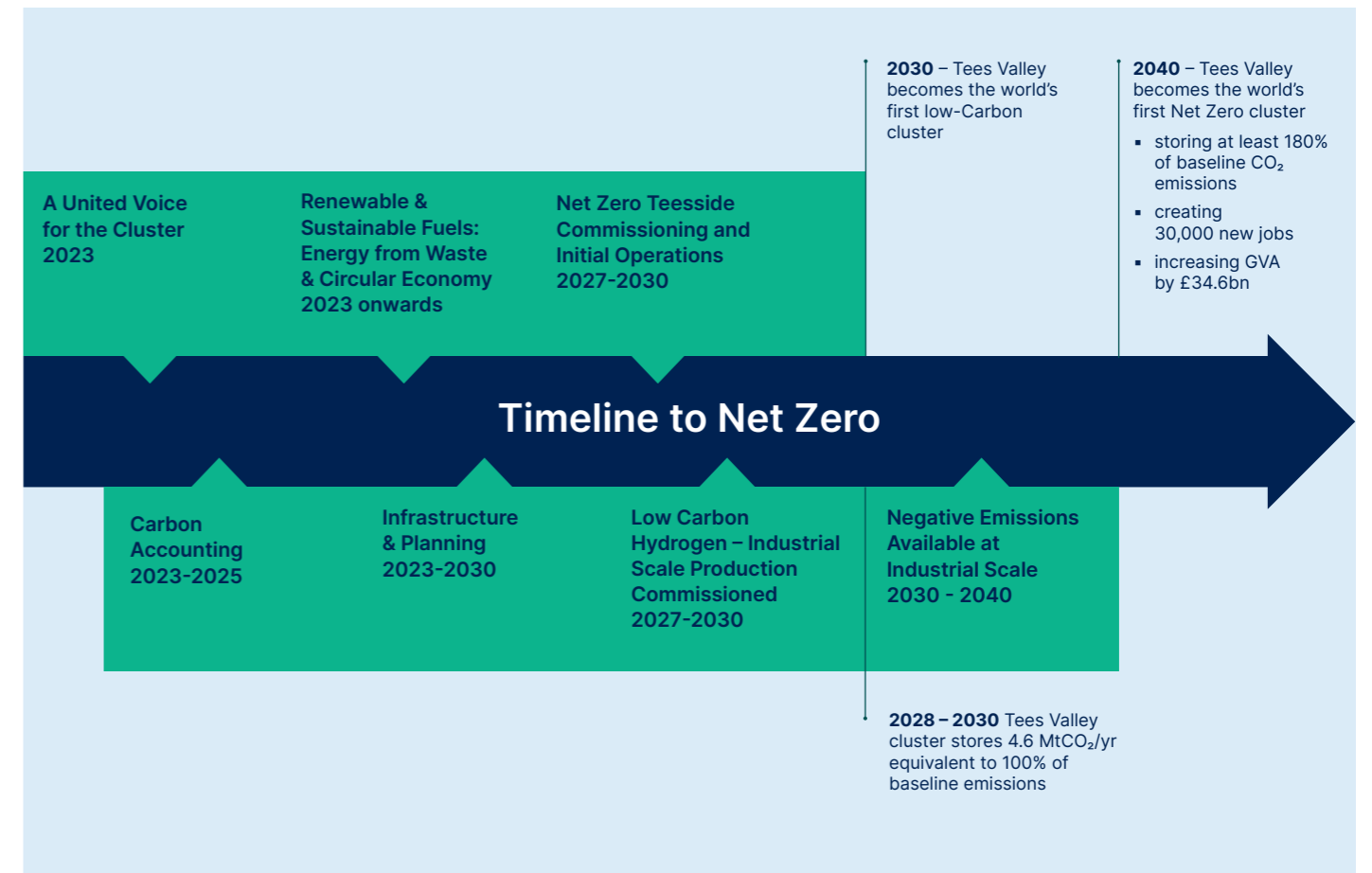
The Tees Valley industrial cluster is already a hub for Energy from Waste and e-fuels. We will continue to support and promote all Energy from Waste projects in the Tees Valley industrial cluster with the goal to develop CO₂ capture and connect to the Net Zero Teesside CCS transport and storage system.

We will work with our existing renewable fuels companies which are already providing alternatives to hydrocarbon fuels that help the wider UK meet its Net Zero 2050 target. We will promote and support new circular economy fuels, helping create the right conditions for them to invest here, bringing production technologies for SAF, rDME (LPG replacement) and others.

National Coordination

We will continue to take a lead role in the Multi-Cluster Forum – the group of all industrial clusters in the UK – to share experiences and coordinate mutually beneficial activities. We will continue our engagement with the Carbon Capture and Storage Association and the Department for Energy Security and Net Zero to ensure that national policy is informed by the local requirements in the Tees Valley. We will continue our engagement with stakeholders across the academic community – our local universities, the Teesside University Net Zero Innovation Centre and the IDRIC group – to help inform and develop Net Zero research and innovation.

We will work across government departments to ensure that the Tees Valley Net Zero planning informs and supports our work on the Local Skills Improvement Plan (LSIP) with the Department for Education and our work on the Hydrogen Transport Hub with the Department for Transport.



Endorsements

“There is no path to Net Zero without partnerships. The Cluster Plan, and our work with partners to develop H2Teesside, HyGreen Teesside and Net Zero Teesside Power, are testament to this. We are so proud to be playing our part alongside the TVCA and our partners to help drive Teesside’s transformation into a world-class low carbon hub. We are still at the start of this journey and absolutely committed to making this fantastic opportunity a reality.”



Matt Williamson, bp's head of UK Hydrogen

“The Northern Endurance Partnership will underpin the East Coast Cluster by providing the shared CO₂ transportation and storage infrastructure to serve carbon emitting projects across Teesside and the Humber. Working in partnership with the Tees Valley Combined Authority and other key regional stakeholders, we are embarking on a journey which will enable an unparalleled and diverse mix of low-carbon projects which will create and support thousands of skilled jobs in exciting new industries.”



Andy Lane, Managing Director of the Northern Endurance Partnership

Industrial Contributors

8 RIVERS



Authors

Tees Valley Net Zero Project Board

- Hamish Bennell, bp
- Phillip Aldridge, NEPIC
- Chris Rowell, TVCA

Tees Valley Net Zero Project Manager

- Chris Robinson, CER Technologies Ltd (seconded to TVCA).

Acknowledgements

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We would especially like to thank Dr Bryony Livesey, the director of the Industrial Decarbonisation Challenge at Innovate UK, and her staff; and Seyhan Turan, our Monitoring Officer who has provided invaluable support throughout the years of this project.

