Department for
Business, Energy
& Industrial Strategy

Net zero in the North East: Regional transition impacts

Final report

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Executive Summary

The UK brought forward legislation in 2019 committing to net zero greenhouse gas emissions by 2050, building on commitments made as part of the Paris Agreement. It was the first major economy to legislate and commit to net zero, ahead of holding the Presidency to the 26th Conference of the Parties (COP26). A transition on this scale will bring opportunities and risks across the economy. These risks and opportunities will depend, in part, on the industrial, skills and governance assets in different regions of the country. They will also be conditioned by the decarbonisation pathways, policy and investment decisions that will be taken by the government and businesses in the coming years.

The aim of this report is to explore some of the implications of national net zero scenarios and their potential impact on the North East region. The aim is also to develop and test an experimental approach for assessing the potential impacts of transition in a way that can be replicated and compared across the country, with a view to applying a successful methodology in other regions.

The North East region was selected as the basis of this study as it is geographically diverse, with both large rural and highly urban areas. It is an industrialised region that also faces economic challenges, such as higher rates of unemployment, poverty and deprivation, compared to the UK average. The region comprises twelve Local Authorities (LAs) which are grouped into three Combined Authorities (CAs) and two Local Enterprise Partnerships (LEPs). For the purposes of this report, the focus is on the two LEP areas (North East LEP and Tees Valley LEP).

North East and national net zero pathways

To achieve net zero on a national level, substantial investment is required from the government and the private sector. According to the Climate Change Committee (CCC), delivering the Sixth Carbon Budget will require £50 billion annual investment by 2030,[1] which will need to be sustained until 2050, compared to current investment levels of £10 billion per year.[2] The UK government has made commitments to increase investment over the coming years, including the Ten Point Plan for a Green Industrial Revolution, and Innovation Strategy. It has also set out sectoral strategies, including its industrial decarbonisation strategy, on how industry can decarbonise while remaining competitive. In the Net Zero Strategy, published alongside this research report in October 2021, the Government has set out its plan for the UK to reach zero greenhouse gas emissions by 2050.

The estimates of the potential regional economic impact of net zero on the North East in this report use as their starting point BEIS UK TIMES (UKTM) modelling results on the UK wide transition to net zero.[3] The underlying national modelling is consistent with achieving the

[1] Climate Change Committee (2020) The Sixth Carbon Budget: The UK's path to Net Zero. Available from https://www.theccc.org.uk/uk-action-on-climate-change/reaching-net-zero-in-the-uk/. Accessed 19 January 2021

[2] Ibid.

[3] UKTM is an energy system model of the UK. It has been developed by UCL and the BEIS and is used to inform UK government policy.

legislated level of emissions reductions set out in the Sixth Carbon Budget, and has been separately used in the Impact Assessment for that decision.[4]

To apply these national results at a regional level, this report makes a number of additional assumptions which are not featured in the Impact Assessment. These assumptions set out how national level investment and demand shifts implied by the Sixth Carbon Budget might apply at a regional level, based on regional characteristics and existing policy. The regional estimates also seek to account for net zero demand from the international sector, and for the investment that may flow to other parts of the UK or abroad, based on the type of spending and distribution of certain industries in the UK. The assumptions are designed as an experimental approach, and are not a statement of policy.

The analysis in this report focuses on five sectors in the North East, which are an aggregation of existing groupings used in UKTM and sectors defined by the CCC, grouped after holding stakeholder interviews.

The five sectors analysed are:

1. **Energy and electricity** - including nuclear energy capacity, hydrogen, offshore and onshore wind, solar, biomass, other renewables, and supporting energy infrastructure including in transport and for buildings (e.g. pipelines and meters). This sector also includes energy from oil and gas;
2. **Transport** - including surface transport, shipping, and aviation. Surface transport is the main form of transport in the region and includes cars, buses, passenger rail, and freight and goods vehicles. The transport sector also includes the manufacture of vehicles for transport, which in the case of the North East is focused on the transition to electric vehicle manufacturing;
3. **Buildings** - including residential and commercial buildings and their heat decarbonisation strategy (e.g. through the adoption of hydrogen boilers or heat pumps), and retrofitting to improve energy efficiency. Buildings also includes domestic and commercial appliances;
4. **Industry and carbon capture** - including industry, manufacturing, and carbon capture, usage and storage (CCUS)[5]; and
5. **Land use and agriculture** - including planting of trees and restoration of peatlands, livestock farming and agriculture.

Importantly, some key sectors of the economy are not covered, including those which are service-based such as finance and insurance activities. These sectors are excluded because the analysis is based on direct supply chain impacts related to sectors analysed in UKTM as part of the net zero transition. The UKTM is an energy system model which does not cover all sectors of the economy in detail.

To analyse each sector, a review of literature and reports related to net zero and the North East was undertaken alongside 17 stakeholder interviews (a full list of stakeholders is available in Annex C) conducted in January and February 2021. This review covered UK policy documents, local strategic documents and sector-specific sources, and it explored how

[4] Department for Business, Energy and Industrial Strategy (2021) *Impact Assessment for the sixth carbon budget*. Available from https://www.legislation.gov.uk/ukia/2021/18/pdfs/ukia_20210018_en.pdf. Accessed 29 June 2021

[5] Including biomass and gas CCUS for power.

national net zero scenarios for the UK might apply to different regions of the country based on the region's economic characteristics. These insights were combined with data from the ONS and other relevant government departments to create an analytic tool that estimated the potential regional impact of the 'core' national decarbonisation scenario in the Sixth Carbon Budget on four sectors (land use and agriculture was not included for reasons outlined in the main report). Future work could explore different pathways to net zero given the various routes that can be taken to achieve it. Qualitative analysis of **governance**, **infrastructure** and **skills** is also undertaken.

Findings

The North East could potentially benefit from the transition to net zero, over and above the benefits that may accrue at a national level. This is driven primarily by potentially higher investments in the energy and electricity sector in the North East. Investment in these areas may in part be due to the geography and industrial history (sites suitable to enable carbon storage, existing industrial need for carbon capture and existing hydrogen distribution capacity), and supported by national policy commitments announced in the Ten Point Plan for a Green Industrial Revolution. Stakeholder interviews reflected this view, with most showing optimism around the opportunities for the North East as the region transitions to net zero.

Overall, the analysis shows that, in real terms, an additional **£1.9 billion** (3.4% of 2020) could be added to annual direct gross value added (GVA), leading to just over **27,000** (2.3% of 2020) more direct jobs by 2050 compared to 2020 levels under the core decarbonisation pathway.[6] These increases are in comparison to the current North East GVA of £55.3 billion and jobs figures of around 1.2 million in 2019.[7] Under the counterfactual (the UK does not aim for net zero by 2050), these changes are **£0.7 billion** (1.3% of 2020) and around 10,000 jobs (0.9% of 2020).

The analysis by sector is set out in Table 1 below.

Table 1: Potential exposure impacts for the North East from net zero transition

Sector name	Findings
Energy and electricity	• A potential net increase of **£830 million** (opportunity: £1.41bn, risk of £580m) in GVA terms by 2050 compared to 2020 levels, and **13,500 direct jobs**.
Transport	• A potential net increase of **£500 million** (opportunity: £1.2bn, risk: £700m) to the GVA of the North East region by 2050 compared to 2020 levels, and **6,500 direct jobs**.

[6] Gross Value Added (GVA) represents the value of goods and services produced in a region, industry or sector of an economy, before taxes and subsidies. An impact in direct terms refers to the activity generated from the initial spending in the economy.

[7] ONS (2021) *Regional gross value added (balanced) by industry: all ITL regions*. Available from https://www.ons.gov.uk/economy/grossvalueaddedgva/datasets/nominalandrealregionalgrossvalueaddedbalancedbyindustry. Accessed 26 July 2021
ONS (2021) *JOBS05: Workforce jobs by region and industry*. Available from https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/datasets/workforcejobsbyregionandindustryjobs05/current. Accessed 26 July 2021

Buildings	• A potential net increase of **£350 million** (opportunity: £440m, risk: £90m) in GVA terms by 2050 compared to 2020 levels, with **5,200 direct jobs**.
Industry and carbon capture	• A potential net increase of **£230 million** (opportunity: £580m, risk: £350m) in GVA terms by 2050 compared to 2020, with **2,000 direct jobs**.

Energy and electricity

Energy was generally seen as an area of significant opportunity for the North East under net zero. Stakeholders mentioned that the region has an established offshore energy subsea technology cluster and expertise in the different stages of the offshore energy supply chain, with Tees Valley currently producing at least half of the commercially available hydrogen in the UK.

The largest drivers of the potential net GVA increase in Table 1 are the emerging hydrogen, offshore wind, nuclear and biomass sectors. In terms of employment, the offshore wind sector could see a net 3,400 direct jobs as the UK government sets out to quadruple offshore wind capacity by 2030. The energy and electricity sector accounted for the largest net opportunity in the North East among sectors analysed.

Transport

Impacts from the transport sector are second largest, with the transition to electric vehicles (EVs) and other low-carbon emission cars having the potential to generate significant economic activity.

Road transport accounts for 90% of the potential GVA impact estimate in Table 1, with the economic benefit of vehicle purchases falling not only to vehicle manufacturers, but also to associated industries such as wholesale and retail, and repair. The high opportunity associated with road vehicles in the North East therefore reflects the relatively high national spend as modelled by the UKTM in this area as part of the overall net zero transition. As noted in the literature and stakeholder interviews, there is a potential for the North East to further benefit by capitalising on the existing presence of electric vehicles manufacturing in the North East.

Buildings

The pace of retrofitting will need to increase in the North East and across the country, as the current pace is far below what is necessary to be on the path to achieving net zero in this sector. In line with this challenge, the analysis suggests that a peak of up to 10,600 jobs could be added by 2025 compared to 2020, due to efforts in the next 10 years. Aside from the general challenges with pace faced across the country, the North East also has specific challenges, including fuel poverty and a relatively inefficient housing stock, both of which could be improved if this sector transitions to net zero successfully.

Industry and carbon capture

Industry and carbon capture focuses on chemical and process manufacturing and other high-emitting industries for the North East, and one of the proposed approaches to decarbonise these industries: CCUS technology.

One concern cited in the stakeholder interviews was around how to mitigate risks if CCUS is not as effective as originally expected, or if there is a slow transition. In this scenario existing industries may become uncompetitive due to carbon prices and other pressures. Given the region's reliance on carbon intensive industries, jobs in those sectors face greater exposure to a net zero transition as a result.

Land use and agriculture

Land use and agriculture are an important sector for the North East, especially in the more rural parts of the region and in light of the large areas of natural reserves that act as carbon sinks. Stakeholders interviewed for this research mentioned risks around cattle farmers as a result of transition, but also opportunities from nature based solutions. Further analysis is required on the potential impact on land use and agriculture from net zero and the potential distributional implications, and so potential impact estimates are not included in this report.

Governance, infrastructure and skills

To realise potential sectoral opportunities and mitigate risks of net zero transition, strong **governance** will be needed. While stakeholders noted their ability to work together and the presence of important net zero collaboration across the public, private and third sectors, challenges remain. In particular, working across multiple layers of governance across the North East is a challenge, and there may be further opportunities for LAs to work more closely together. In addition, stakeholders noted that, while competitions amongst regions and clusters can drive efficiency and innovation, they can also create a barrier to knowledge-sharing. A key challenge that was raised on cluster competition was the uncertainty it creates, weakening industry confidence and investment in new technologies.

Stakeholders generally said less about **physical infrastructure** needs for net zero, which may result from the future net zero technology pathway still being unclear at the time of the research being conducted. However stakeholders were positive about the region's industrial infrastructure, specifically existing gas infrastructure and the ability to repurpose that to suit transport of hydrogen fuel.

Stakeholders were also positive about the **social infrastructure** (for example education and housing) in the North East, in particular the universities and the further education capabilities in the region, and how these educational institutions work with industry. They also felt that colleges and other further education institutions were responsive to changes in the labour market and would offer new courses if there is demand for them from prospective students and employers. Stakeholders cited that it may be challenging to ensure that enough skilled workers are available in the labour market due to concerns around timing and supply moving quickly enough to keep up with demand.

The impact of net zero on **skills** depends on the current skills base, the skills needed during the transition and the quality of jobs created from the transition. Stakeholders were positive about the potential for the North East to benefit from the transition, through new jobs being created in emerging low-carbon sectors. They also suggested that sectors which face significant exposure to net zero would successfully transition. The consensus from stakeholders was that much of the skills base within the North East is transferable to a net zero economy and while some retraining will be necessary, it is unlikely that many will need to

undergo full retraining. Stakeholders were positive about the quality of jobs being created during the transition, with almost all stakeholders expecting new jobs of equal or greater quality compared to those jobs lost or replaced.

Skills gaps were cited as a potential issue, in particular for new technologies. As an example, stakeholders mentioned CCUS construction, given the technology and processes are new, and the retrofitting skills needed in the North East, given the number of people needed with these skills. Certain skills gaps could also be exacerbated by the high rates of out-migration of students who attend the region's universities.

Overall, the analysis and stakeholder interviews suggested the North East has the potential to benefit significantly from the transition to net zero, but it also experiences risks since higher-carbon industries must adapt as new skills are needed for new net zero technologies or face decline. If the risks to a net zero transition are managed effectively in the region, with cooperation across different layers of government and the private and third sector, the North East may be able to transition to net zero in a way that capitalises on its existing advantages and leverages its existing skills base.

1. Introduction

The UK has long been a leader and strong advocate for ambitious climate action. The 2008 Climate Change Act was the first legally binding national commitment to cut greenhouse gas emissions in the world.[8] It committed the UK to cut emissions by at least 80% by 2050, relative to 1990 levels. In 2019, the target was updated with a goal of net zero[9] by 2050, making the UK the first major economy to legislate and commit to net zero.[10] In the Net Zero Strategy, published alongside this research report in October 2021, the Government has set out its plan for the UK to reach zero greenhouse gas emissions by 2050.

1.1. Achieving net zero

Following the UK announcement, the number of commitments to net zero around the world have increased.[11] However, global commitments remain short of what is required to keep temperature rises below 1.5°C compared to pre-industrial levels.[12] As President of the upcoming 26th Conference of the Parties (COP26) to the United Nations Framework Convention on Climate Change in November 2021, the UK has an opportunity to demonstrate its climate leadership and to raise climate ambition, both domestically and internationally.

In the UK, reaching net zero by 2050 is significantly more ambitious than the UK's previous target of achieving an 80% reduction in 1990 emissions by 2050. In its Sixth Carbon Budget, the Climate Change Committee (CCC), the UK's independent climate advisory body, estimated that to reach its new 2050 target, the UK will need to reduce emissions by 78% from 1990 levels by 2035.[13] In response, the UK government enshrined the target of a 78% reduction by 2035 in law in April 2021[14], going beyond the Nationally Determined Contributions (NDC) target set in 2020 under the Paris Agreement.[15] This pathway advances the timescales of transition by fifteen years compared to prior targets. The new target is even more challenging given that the Department for Business, Energy & Industrial Strategy (BEIS) predicted that the

[8] Climate Change Committee (2019) Net Zero: The UK's contribution to stopping global warming. Available from https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf Accessed 17 September 2021

[9] Net zero is defined as the target of reducing the UK's net greenhouse gas (GHG) emissions by at least 100%

[10] Department for Business, Energy & Industrial Strategy (2019) *UK becomes first major economy to pass net zero emissions law*. Available from https://www.gov.uk/government/news/uk-becomes-first-major-economy-to-pass-net-zero-emissions-law. Accessed 19 January 2021

[11] Climate Change Committee (2020) *Policies for the sixth carbon budget and net zero*. Available from https://www.theccc.org.uk/wp-content/uploads/2020/12/Policies-for-the-Sixth-Carbon-Budget-and-Net-Zero.pdf. Accessed 20 January 2021

[12] Climate action tracker (2020) *CAT Emissions Gaps.* Available from https://climateactiontracker.org/global/cat-emissions-gaps/. Accessed 23 July 2021

[13] Climate Change Committee (2020) The Sixth Carbon Budget: The UK's path to Net Zero. Available from https://www.theccc.org.uk/wp-content/uploads/2020/12/The-Sixth-Carbon-Budget-The-UKs-path-to-Net-Zero.pdf Accessed 2 September 2021

[14] UK Government (2021) *UK enshrines new target in law to slash emissions by 78% by 2035*. Available from https://www.gov.uk/government/news/uk-enshrines-new-target-in-law-to-slash-emissions-by-78-by-2035.Accessed 7 July 2021

[15] Department for Business, Energy & Industrial Strategy (2020) The UK's Nationally Determined Contribution under the Paris Agreement. Available from https://www.gov.uk/government/publications/the-uks-nationally-determined-contribution-communication-to-the-unfccc Accessed 14 September

UK could miss its previous carbon reduction milestones set by the Fourth Carbon Budget (2023-2027) unless additional policy action is taken.[16]

The CCC's Sixth Carbon Budget recommendations - which set out possible pathways to net zero by 2050 - are based on significant changes in people's lifestyles and technological transformations of large parts of the economy. These shifts create opportunities in low-carbon industries (such as offshore wind), but may put some high-carbon industries at risk if they are unable to transition.

1.1.1. National policies to support net zero pathways

In order to achieve these emission reduction targets, substantial investment is required from the government and the private sector. According to the CCC, delivering the Sixth Carbon Budget will require a £50 billion annual investment by 2030 in order to reach the 2050 target, compared to current investment of around £10 billion per year.[17] However, the CCC estimates that effective policy could cut the annual investment into cost of capital from £17 billion to £3 billion by 2050.[18] Low-carbon technologies can have high upfront costs, such as low-carbon heating, even though longer-run operational costs tend to be lower than their high carbon alternatives.[19] Technologies such as carbon capture use and storage (CCUS) are still in the development and demonstration phase, and so investment will be necessary to commercialise these technologies and deploy them at scale.

To support and accelerate progress to net zero, the Prime Minister's Ten Point Plan for a Green Industrial Revolution was announced in November 2020. The Plan sets out to mobilise public investment worth £12 billion, with potentially up to three times more from the private sector, to create and support a quarter of a million green jobs by 2030.[20] The plan covers offshore wind, hydrogen, nuclear power, CCUS, green transport, green buildings and green finance, and is intended to generate a 180 million tonne (Mt) reduction of carbon dioxide equivalent emissions between 2023 and 2032.[21]

Alongside the Ten Point Plan, significant government net zero investments were also announced in the 2020 and 2021 Budgets and Spending Review 2020. These announcements

[16] National Audit Office (2020) *Achieving net zero*. Available from https://www.nao.org.uk/wp-content/uploads/2020/12/Achieving-net-zero.pdf. Accessed 21 January 2021

[17] Climate Change Committee (2020) The Sixth Carbon Budget: The UK's path to Net Zero. Available from https://www.theccc.org.uk/wp-content/uploads/2020/12/The-Sixth-Carbon-Budget-The-UKs-path-to-Net-Zero.pdf Accessed 8 September 2021

[18] Sixth Carbon Budget Advisory Group (2020) The Road to Net-Zero Finance. Available from https://www.theccc.org.uk/publication/the-road-to-net-zero-finance-sixth-carbon-budget-advisory-group/ Accessed 17 September 2021

[19] Climate Change Committee (2020) *Policies for the sixth carbon budget and net zero*. Available from https://www.theccc.org.uk/wp-content/uploads/2020/12/Policies-for-the-Sixth-Carbon-Budget-and-Net-Zero.pdf. Accessed 1 March 2021

[20] HM Government (2020) *The Ten Point Plan for a Green Industrial Revolution*. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/936567/10_POINT_PLAN_BOOKLET.pdf. Accessed 21 January 2021

[21] HM Government (2020) *The Ten Point Plan for a Green Industrial Revolution*. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/936567/10_POINT_PLAN_BOOKLET.pdf. Accessed 25 March 2021

built on the 2017 Clean Growth Strategy,[22] and included a pledge to at least double funding for energy innovation and the creation of a Carbon Capture and Storage (CCS) Infrastructure fund to establish CCS in at least two sites in the UK. At the Spending Review in November 2020, the Carbon Capture and Storage Infrastructure Fund's allocation of £1 billion was confirmed.[23] The 2021 Budget announced that the UK would be issuing its first sovereign green bond, or green gilt, totalling a minimum of £15 billion for this financial year to help meet the government's green objectives.[24] The first green gilt is set to be issued in September 2021, and Green Savings Bonds are set to go on sale later in the year.[25] In June 2021, the government also launched a new Infrastructure Bank that will be used to play a part in helping the government achieve its net zero target.[26]

The Ten Point Plan also recognised that investment alone is not enough and committed the government to devise sectoral strategies, in conjunction with the overall UK Net Zero Strategy, to meet targets. To date[27] the government has published its industrial decarbonisation strategy[28], transport decarbonisation plan[29], hydrogen strategy[30], energy white paper[31], and 25 year environment plan[32], amongst others. The Green Jobs Taskforce was also launched as part of the Ten Point Plan, with the main aim of the taskforce being to determine the skills needed across all sectors for the transition to net zero. They published findings as part of an independent report[33] in July 2021.

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[22] HM Government (2017) *The clean growth strategy*. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700496/clean-growth-strategy-correction-april-2018.pdf. Accessed 19 January 2021
HM Government (2020) *The Ten Point Plan for a green industrial revolution*. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/936567/10_POINT_PLAN_BOOKLET.pdf. Accessed 19 January 2021

[23] Department for Business, Energy and Industrial Strategy (2021) *The Carbon Capture and Storage Infrastructure Fund: an update on its design*. Available from https://www.gov.uk/government/publications/design-of-the-carbon-capture-and-storage-ccs-infrastructure-fund/the-carbon-capture-and-storage-infrastructure-fund-an-update-on-its-design-accessible-webpage Accessed 6 July 2021

[24] HM Treasury (2021) *Budget 2021: Protecting the jobs and livelihoods of the British people*. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/966868/BUDGET_2021_-_web.pdf. Accessed 12 March 2021

[25] Timing would be subject to demand and market conditions. HM Treasury (2021) *UK Government Green Financing*. Available from https://www.gov.uk/government/publications/uk-government-green-financing#history. Accessed 6 July 2021

[26] HM Treasury (2021) *UK Infrastructure Bank Policy Design*. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/966131/UKIB_Policy_Design.pdf. Accessed 25 March 2021

[27] As of July 2021.

[28] HM Government (2021) *Industrial Decarbonisation Strategy*. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/970229/Industrial_Decarbonisation_Strategy_March_2021.pdf. Accessed 24 March 2021

[29] UK Government (2021) *Transport decarbonisation plan*. Available from https://www.gov.uk/government/speeches/transport-decarbonisation-plan. Accessed 16 July 2021

[30] UK Government (2021) *UK hydrogen strategy*. Available from https://www.gov.uk/government/publications/uk-hydrogen-strategy. Accessed 18 August 2021.

[31] UK Government (2020), *Energy white paper: Powering our net zero future*. Available from https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future. Accessed 16 July 2021.

[32] UK Government (2019), A Green Future: Our 25 Year Plan to Improve the Environment. Available from https://www.gov.uk/government/publications/25-year-environment-plan. Accessed 19 February 2021.

[33] Green Jobs Taskforce (2021) *Green Jobs Taskforce report*. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1002112/green-jobs-taskforce-report__1_.pdf. Accessed 16 July 2021

The CCC advised in their 2019 Net Zero report[34] that policies will fail if they are seen as unfair or if they are not sufficiently funded. The report recommended that a review should be undertaken by HM Treasury to understand where costs may fall and how the transition could be funded. HM Treasury accepted this recommendation and published their Net Zero Review: Interim Report in 2020.[35] The UK Innovation Strategy[36] was also published in July 2021 and sets out the government's plans to transform the UK into a global hub for innovation by 2035, which could help to tackle issues including climate change.

Alongside investment, a policy approach will also need to address the international aspects of the net zero transition. Ambitious net zero targets without similar efforts by trading partners raise a risk of the UK losing its competitive advantage in highly traded and carbon exposed sectors (e.g. steel, chemicals) through carbon leakage.[37] At the same time, as trading partners put in place carbon requirements for imports, UK decarbonisation will be increasingly important to accessing markets. Collaborative international efforts to decarbonise are required alongside the UK's domestic measures to ensure the net zero transition enables competitive UK business. The UK government's climate ambitions and global leadership at this key moment for climate action as it pushes sits alongside broader aims of promoting a Global Britain.

1.1.2. Regional impacts of net zero transition

There are multiple pathways to net zero and government policy is key not only in achieving decarbonisation, but also in ensuring that all regions make the most of opportunities that result from a net zero future. Given regional variations in the distribution of new and at-risk sectors, there will likely be different opportunities and challenges for each region of the UK. This variation, along with the associated impacts on jobs and skills, will require a national strategy with a localised approach, which fully addresses issues and challenges faced at the local level. Closer collaboration between national and local government will be necessary to achieve this aim.[38]

There is also a growing emphasis, both within government and in the private sector, that the transition to a net zero economy must be fair. Achieving a fair transition includes ensuring that the benefits of the transition are felt widely across the population, and that vulnerable groups are largely protected from negative impacts. Greater understanding of the distributional impacts of a net zero transition is therefore needed.

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[34] Climate Change Committee (2019) *Net Zero – The UK's contribution to stopping global warming*. Available from https://www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/. Accessed 3 March 2021

[35] HM Treasury (2020) *Net Zero Review: Interim repor*t. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/945827/Net_Zero_Review_interim_report.pdf. Accessed 3 March 2021

[36] Department for Business, Energy and Industrial Strategy (2021) UK Innovation Strategy. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1009577/uk-innovation-strategy.pdf Accessed 9 September 2021

[37] Defined by the The Intergovernmental Panel on Climate Change (IPCC) as ''the increase in CO2 emissions outside the countries taking domestic mitigation action divided by the reduction in emissions of these countries'. Available from https://www.ipcc.ch/report/ar4/wg3/. Accessed 7 July 2021

[38] Place-based climate action network (2021) *Trends in local climate action in the UK*. Available from https://pcancities.org.uk/sites/default/files/TRENDS%20IN%20LOCAL%20CLIMATE%20ACTION%20IN%20THE%20UK%20_FINAL.pdf. Accessed 30 March 2021

The aim of this report is to explore some of the potential implications of national net zero scenarios and their impact on a regional basis, specifically with respect to the North East.

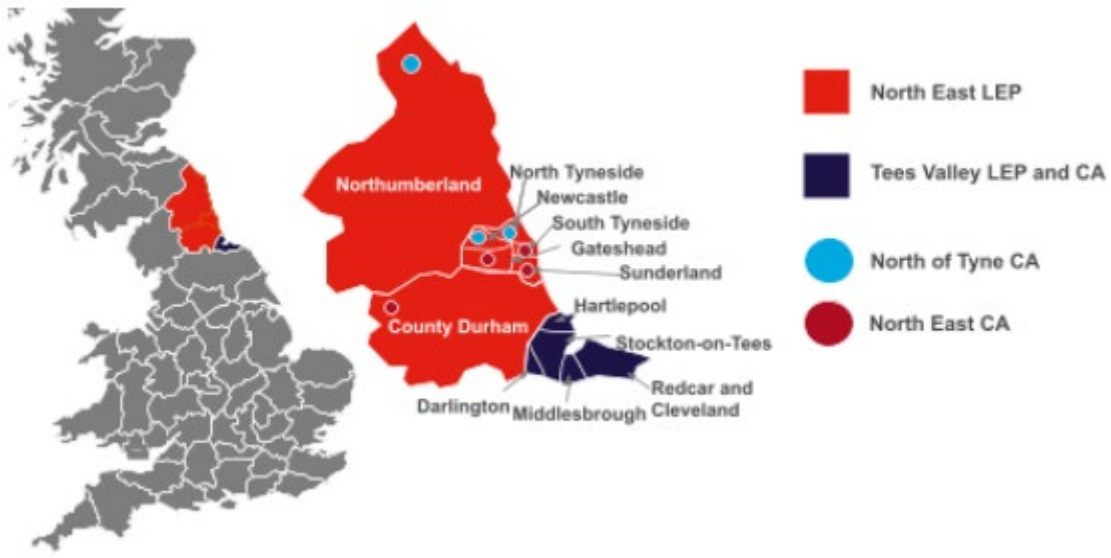
1.2. Scope of the study

This report and the accompanying analysis aim to develop and pilot a methodology that provides an experimental assessment of the potential impact of different net zero transition scenarios on regions of the UK. The study focuses on the North East to develop and test an approach for assessing the impact of the transition in a way that can be replicated and compared across regions, with a view to applying the methodology in other regions. The North East region was selected as it is geographically diverse, with both large rural and highly urban areas. It is an industrialised region that also faces economic challenges such as relatively high levels of unemployment, poverty and deprivation compared to the UK average. Further detail on the composition of the North East region is set out in Annex A.

The next subsections set out definitions of the North East as the region of analysis and of the sectors analysed, before providing an overview of the methodology used in the analysis.

1.2.1. Defining the North East region

The North East area comprises twelve local authorities (LAs) which are grouped into three combined authorities (CAs) and two local enterprise partnerships (LEPs). The CAs are the North of Tyne (mayoral), North East (non-mayoral), and Tees Valley (mayoral), while the LEPs are the North East LEP and the Tees Valley LEP. The North East LEP comprises both the North of Tyne and North East CAs. For the purposes of this study, the focus is on the two LEPs (North East and Tees Valley).



Source: Office for National Statistics (ONS), PwC calculations (2018, 2019)

The North East LEP

The North East LEP is the most northerly LEP in England, and borders Scotland, Cumbria LEP, York and North Yorkshire LEP and Tees Valley LEP. This LEP also borders the North Sea, offering natural opportunities for trade and offshore energy.

Within the North East LEP are the seven LAs - County Durham, Gateshead, Newcastle, North Tyneside, Northumberland, South Tyneside and Sunderland - all of which have declared a climate emergency.[39] There are three cities in the LEP area: Newcastle, Durham and Sunderland. Newcastle is a key transport gateway, and hosts important science, education, culture, digital and service sectors. Durham contributes to the science sector as home to one of the region's leading universities, and is also an important city for culture and tourism in the North East. Nissan, the UK's largest automotive manufacturing company in 2020[40] has its single biggest European production site in the UK in Sunderland. The North East LEP's economic strategy also notes that Sunderland has strong digital software, education and culture sectors.[41] The LEP contains four universities; Newcastle, Durham, Northumbria and Sunderland.

The North East LEP spans over an area of over 3,000 square miles, making it the sixth largest LEP area[42] in England.[43] In addition to its urban centres, the region has agricultural land and large areas of nature reserves, such as Northumberland National Park, which contribute to the net negative carbon dioxide (CO2) emissions from the region's land use sector.[44] It is also the ninth largest LEP in terms of population out of the 38 LEPs in England, with almost two million residents. Across the LEP area there is a mix of urban, suburban and rural areas.

Economically, the North East LEP is generally similar to the UK in terms of its overall economic structure, with most jobs and gross value added (GVA)[45] coming from the services sector. However, the region has traditionally had a focus on the mining and manufacturing sectors.

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[39] Committee on Climate Change (2020) *Local Authorities and the Sixth Carbon Budget*. Available from https://www.theccc.org.uk/wp-content/uploads/2020/12/Local-Authorities-and-the-Sixth-Carbon-Budget.pdf. Accessed 11 March 2021

[40] The Guardian (2021) *UK car production in 2020 slumped to lowest level since 1984*. Available from https://www.theguardian.com/business/2021/jan/28/uk-car-production-in-2020-slumped-to-lowest-level-since-1984. Accessed 13 July 2021

[41] North East Local Enterprise Partnership (2019) The North East Strategic Economic Plan. Available from https://www.nelep.co.uk/wp-content/uploads/2019/02/north-east-strategic-economic-plan-jan-2019-final.pdf. Accessed 17 September 2021

[42] North East Local Enterprise Partnership (2019) *The North East Strategic Economic Plan*. Available from https://www.nelep.co.uk/wp-content/uploads/2019/02/north-east-strategic-economic-plan-jan-2019-final.pdf. Accessed 13 January 2021

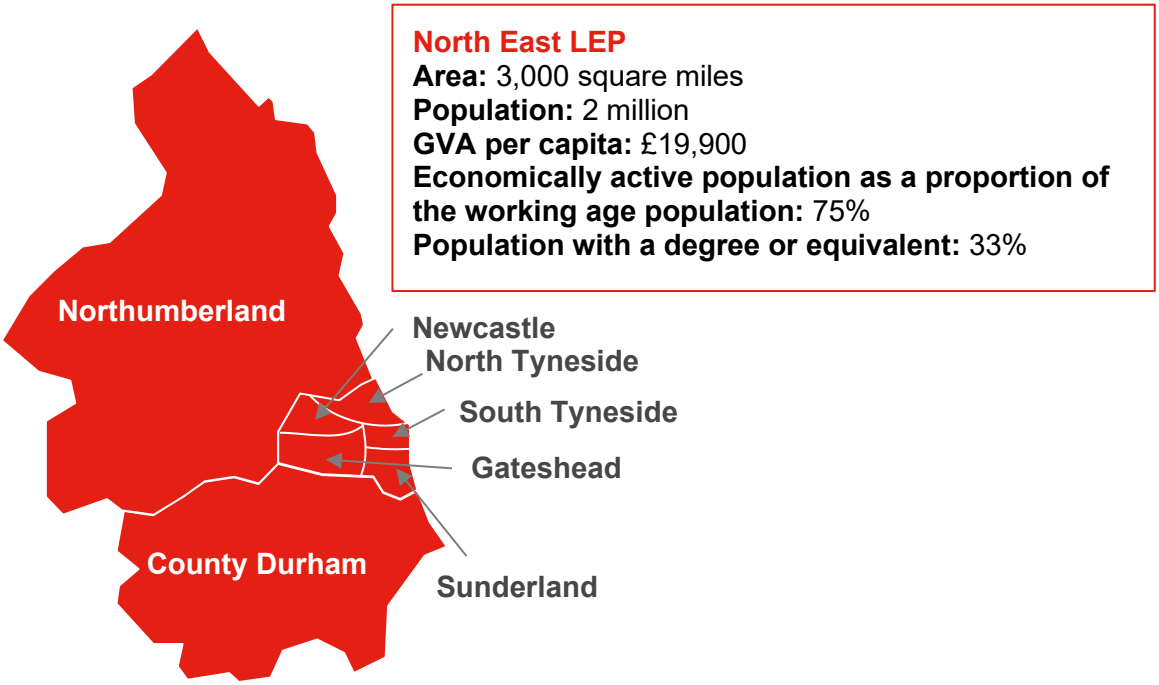
[43] Office for National Statistics (2020) *Local Enterprise Partnerships (April 2020) Boundaries*. Available from https://geoportal.statistics.gov.uk/datasets/local-enterprise-partnerships-april-2020-boundaries-en-bfe/explore. Accessed 13 July 2021

[44] Based on current emissions accounting. Department for Business, Energy and Industrial Strategy (2020) *UK local authority carbon dioxide emissions estimates 2018*. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/894785/2005-18-local-authority-co2-emissions-statistical-release.pdf. Accessed 29 June 2021

[45] Gross Value Added (GVA) represents the value of goods and services produced in a region, industry or sector of an economy, before taxes and subsidies. An impact in direct terms refers to the activity generated from the initial spending in the economy

Manufacturing continues to be an important focus in the area, with other clusters in automotive and medicine manufacturing.[46]

Figure 2: The North East LEP



Source: ONS, PwC calculations (2018, 2019)

The Tees Valley LEP

The Tees Valley LEP is situated south of the North East LEP and borders the York and North Yorkshire LEP and the North Sea.

Within the Tees Valley LEP there are five LAs: Darlington, Hartlepool, Middlesbrough, Redcar and Cleveland and Stockton-on-Tees, three of which have declared a climate emergency (Redcar and Cleveland, Darlington and Middlesbrough,). The LEP is home to Teesside University in Middlesbrough and the University of Durham (Queens Campus), with other further education colleges also offering higher education courses.[47] The Tees Valley LEP covers five distinct town centres. Notably, Darlington acts as the area's gateway to the rest of the UK with a major rail hub that provides north-south connectivity, Hartlepool which is home to a major exporting port provides a gateway to world markets and Teesport which is the largest trading port in the North East. Teeside has also recently received Freeport status[48], which covers a

[46] North East LEP (2019) *North East Energy for growth*. Available from https://www.nelep.co.uk/wp-content/uploads/2019/08/full-strategy-energy-for-growth-strategy.pdf. Accessed 8 March

[47] Tees Valley Combined Authority (2020) *Tees Valley Economic Assessment*. Available from https://teesvalley-ca.gov.uk/wp-content/uploads/2021/02/Tees-Valley-Economic-Assessment-2020.pdf. Accessed 12 July 2021

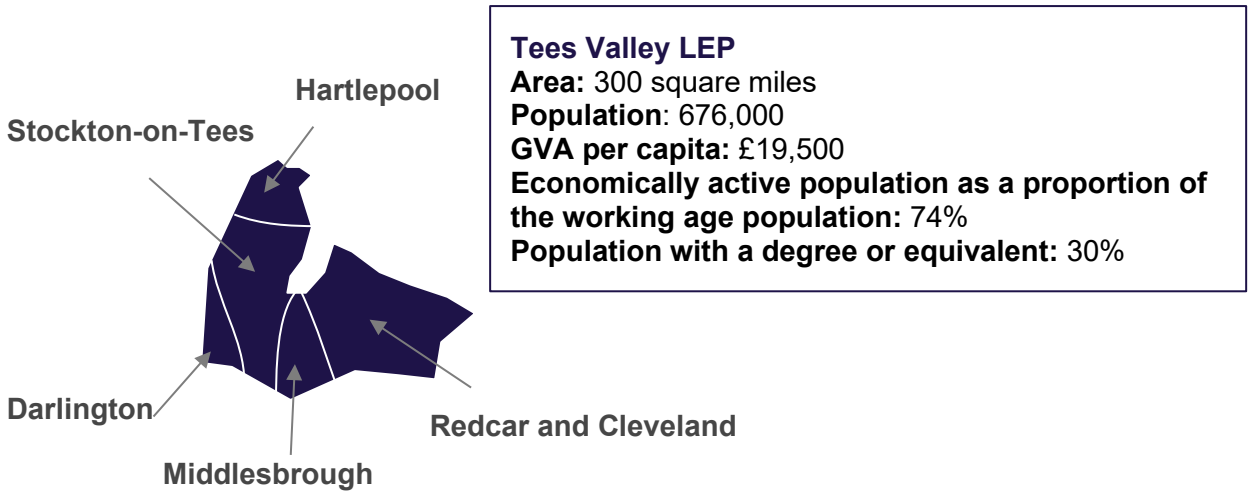
[48] HM Treasury (2021) Budget 2021. Available from https://www.gov.uk/government/publications/budget-2021-documents Accessed 17 September 2021

range of sites including Teesport, the Port of Hartlepool, and the Port of Middlesbrough, among others.

In contrast to the North East LEP, the Tees Valley LEP covers only 300 square miles and is highly urbanised, with 90% of the population found in urban areas.[49] The population of Tees Valley LEP stood at 676,000 in 2019 making it the smallest LEP in terms of population in England.[50]

Economically, Tees Valley LEP has an economic structure broadly similar to the UK, with services sectors overall accounting for the majority of employment and GVA. However, it is also home to important industrial clusters, with relatively high carbon emissions, evidenced by the 'industrial, commercial, and public' sector category in the North East region producing 2.9 Mt CO2 emissions per capita in 2018, 0.9 Mt higher than the UK average.[51] The Tees Valley LEP highlighted the large chemicals and processing industry in the region in the Tees Valley Strategic Economic Plan, with the plan also noting that employment levels in advanced manufacturing are at least one and a half times the national average.[52]

Figure 3: The Tees Valley LEP



Source: ONS, PwC calculations (2018, 2019)

Despite their differences, the two LEPS share characteristics which may affect their exposure to the net zero transition. Compared to the UK average, both LEPs have relatively low per

[49] Tees Valley Combined Authority (2018) *Tees Valley Economic Assessment*. Available from https://teesvalley-ca.gov.uk/wp-content/uploads/2019/03/Tees-Valley-Economic-Assessment-2018.pdf Accessed 19 January 2021

[50] ONS (2020) *Estimates of the population for the UK, England and Wales, Scotland and Northern Ireland*. Available from https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/populationestimatesforukenglandandwalesscotlandandnorthernireland. Accessed 10 February 2021

[51] Department for Business, Energy & Industrial Strategy (2020) *UK local authority carbon dioxide emissions estimates 2018*. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/894785/2005-18-local-authority-co2-emissions-statistical-release.pdf. Accessed 21 July 2021

[52] Tees Valley Combined Authority (2016) *Tees Valley Strategic Economic Plan: The Industrial Strategy for Tees Valley*. Available from https://teesvalley-ca.gov.uk/wp-content/uploads/2016/03/TVCA-Strategic-Economic-Plan-2016-26.pdf. Accessed 8 March 2021

capita income, with GVA per capita at around only 70% of the UK average of £27,700.[53] Since 1992 (the earliest year for which regional figures are available), the unemployment rate in the North East region has also been consistently higher than the UK average.[54] The local labour market continues to be weaker, with unemployment rates of 6.1% (Tees Valley LEP) and 6.3% (North East LEP) compared to the UK average of 4.2% in 2020.[55,56] Further, the North East region has lower levels of higher educational qualification (NVQ4+), which stand at 30% (Tees Valley) and 33% (North East) compared to the UK average of 40%.[57] Overall, the region also has a relatively high level of deprivation, with Tees Valley LEP and the North East LEP ranked 5th and 6th highest out of 38 LEPs in England based on the index of multiple deprivation.[58] Together, these characteristics may lead to greater exposure in the North East if lower average incomes and higher joblessness are exacerbated by the changes of transition.

Beyond labour market and income measures, the regional industrial base and research infrastructure may also affect the North East's exposure to transition. Overall, the relative size of manufacturing clusters (chemical, process and advanced manufacturing sectors etc.) and relatively higher number of people in process, plant and machine operative roles in the North East mean that the region faces greater exposure to net zero transition if it cannot decarbonise, but also serve as an opportunity for forming a green industrial base.[59]

The region is well connected globally, with the highest proportion of its exports going to non-EU countries, at 62%[60], which could provide a basis for newly decarbonised industry to flourish through trade and could create a role for the North East in transport decarbonisation, given the automotive manufacturing cluster based in the region. Finally, as noted above, the region is also home to several important universities, which award a significant number of research degrees related to the low-carbon economy, such as electronic and chemical engineering.[61] However, graduate retention has been identified as an issue,[62] and despite higher unemployment rates in the region, businesses regularly report skills shortages which point to a potential skills mismatch in the labour market.[63]

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[53] GVA per capita of £19,900 for the North East LEP. GVA per capita of £19,500 for the Tees Valley LEP.

[54] ONS (2021) *LFS: ILO unemployment rate: North East: All: %: SA*. Available from https://www.ons.gov.uk/employmentandlabourmarket/peoplenotinwork/unemployment/timeseries/ycnc/lms. Accessed 23 March 2021

[55] NOMIS (2019*) Annual Population Survey*. Available from https://www.nomisweb.co.uk/. Accessed 9 March 2021

[56] The data used is pre-covid (2019 to 2020) and therefore there are potential effects of Covid-19 that may not be accounted for in these figures.

[57] NOMIS (2019) *Qualifications (NVQ) by age*. *Annual Population Survey*. Available from https://www.nomisweb.co.uk/query/select/getdatasetbytheme.asp?opt=3&theme=&subgrp=. Accessed 21 January 2021

[58]UK government (2019) Local Enterprise Summaries. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/834002/File_12_-_IoD2019_Local_Enterprise_Partnership__LEP__Summaries.xlsx Accessed 10 September 2021

[59] NOMIS (2019) *Annual Population Survey*. Available from https://www.nomisweb.co.uk/. Accessed 9 March 2021

[60] HMRC (2017) *UK Regional Trade in Goods Statistics* in D. Baxter, J. Emden, L. Laybourne-Langton and H. Lloyd (2017) *Net-Zero North: Delivering the decarbonisation mission in the north of England* (reference) Available from https://www.ippr.org/files/2017-12/net-zero-north-report-1712.pdf. Accessed 19 January 2021.

[61] Joshua Emden and Luke Murphy (2019) A just transition - realising the opportunities of decarbonisation in the north of England. Available from https://www.ippr.org/files/2019-03/energy-skills-march19.pdf. Accessed 8 September 2021.

[62] Joshua Emden and Luke Murphy (2019) *A just transition - realising the opportunities of decarbonisation in the north of England*. Available from https://www.ippr.org/files/2019-03/energy-skills-march19.pdf. Accessed 21 January 2021.

[63] Vivid Economics (2020) *Net Zero Teesside*. Available from https://www.netzeroteesside.co.uk/wp-content/uploads/2020/06/20200508_NZT_Economic_Benefits_Report_Edited_Clean_web.pdf. Accessed 9 March 2021

1.2.2. Sectors within scope of this report

There are different ways to categorise sectors when analysing net zero. For the purpose of this report five categories have been defined based on the types of climate action required. These are an aggregation of existing model groupings (UKTM[64] model sector outputs and sectors defined by the CCC), which were grouped following discussions in stakeholder interviews.[65]

1. **Energy and electricity** - including nuclear energy capacity, hydrogen, offshore and onshore wind, solar, biomass, other renewables, and supporting energy infrastructure including in transport and for buildings (e.g. pipelines and meters). This sector also includes energy from oil and gas;
2. **Transport** - including surface transport, shipping, and aviation. Surface transport is the main form of transport in the region and includes cars, buses, passenger rail, and freight and goods vehicles. The transport sector also includes the manufacture of vehicles for transport, which in the case of the North East is focused on the transition to electric vehicle manufacturing;
3. **Buildings** - including residential and commercial buildings and their heat decarbonisation strategy (e.g. through the adoption of hydrogen boilers or heat pumps), and retrofitting to improve energy efficiency. Buildings also includes domestic and commercial appliances;
4. **Industry and carbon capture** - including industry, manufacturing, and carbon capture, usage and storage (CCUS)[66]; and
5. **Land use and agriculture** - including planting of trees and restoration of peatlands, livestock farming and agriculture.

The analysis does not cover all parts of the economy. This is because the analysis is based on direct supply chain impacts related to sectors analysed in UKTM, which is an energy systems model rather than a full economy-wide model.[67] Importantly, some key sectors of the economy are not covered, including those which are service based such as finance and insurance activities. Additionally, experimental estimates of net zero exposure focus on the first four sectors listed above. This focus is due to the regional impact tool and available data being unsuitable for estimating the impact of net zero transition on the land use and agriculture sector. However, the report discusses this sector qualitatively and using the data available in section 3.5, given its relative importance to the region.

[64] UKTM is an energy system model of the UK. It has been developed by UCL and the BEIS and is used to inform UK government policy.

[65] UKTM is an energy system model of the UK. It has been developed by UCL and the BEIS and is used to inform UK government policy.

[66] Including biomass and gas CCS for power.

[67] Further details on the sectors in the UKTM are available in Annex D.

1.3. Overview of methodology and approach

There were two main workstreams undertaken in parallel as part of the study. The first was a qualitative workstream, where a review of literature related to net zero and the North East region was conducted, and was supplemented by stakeholder interviews with LEP officials, central government, academics, industry associations and citizen groups. The interviews were conducted in January and February 2021. The literature review covered primarily UK policy documents, local strategic documents and sector specific sources.

The second workstream used a quantitative approach to generate experimental estimates of the potential impact of net zero for the North East. This work included exploring different national net zero scenarios for the UK and how they might be "localised", in other words, how the national scenarios might be applied to different regions of the country, taking into account the region's economic characteristics. Localisation assumptions and national level estimates on net zero transition were brought together in a regional impact tool to produce estimates of the potential exposure of the North East to the net zero transition.

This approach is considered experimental and the intention is to continue refining this methodology as research is undertaken on approaches to localisation of net zero transition. Future work could also explore different scenarios/pathways to net zero given the uncertainty around how net zero will be achieved.

1.4. Structure of the report

The remainder of this report is structured as follows:

Chapter 2 discusses the national net zero pathways and the approach taken to localising these pathways for the regional impact tool analysis in Chapter 3.

Chapter 3 outlines the potential impact of net zero on the North East region. It looks across five key sectors: energy and electricity, transport, buildings, industry and carbon capture, land use and agriculture.

Chapter 4 considers the opportunities and risks in terms of governance, infrastructure and skills in the North East region as a result of net zero transition.

Chapter 5 brings together the findings and the results to make an overall assessment of the potential impact of a net zero transition for the North East, and to discuss exposure of the North East to the transition region.

2. Understanding transition exposure in the North East

While there are national plans and scenarios to achieve net zero for the UK as a whole, regional variation of sectors and industries mean that these plans will differ on a regional and local basis. This chapter examines these national net zero pathways and then sets out the approach to applying these pathways in the North East region, in the context of stakeholder interviews and the available literature, to generate estimates of the potential impact on the North East.

2.1. National net zero pathways

There are many different pathways that could be taken to achieve the net zero target. As part of the analysis for the setting of the Sixth Carbon Budget, BEIS modelled four pathways of investment and technological change by which the UK could reach net zero by 2050. The variation in the four pathways is due to technological and behavioural factors, and more detail can be found in Annex E, as well as in the published Impact Assessment for the Sixth Carbon Budget.[68] The potential net zero exposure estimates in this report use the core national net zero pathway to assess the impact of net zero on the North East, in line with the Sixth Carbon Budget Impact Assessment.

2.2. Approach to understanding transition exposure in the North East

The analysis of net zero exposure in the North East comprises two key elements. Firstly, sector based analysis is undertaken (Chapter 3 of this report), based on the five sector groupings[69] set out in section 1.2 above. For each sector, four key areas are covered to build an understanding of the current and potential future state:

a. **The current state of the sector**, including the sector's current emissions;
b. **Key findings from interviews and stakeholder engagement**;
c. **The localisation approach** used for the sector to adapt the Sixth Carbon Budget national net zero scenarios to the region; and
d. **Experimental estimates of the potential impacts of net zero transition to 2050.**[70] This analysis uses the regional impact tool to estimate potential exposure to net zero in the North East. The analysis distinguishes between the potential 'opportunity' (e.g. new jobs or economic activity) and 'risk' (potential losses, primarily associated with legacy

[68] Department for Business, Energy and Industrial Strategy (2021) *Impact Assessment for the sixth carbon budget*. Available from https://www.legislation.gov.uk/ukia/2021/18/pdfs/ukia_20210018_en.pdf. Accessed 29 June 2021

[69] These are an aggregation of existing model groupings (UKTM model sector outputs and sectors defined by the CCC), grouped after holding stakeholder interviews.

[70] The regional impact analysis also considers the impact of international markets, Refer to the Annex D for more detail.

industry or technology) of net zero transition in order to get a broad sense of the scale of transformation needed.

Secondly, analysis of the opportunities and risks in governance, infrastructure and skills in the North East is undertaken (Chapter 4), predominantly through the stakeholder interviews, and based on relevant reports and literature.

The remainder of this chapter sets out the approach taken to conduct the analysis of potential regional impacts in Chapter 3.

The current state of the sector

To understand the current state and exposure of the North East's economy to a transition to net zero, various indicators (such as emissions per capita, renewable energy generation and installed vehicle charging infrastructure) are used across key industries for both LEPs in the North East, as well as across the regions of England. These indicators cover a range of areas which may make a regional economy more exposed, such as CO2 emissions or GVA per capita.

The full tables (which also include the LEPs' direct exposure of employment and the exposure of occupation types, across sectors, compared to the North East as a whole, and relative to England) are provided in Annex B, with key highlights covered in Chapter 3.[71]

Findings from interviews and stakeholder engagement

In order to build a deeper understanding of the opportunities and challenges facing the North East as it transitions to net zero, interviews were held with 17 regional and sectoral stakeholders. Interviews were held with LEP officials, central government, academics, industry associations and citizen groups. Key findings from the interviews are presented alongside analysis of the literature to support overall conclusions and results from the regional impact tool in Chapter 3 and 4. A full list of interviewees is available in Annex C.

Localisation approach

The decarbonisation scenarios used in this report are based on national scenarios generated from the UKTM model[72] as part of the Sixth Carbon Budget analysis. These scenarios are then 'localised' to analyse how impacts of the net zero transition may vary across the UK. There are several reasons why the effects of decarbonisation could vary across regions. These include:

1. Existing industry mix;
2. Infrastructure and geography; and
3. Differing technological or policy pathways.

Firstly, the industry mix of regions across the UK differs, leading to variance in the extent to which each region is exposed to decarbonisation. For example, the North East has a relatively high mix of high-carbon industries like natural gas extraction, compared to the Midlands and

[71] A greater degree of relative exposure in a region is assumed to be where employment is comparatively focused in high-carbon sectors or sectors which are anticipated to be impacted by a net zero transition.

[72] Dynamic Dispatch Model (DDM) results were used for certain energy and electricity sectors.

Southern regions.[73] Therefore, decarbonisation scenarios centred on phasing out natural gas would affect the North East in a different way to other regions.

Secondly, investments may also be concentrated in specific regions. Investment decisions in both existing or new sectors, can be based on a combination of geographic, business and policy factors, which again vary region to region.[74] For example, investments related to the expansion of the offshore wind industry may occur in areas with established ports.

Finally, different atmospheric conditions or socio-economic factors may also make one technology more suitable than another, increase the uptake or adoption in another, or affect its cost. For instance, temperature may impact the adoption of heat pumps regionally, while income levels could affect uptake of high cost low-carbon products.

To reflect the differences in regional characteristics such as those highlighted above, localisation assumptions were applied to each sector. These were developed on the basis of existing studies and data, policies on key sectors or regional challenges, and interviews with stakeholders in the North East.

The scenarios do not represent locally developed decarbonisation pathways, nor should they be interpreted as a statement of government policy. Instead, they are illustrative of how national changes in demand, capital and operational expenditure, and carbon emissions to reach net zero might apply in a region after considering local characteristics.

The approach used to develop localised scenarios can be compared to a top-down approach, rather than bottom-up, which uses assumptions to apply national scenarios to the region. Headline requirements to meet net zero at the national level are localised to the regional level based on a set of factors including, for example, population, policy statements, and existing infrastructure plans.

For most sectors and technologies, scenarios are localised in a proportionate way based on existing data, for instance, based on the number of households or jobs in the North East relative to other regions. However, in some emerging areas (e.g. CCUS) or areas where there was evidence from stakeholder interviews and the literature that a scenario would not be fully proportionate (e.g. heating), high-level assumptions were developed as an alternative. These high-level assumptions were generated in the absence of detailed data-driven alternatives, and should therefore be viewed as illustrative. A full list of the assumptions used to localise national scenarios is set out in Annex D.

Further, while localisation assumptions were used to attribute headline spending, demand changes, and carbon emissions to a region, this does not directly translate into an impact on jobs and economic value added in a region. For instance, when investment is made to install offshore wind capacity in the North East, a substantial amount of this spend may go to suppliers of turbines and other components sourced from outside the region. Accounting for

[73] D. Baxter, J. Emden, L. Laybourn-Langton and H. Lloyd (2017) *Net Zero North: Delivering the decarbonisation mission in the north of England*. Available from https://www.ippr.org/files/2017-12/net-zero-north-report-1712.pdf. Accessed 29 March 2021

[74] LSE (2020) *Jobs for strong and sustainable recovery from Covid-19*. Available from https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2020/10/Jobs_for_a_strong_and_sustainable_recovery_from_Covid19.pdf. Accessed 11 February 2021

these effects is an important part of the approach, but distinct from the localisation assumptions to attribute headline scenarios to the region.

To account for these effects in the estimates of potential regional exposure (see Chapter 3), a set of high level assumptions are made about how operational and capital expenditure will flow (after accounting for trade effects at a national level). In general, it is assumed that headline spending for operating expenditure and for installation is retained in the regional economy. With regard to capital expenditure, assumptions are based on the UK being a fully integrated market, and headline spending (both local and non-local) on net zero flows across regions are based on the relative size of the industry from which the capital expenditure is sourced. The underlying industry mix of the region is taken as constant over time, so changes in terms of new industry creation in the region are not estimated.

While these broad assumptions align with assumptions in some previous high-level work on new net zero technologies at a national level, they may not fully capture regional / national dynamics. For instance, jobs related to installation or operational expenditure could be filled by neighbouring regions, and installation contracts could be awarded to firms outside the region, with impacts for the local economy. Additional work could be undertaken to further investigate these dynamics and refine these broad underlying assumptions.

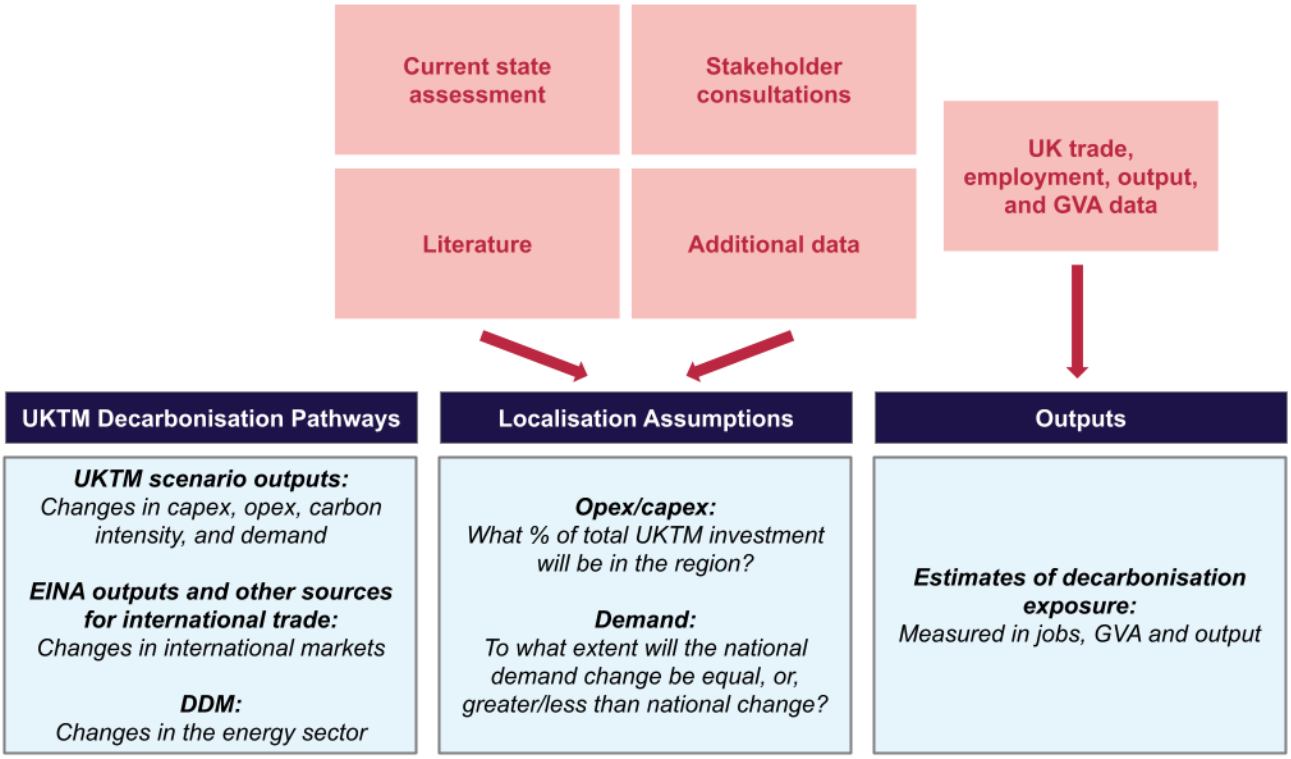
An important further note is that the regional impact tool takes into consideration the international sector - for instance, the potential market for UK firms as a result of decarbonisation around the world. At the national level, these estimates are based on existing work conducted for the Energy Innovation Needs Assessment (EINA), supplemented with sectoral trade data and information on the level of international ambition compared to UK decarbonisation ambition. These estimates are then localised using the same approach that was taken to localise national net zero impacts. This approach assumes that national investment in certain industries and areas attracts international expenditure as well.

Experimental estimates of the potential impact of a net zero transition

As part of the approach, a regional impact tool was developed to gain a forward-looking picture of the potential economic impacts of a net zero transition in the North East to 2050, as compared to 2020.

The tool combines the localisation assumptions set out in the previous subsection with data on UK trade and the international market, regional and national employment and economic value added, and the Sixth Carbon Budget national decarbonisation results, to estimate decarbonisation exposure primarily in terms of GVA and jobs.

Figure 4: Economic impact of a net zero transition (high level schematisation)



Source: PwC analysis
Note: EINA is an acronym for Energy Innovation Needs Assessment which support evidence and analysis on the role of different technologies in the UK's future energy system

The economic impacts of a net zero transition are presented as opportunities and risks at five-year intervals relative to 2020, up to 2050. Opportunities reflect a potential increase in GVA or jobs and may arise as existing sectors grow, such as offshore wind, or as new sectors emerge, such as CCUS. Risks are represented by a potential fall in GVA or jobs, as high-carbon sectors are phased out or contract. The opportunities and risks are offset to reflect the net exposure, or the economic value or jobs which are transferred from high-carbon to low-carbon sectors. Figures reflect direct supply chain impacts and do not include wider or indirect impacts, and do not provide any estimates or speculation on changes in wages, unemployment or the wider welfare impacts of net zero.

All figures presented in the body of this report are expressed as changes compared to 2020 values under the UKTM 'core scenario' (monetary figures are expressed in real terms, base year 2018). The estimates therefore include some element of underlying economic growth. To provide context on the relative impact of growth within the estimates, Figure 5 below compares the net job impacts under the UKTM core scenario and the alternative 'counterfactual' UKTM scenario.

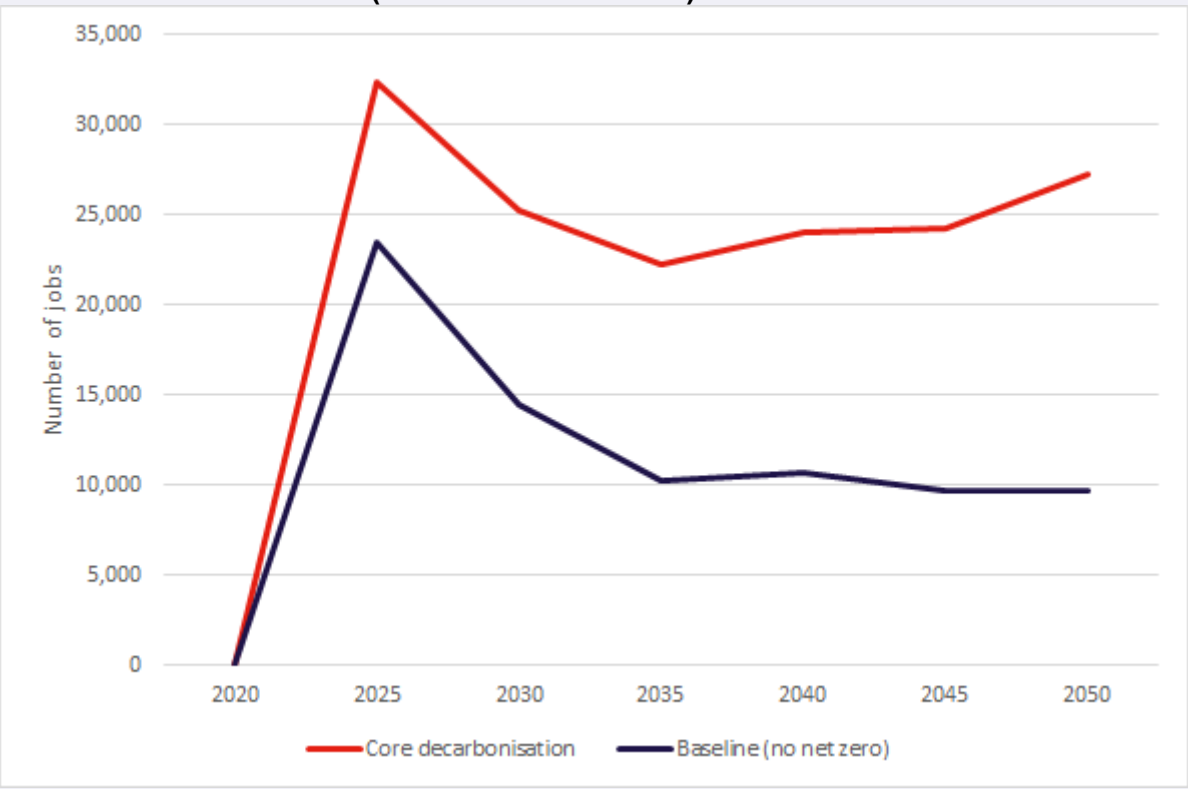
Box 1: Understanding the economic exposure estimates of a net zero transition in this report

The national net zero transition scenarios used as the basis of analysis come primarily from outputs of the Sixth Carbon Budget Impact Assessment.

The 'counterfactual' scenario in UKTM is based on the same underlying economic and growth assumptions as the core scenario, but considers how UK emissions could evolve from now in the absence of new (yet unannounced) policy action to reduce emissions (see Annex E for further information). As a result, it represents the impact of underlying growth assumptions in UKTM without achieving a net zero 2050 trajectory.

As can be seen in Figure 5 the proportion of net impact which is accounted for by underlying growth falls over time, from around two thirds to just over one third of net impact. This comparison should be kept in mind when interpreting results in the remainder of this report. Note the relative impact of growth compared to decarbonisation impact will vary sector to sector and by technology.

Figure 5: North East net job impacts compared to 2020 under the core and counterfactual scenario (for included sectors)



Source: PwC analysis

The exposure estimates presented in this report focus on jobs and GVA, and do not consider any household sector or distributional impacts. Impacts were in general estimated by associating changes in spending (operating and capital expenditure) and demand with changes in economic output in specific industry sectors (e.g. based on the principle that expenditure is equal to economic output at an aggregate level). GVA and jobs were estimated by using industry-specific ratios of jobs and GVA to output. As mentioned previously, in estimating the job impacts, the tool does not provide any estimates on changes in wages, unemployment or the wider welfare impacts of net zero.

In addition, the impacts are only estimated for a set of key sectors which are relatively directly impacted by decarbonisation, by either relating closely to the green economy or being an at-risk carbon-intensive industry. Some key sectors, such as financial services, are not included. As mentioned, impacts related to agriculture and land use are also excluded from the results because the regional impact tool and data available are not able to produce appropriate estimates of the impact of net zero on the sector. As such the results do not reflect the full list of sectors or show all job changes in the economy.

Finally, cost outputs from the UKTM dataset are in annualised terms, meaning that they distribute costs over the lifetime of assets rather than counting the full cost in the year the cost was incurred. For the purposes of understanding potential exposure, however, it is desirable to assign capital spending to the year in which it occurs: jobs in installation will be concentrated at the start of a project, rather than distributed evenly across the years it is in operation. To provide some understanding of the time profile based on actual outlay, data from the CCC's Sixth Carbon Budget total investment estimates and other non-annualised data provided by BEIS teams was used. In cases where CCC investment profiles are used to 'de-annualise' data (in Buildings, Industry and carbon capture, Transport, and some parts of the energy sector), this was based on both CCC and UKTM data reaching a steady state by 2050.[75] To the extent that this is not the case, exposure estimates (see Annex D) could vary. Exposure estimates should thus be interpreted as illustrative rather than precise estimates. It should also be noted that CCC figures[76] do not account for investment before an asset becomes operational, which may mean that exposure estimates in this report may appear in a later year than that they would occur in reality.

Further detail regarding the localisation approach for the regional impact tool is set out in the Annex D.

[75] The steady state being when the transition is 'completed', and when annualised costs are broadly equivalent to de-annualised costs, considering regular decommissioning and re-investment in assets.

[76] Climate change committee (2020) *Sixth Carbon Budget - Methodology Report*. Available from https://www.theccc.org.uk/wp-content/uploads/2020/12/The-Sixth-Carbon-Budget-Methodology-Report.pdf Accessed 26 July 2021

3. The impact of net zero on the North East

This chapter takes a closer look at the five sectors defined in section 1.2 (energy and electricity, transport, buildings, industry and carbon capture, and land use and agriculture) in the North East and how they may be affected by the net zero transition.

3.1. Energy and electricity

To successfully reach net zero, decarbonisation of energy and electricity generation will be key, as it contributed 27% to the UK's CO2 emissions in 2018.[77] This section looks at existing and new technologies in energy and electricity generation, and potential impacts for the North East as a result of the net zero transition in this sector. It covers low-carbon technologies (offshore and onshore wind, solar, nuclear, biomass, hydrogen fuel and other renewables such as hydro), as well as fossil fuels and energy related infrastructure.

3.1.1. Analysis of interview responses and literature

The advice provided by the CCC on the Sixth Carbon Budget was to set ambitious energy generation targets from renewables to help ensure the 2050 target is achieved. In line with these recommendations, BEIS and the UK government are developing a range of sectoral strategies to help meet the targets set. The three key low-carbon areas of relevance to the North East are hydrogen, offshore wind and nuclear, as there are a number of existing assets and supporting infrastructure which can help the transition.

Hydrogen

The use of hydrogen is seen as one of the key enablers in achieving a successful transition to net zero.[78] At a UK level, investment in this technology is already being announced. This includes the £240 million Net Zero Hydrogen Fund in the Budget 2020 to develop up to 5GW of low-carbon hydrogen capacity by 2030.[79]

The North East and Teesside in particular is already benefiting from new investment in hydrogen. In March 2021 BP announced the UK's largest hydrogen project based in Teesside, with the aim of producing 1GW and developing an industrial hydrogen cluster.[80] Tees Valley

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[77] Department for Business, Energy, and Industrial Strategy (2019) 2018 UK Greenhouse Gas Emissions, Provisional Figures. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/790626/2018-provisional-emissions-statistics-report.pdf . Accessed on 10 March 2021

[78] HM Government (2020) *The Ten Point Plan for a green industrial revolution*. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/936567/10_POINT_PLAN_BOOKLET.pdf. Accessed 19 January 2021

[79] HM Treasury (2020) *Net zero review: interim report*. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/945827/Net_Zero_Review_interim_report.pdf. Accessed 19 January 2021

[80] BP (2021) *BP plans UK's largest hydrogen project.* Available from https://www.bp.com/en/global/corporate/news-and-insights/press-releases/bp-plans-uks-largest-hydrogen-project.html. Accessed 30 March 2021

was also selected as the UK's first hub for a hydrogen transport pilot, securing £3 million in government funding which could create up to 5,000 new jobs.[81]

The majority of stakeholders interviewed mentioned the potential for hydrogen in the North East. Stakeholders highlighted that Tees Valley was already producing at least 50% of the commercially available hydrogen in the UK[82] and decarbonising the existing production facilities could be achieved through CCUS (discussed later in section 3.4), an area which has high potential in the region both on and off shore in the North Sea.

The North East is also well positioned for storing hydrogen due to the availability of salt caverns, particularly along the North East coast. [83]There are already operational salt caverns in Tees Valley (as well as in Cheshire and Warrington elsewhere in England) that store other gases and which have potential for expansion to meet increasing demand. The region also has a large chemicals processing value chain and asset base that could drive initial demand for low-carbon hydrogen production projects, as firms in the sector have historic capability and experience in hydrogen production, compared to other sectors. Stakeholders also highlighted how the existing gas infrastructure is currently well connected to ports in the region, allowing for the trade and distribution of hydrogen, which is factored into the plan by the H21 suite of gas industry projects to repurpose the existing gas network for hydrogen.[84]

A key concern amongst stakeholders was that there was no national framework or strategy for hydrogen at the time of writing. As a result, stakeholders noted that it was difficult for existing firms to channel private investment as they were not able to identify the correct opportunities. Stakeholders in government were aware of this issue and wider concerns around competition between clusters for public funding for this emerging technology. The UK's hydrogen strategy,[85] released in August 2021, looks to overcome these issues by setting out an approach for developing a low-carbon hydrogen sector. This includes a framework for business models in hydrogen at different levels of scale in order to achieve the target of 5GW production capacity by 2030.[86]

While electrification may be suitable for cars and light vehicles, heavy goods vehicles (HGVs) and larger vehicles like buses may be better suited for a switch to hydrogen. The high energy density of hydrogen compared to electric batteries is preferable for HGVs, as well as the speed at which hydrogen fuel cells can be refuelled. For refuelling in particular, a Teesside project has received £2.25 million of funding from the Office for Zero Emission Vehicles (OZEV) hydrogen for transport fund, in order to supply two of the first publicly-accessible hydrogen

[81] UK Government (2021) *UK's first ever hydrogen transport hub kick-started by £3 million government investment.* Available from https://www.gov.uk/government/news/uks-first-ever-hydrogen-transport-hub-kick-started-by-3-million-government-investment. Accessed 5 July 20201

[82] UK Government (2021) *UK's first ever hydrogen transport hub kick-started by £3 million government investment.* Available from https://www.gov.uk/government/news/uks-first-ever-hydrogen-transport-hub-kick-started-by-3-million-government-investment. Accessed 25 March 2021

[83] H21 (2021) H21 Pioneering a UK hydrogen network. Available from https://www.h21.green/. Accessed 10 March 2021

[84] H21 (2021) *H21 Pioneering a UK hydrogen network.* Available from https://www.h21.green/. Accessed 11 March 2021

[85] Department for Business, Energy & Industrial Strategy (2021) UK hydrogen strategy. Available from https://www.gov.uk/government/publications/uk-hydrogen-strategy Accessed 17 Septemer 2021

[86] UK government (2021) UK hydrogen strategy. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1011283/UK-Hydrogen-Strategy_web.pdf. Accessed 13 September 2021.

refuelling stations.[87] Stakeholders are optimistic that if the region could build on these opportunities, the associated jobs and growth impacts and infrastructure would be positive for the region.

Hydrogen production in a net zero economy will also be closely linked with CCUS and power, so colocation with industry and CCUS clusters generally (covered in section 3.4 below) will be important.

Offshore wind

Alongside increases in domestic solar panels and onshore wind, offshore wind has helped drive dramatic declines in the carbon intensity of UK energy over the last 18 years. In this context, the North East already has an established offshore energy and subsea technology industry cluster. It is home to expertise in subsea engineering, planning and development, as well as the design and manufacture of elements used in offshore wind, such as wind turbine foundations and pipelines.

For example Blyth, Northumberland is home to a deep water seaport (Port of Blyth) and an existing cluster of successful energy businesses. It is also home to renewable energy innovation assets, including ORE Catapult (one of the key stakeholders interviewed for this report). Blyth also offers access to offshore wind development sites, including Dogger Bank. Similarly Northumberland Energy Park, on the Blyth Estuary, is one of the UK's largest coastal development sites, offering 235 hectares of development land with direct access to deep-sea facilities and the UK-Norway energy interconnector. There are also key offshore renewable assets on the River Tyne, including Equinor's Operations and Maintenance base for the Dogger Bank wind farm. GE Renewable Energy also announced in March 2021 plans to open a new blade manufacturing facility in Teesside.[88] The North East is also home to a subsea technology supply chain cluster, and the North East LEP notes that the subsea sector itself generates a combined turnover of over £1.5 billion and provides 15,000 jobs.[89]

At a national level, the UK government has set out its objective to quadruple offshore wind capacity to 40GW by 2030.[90] To support the growth of the industry, £160 million has been made available by the government to upgrade infrastructure and ports in places such as

[87] Logan Energy (2020) *Logan Energy gets hydrogen on the road in multi-million pound Teesside project.* Available from https://www.loganenergy.com/logan-energy-gets-hydrogen-on-the-road-in-multi-million-pound-teesside-project/. Accessed 30 March 2021

[88] GE Renewable Energy (2021) GE Renewable Energy plans to open new offshore wind blade manufacturing plant in Teesside, Available from https://www.ge.com/news/press-releases/ge-renewable-energy-plans-open-new-offshore-wind-blade-manufacturing-plant-teesside-uk Accessed 08 September 2021

[89] North East Local Enterprise Partnership (2019) *North East Energy for Growth*. Available from https://www.northeastlep.co.uk/wp-content/uploads/2021/03/full-strategy-energy-for-growth-strategy.pdf. Accessed 21 July 2021

[90] HM Treasury (2020) *Net zero review: Interim report.* Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/945827/Net_Zero_Review_interim_report.pdf. Accessed 19 January 2021

Teesside and the Humber.[91] It is reported that advances in offshore wind could support up to 60,000 jobs (direct and indirect) nationally by 2030[92] which is in line with the Ten Point Plan.

Stakeholders welcomed the government's ambition to expand offshore wind across the country, however they noted the need for a regional plan. One issue that was raised was around the difficulties local firms had to secure public funding for production contracts. Stakeholders noted previous tenders had gone to established firms based abroad rather than to local companies and SMEs. This meant capabilities in offshore wind were not developing as much domestically, leading to the UK government announcing a support deal for the sector.[93] Specifically, up to £250 million will be invested across the UK by the sector to ensure the supply chain and sector remain competitive, with a target of 60% UK content over the lifetime of a wind farm, as part of the Offshore Wind Sector Deal.[94] In doing so, the Offshore Wind Growth Partnership will be established to improve productivity and competitiveness.

Nuclear capacity

Nuclear energy is expected to remain prominent in the UK's energy mix according to the Sixth Carbon Budget core scenario. This presents an opportunity for the region as the UK looks to replace nuclear assets that are due to be decommissioned in the next decade. Included in this category is the North East's only nuclear power plant, Hartlepool, which is scheduled for decommissioning in 2024. A new power plant in the region could make use of the existing workforce and supporting supply chains, although this was not a key sector highlighted in interviews.

3.1.2. Localisation approach and decarbonisation tables

The table below outlines the approach taken to apply the national UKTM and DDM results related to the energy sector to the North East.[95] Changes in national investment and demand for onshore wind, solar, other renewables and biomass were apportioned to the North East based on renewable energy plans with postcodes in the North East. For offshore wind, industry body estimates of employment growth in offshore wind in the region were used to localise the national impacts, given the difficulty of assigning postcodes to an offshore region.

For nuclear energy, existing capacity was used as a proxy to localise the national results. However, in actuality, investment in new generation may be concentrated in a few locations,

[91] UK Government (2020) *New plans to make the UK world leader in green energy*. Available from https://www.gov.uk/government/news/new-plans-to-make-uk-world-leader-in-green-energy#:~:text=%C2%A3160%20million%20will%20be,cent%20of%20our%20electricity%20demand. Accessed 25 March 2021

[92] Industry Europe (2020) *Offshore Wind To Provide Electricity To All UK Homes By 2030.* Available from https://industryeurope.com/sectors/energy-utilities/offshore-wind-to-provide-electricity-to-all-uk-homes-by-2030/. Accessed 25 March 2021

[93] UK Government (2020) *Offshore wind: Sector Deal*. Available from https://www.gov.uk/government/publications/offshore-wind-sector-deal. Accessed 5 July 2021

[94] Department for Business, Energy and Industrial Strategy (2020) *Offshore wind Sector Deal*. Available from https://www.gov.uk/government/publications/offshore-wind-sector-deal/offshore-wind-sector-deal. Accessed 6 July 2021

[95] As set out in the methodology section at the beginning of this Chapter, localisation is seeking to understand how much headline capital and operational expenditure in the North East and how much will carbon/demand shift regionally based on the 'core' national net zero pathway estimated in the Sixth Carbon Budget. Note that localisation approach is before considering the supply chain impacts after headline spending is made. Assumptions on supply chain are consistent across sectors and set out in the methodology section,

rather than proportionally distributed based on current capacity (due to unknown future policy and decommissioning decisions, for instance). As such, the regional exposure results set out below should be interpreted as the estimations if nuclear spending were proportionally distributed based on current capacity.

Finally, the scale of transformation required in hydrogen production under net zero, alongside the emerging policy in this area, makes it challenging to find an existing proxy for the location of future hydrogen investment and industry. To localise UKTM results relating to hydrogen, the approach used was to divide the impact equally between the five regions mentioned as potential hydrogen clusters in the Ten Point Plan. In practice, both private and public investment is likely to follow a different pattern, but in the absence of further data this broad and equalised approach was adopted.

Select alternate assumptions for localisation were tested as part of the sensitivity analysis and are set out in Annex D.

Table 2: Approach to apply national Sixth Carbon Budget pathways at a regional level for energy and electricity

Sector	Localisation principle for UKTM data	Data source
Concentrated with the potential for policy impacts		
Offshore wind	Estimated offshore wind employment growth in the region by 2032	Energy and Utility Skills - UK Offshore wind employment growth by region in 2032 (2018)
Onshore wind	Proportionate to the installed capacity from onshore wind in the region (allocated using postcodes)	UK government Renewable Energy Planning Database (2020 Q3 quarterly extract)
Nuclear	Proportionate to the capacity of existing reactors in the region	UK Parliament (2021) Existing Reactors in the UK by Capacity
Solar	Proportionate to the installed capacity from solar energy in the region (allocated using postcodes)	UK government Renewable Energy Planning Database (2020 Q3 quarterly extract)
Other renewables	Proportionate to the installed capacity from other renewables in the region (allocated using postcodes)	UK government Renewable Energy Planning Database (2020 Q3 quarterly extract)
Hydrogen	In line with the CCUS assumptions as part of a 'SuperPlace' which are equally divided between the five possible regions mentioned in the Ten Point Plan for a Green Industrial Revolution.	UK government (2020) The Ten Point Plan for a Green Industrial Revolution
Biomass	Proportionate to the installed capacity from biomass in the region (allocated using postcodes)	UK government Renewable Energy Planning Database (2020 Q3 quarterly extract)
Relatively evenly spread / demand driven		
Fossil fuels (Including oil, gas and coal)	In line with UK changes in demand based on UKTM estimates	Based on UKTM estimates

Source: Author's analysis

3.1.3. Regional exposure estimates outputs and wider analysis - Energy and Electricity

Based on the localisation approach set out in Table 2, the regional impact tool suggests that the energy and electricity transition could add £830 million of direct GVA to the North East's economy by 2050, compared to 2020. This increase in GVA over time is largely driven by hydrogen, offshore wind and biomass energy sources, which make up 80% of the opportunity. This reflects the existing strength in offshore wind and potential for the North East to be a hub for hydrogen, as well as findings from the stakeholder engagement that anticipates the region being a key destination for investment in energy due to its established foundations.

Overall the net impact on GVA remains positive between 2020 and 2050, with the exception of 2030. This is driven by a combination of factors, in particular the phase out of fossil fuel and biomass towards the end of the current decade, while the full effects of low-carbon sectors are still being phased in.

The GVA generated by the offshore wind sector increases over the next 30 years, initially driven by domestic ongoing operational expenditure and increased capital expenditure expected in the 2020s. From 2030, domestic operating expenditure continues to be an important driver of GVA with a higher stock of offshore wind, but international spending on offshore also starts to play a role in the growth in GVA.

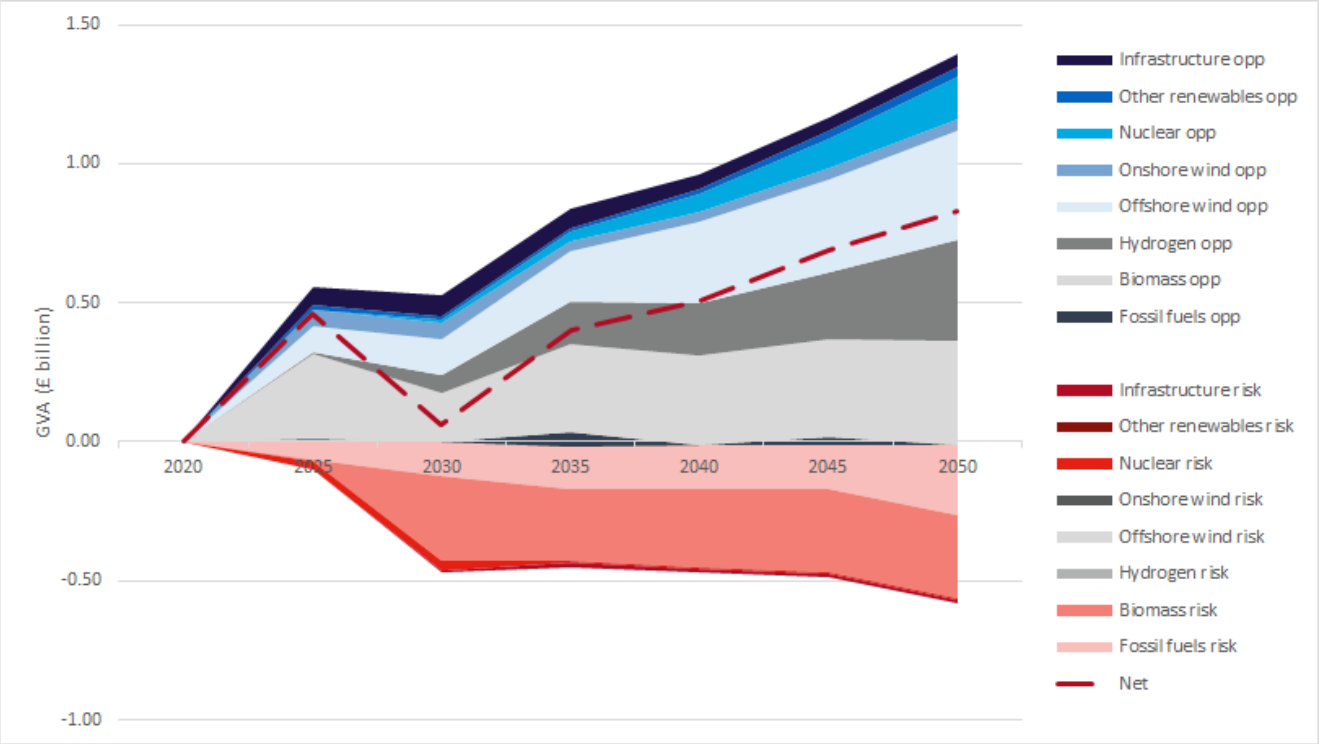
The growth in the hydrogen sector, in contrast to offshore wind, appears to grow more steadily over time. This may in part be due to hydrogen being at an earlier stage of development and commercialisation, compared to more established technology like offshore wind. However, a portion may also be from the capital expenditure adjustment from the CCC not fully capturing the non-annualised profile in the UKTM, or upfront investment. Further data would be needed to test this analysis.

Under the localisation approach used, nuclear energy could add £152 million in GVA by 2050, despite a decline around 2030. This finding is based on the assumption that the North East will continue to generate nuclear energy at the level it does now, and does not take into consideration the plans for the only nuclear plant in the region to be decommissioned in 2024.

From 2025, the fossil fuel sector experiences a decrease in GVA (compared to 2020), leading to a fall of £260 million in GVA by 2050. This trend is driven by the UKTM modelling result that demand for fossil fuels will fall as the UK progresses towards net zero by 2050, a view shared by multiple stakeholders during interviews.

It is also important to note that results of this analysis are sensitive to the localisation assumptions used. The results above are based on 13% of headline nuclear and offshore spending and 20% of headline hydrogen investment being attracted to the region. If the North East did not attract this level of funding, this would affect the level of opportunity.

Figure 6: Energy and electricity GVA impacts in the North East from 2020 to 2050



Source: PwC analysis of the regional impact tool outputs.

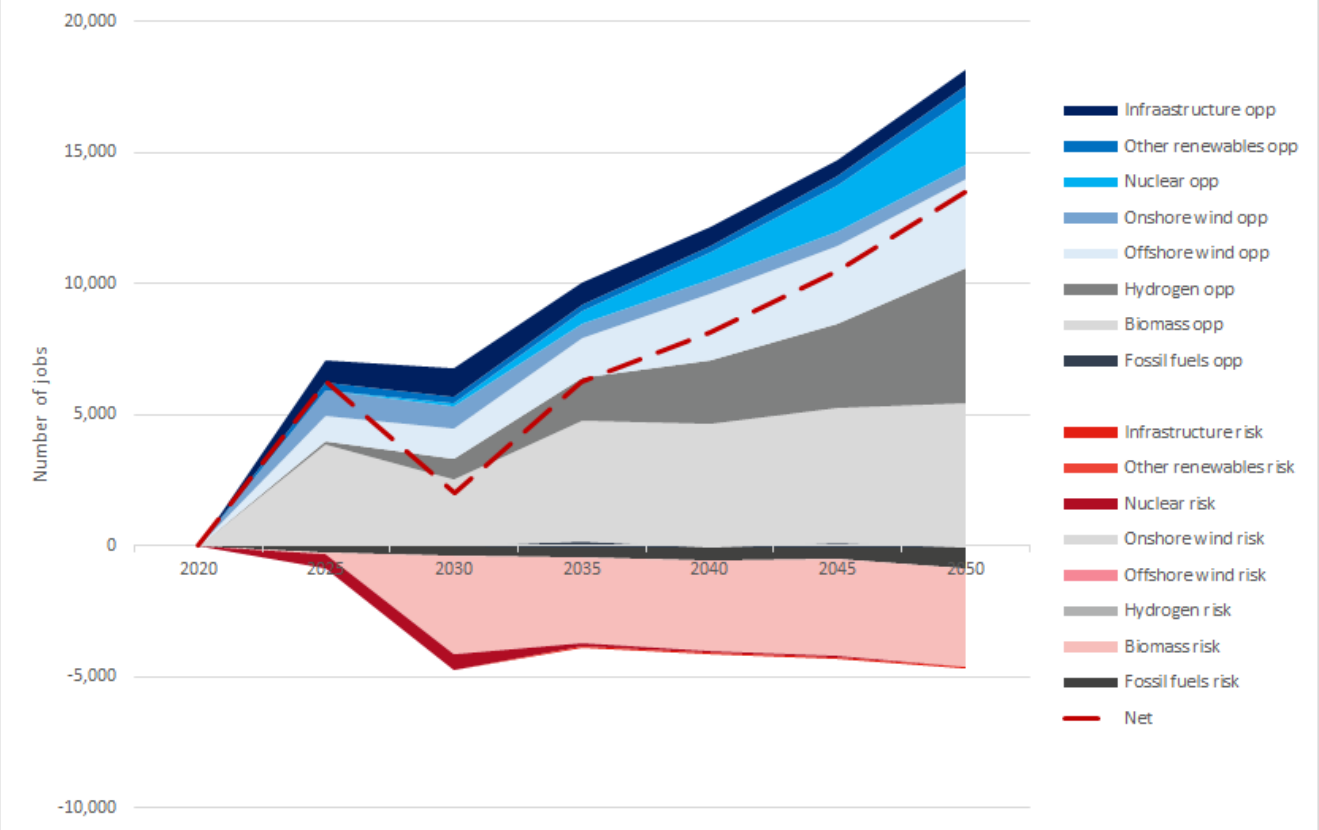
Direct GVA growth is driven largely by hydrogen and offshore wind (due to domestic and increased capital expenditure), nuclear energy (under the condition that energy generation continues after 2024), and the biomass sector. Meanwhile fossil fuels would experience a relative fall in GVA over the same time period. Decarbonisation in the energy and electricity sector could potentially generate a net £830m of GVA to the North East's economy by 2050, compared to 2020. However, if the region attracts lower levels of investment in these key sectors, the potential growth would be lower.

The estimated direct jobs exposure from net zero largely mirrors the impacts in GVA set out above. By 2050, there could be around net 13,500 more direct jobs from the energy and electricity net zero transition compared to 2020, two thirds of which comes from the hydrogen and offshore wind sectors. Around 2,500 jobs could be generated in the nuclear energy sector by 2050, assuming that the sector produces energy in proportion to its current capacity. The fossil fuels sector is the only energy and electricity source estimated to experience a fall in net employment by 2050 of around 850 jobs due to transition out of hydrocarbons. The Green Jobs Taskforce report highlighted how the skills gap in the emerging offshore wind sector could be met by the fossil fuels[96] sector, given the transferability of skills, a finding that was supported in our stakeholder interviews.[97]

[96] The Green Jobs Taskforce report refers to these sectors as the oil and gas sector.

[97] Green Jobs Taskforce (2021) *Green Jobs Taskforce report*. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1002112/green-jobs-taskforce-report__1_.pdf. Accessed 16 July 2021

Figure 7: Energy and electricity employment impacts in the North East from 2020 to 2050



Source: PwC analysis of the regional impact tool outputs.

From decarbonisation in the energy and electricity sector, there could be a potential net increase in direct jobs by 2050 of 13,500, with fossil fuels being the only sector to experience a net fall in employment. The initial increase in employment by 2025 driven by the biomass sector which is then offset by infrastructure risk in the following five years. From 2030 onwards potential jobs are created by rising opportunities in nuclear, offshore wind and hydrogen sectors in particular.

3.2. Transport

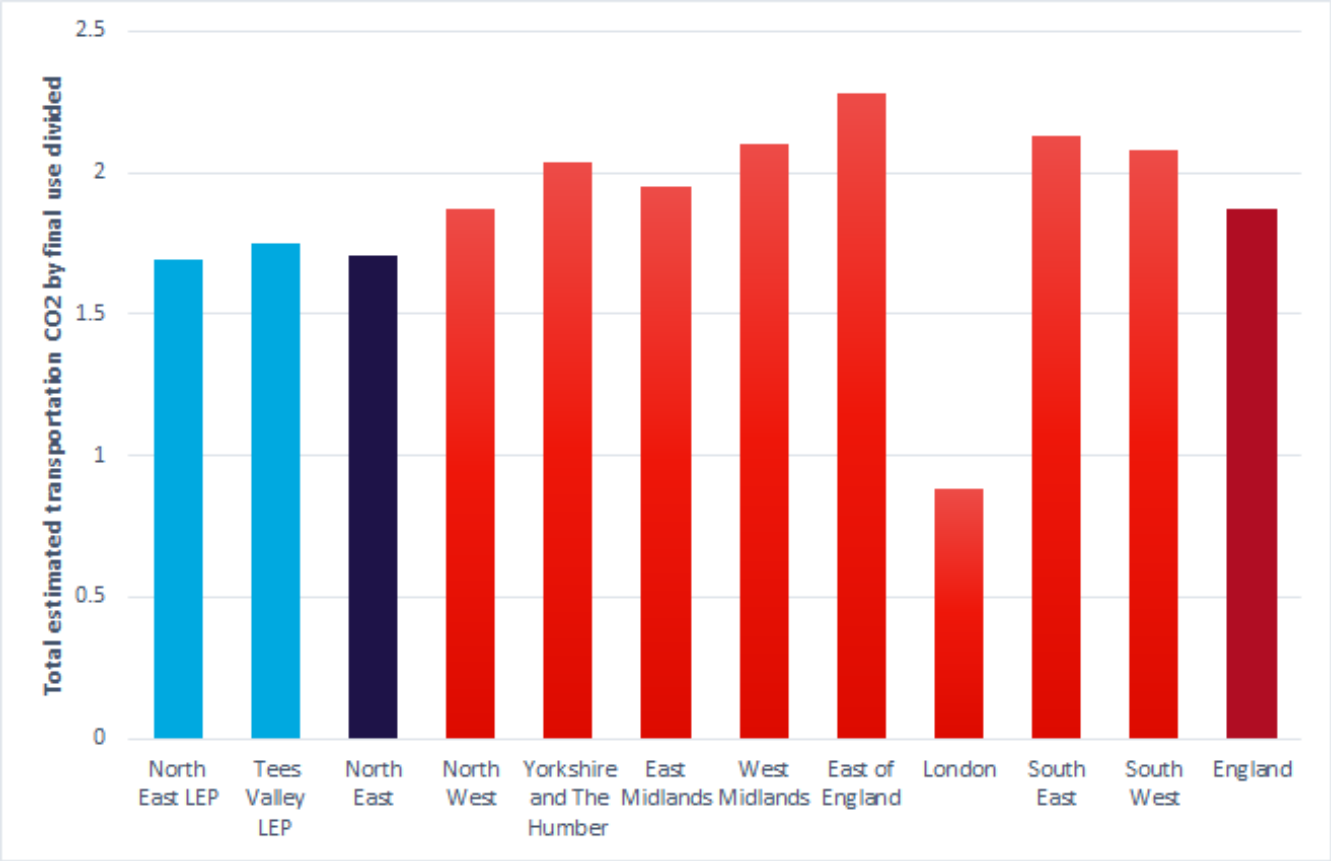
This section covers surface transport, shipping and aviation. Surface transport is the main form of transport in the region and includes cars, buses, passenger rail, freight and goods vehicles. The transport sector described in this section also covers the manufacture of vehicles for transport, which in the case of the North East includes electric vehicles.

The overall CO2 emissions per capita for transport are relatively low in the North East compared to other regions, as shown below in Figure 8.[98] The North East emits 1.71 tonnes per capita from transport, the second lowest region in England behind London at 0.88 tonnes per capita. Transport contributed just over 30% to the North East's total carbon emissions in

[98] The transport sector covered in this chart does not align with the transport sector in our regional exposure estimates due to differences in mapping. Source: Department for Business, Energy & Industrial Strategy (2020) UK local authority and regional carbon dioxide emissions national statistics: 2005 to 2018. Available from https://www.gov.uk/government/statistics/uk-local-authority-and-regional-carbon-dioxide-emissions-national-statistics-2005-to-2018 Accessed 17 September 2021

2018,[99] compared to 33% for the UK as a whole.[100] It was the largest sectoral source of emissions in the UK in 2018.

Figure 8: Snapshot of emissions and transportation by region



Source: ONS and UK government Statistics (2018)

The CO2 emissions may reflect a comparatively greater use of and reliance on public transport due to geographic and demographic considerations. The North East is home to key public transport links and services, such as the East Coast Mainline, the Cross-Country rail line and the UK's largest urban metro outside of London (the Tyne and Wear).[101] The region also had the second highest passenger journeys on local bus services per head in 2019, behind London.[102]

[99] UK Government (2020) *Transport CO2 emissions per capita.* Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/894787/2005-18-uk-local-regional-co2-emissions.xlsx. Accessed 10 March 2021

[100] Department for Business, Energy and Industrial Strategy (2019) 2018 UK Greenhouse Gas Emissions, Provisional Figures. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/790626/2018-provisional-emissions-statistics-report.pdf Accessed 17 September 2021

[101] The North East Local Enterprise Partnership (2019) *The North East Strategic Economic Plan*. Available from https://www.nelep.co.uk/wp-content/uploads/2019/02/north-east-strategic-economic-plan-jan-2019-final.pdf. Accessed 19 January 2021

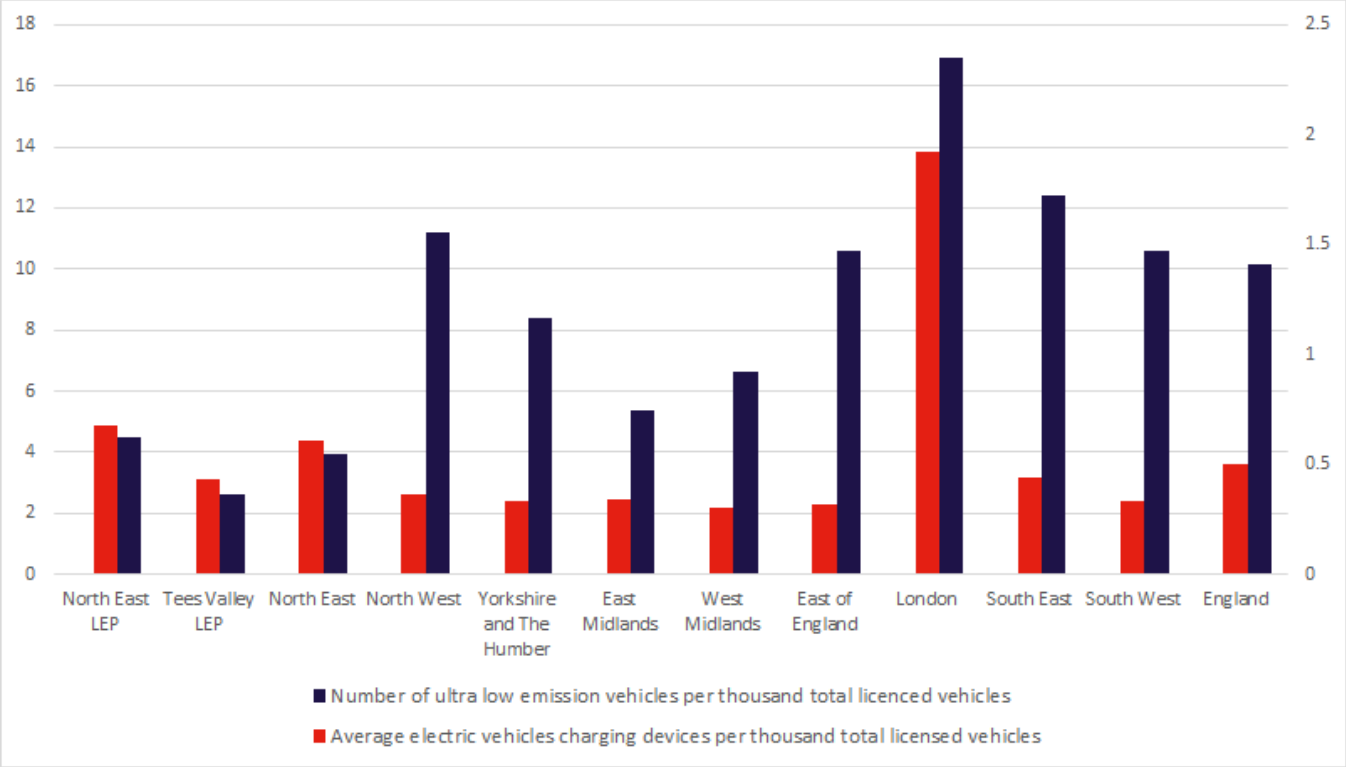
Nexus (2019) *Economic value of Metro and local rail to the North East*. Available from https://www.nexus.org.uk/sites/default/files/vfm_2019.pdf. Accessed 11 March 2021

[102] UK Government (2021) *Passenger journeys on local bus services by region.* Available from *https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/929562/bus0108.ods. Accessed 25 March 2021*

The prevalence of low-carbon alternatives, such as electric vehicles and their infrastructure, can also support a region's decarbonisation as it encourages the transition from traditional high-carbon vehicles. Currently, the North East is second to London in terms of its electric vehicle charging infrastructure relative to the number of licensed vehicles, although the difference between the two regions is significant: London has nearly two electric vehicle charging devices per thousand licensed vehicles, compared to 0.6 in the North East.[103]

However, the North East has the lowest number (around 4) of ultra-low emission vehicles (ULEVs) per thousand total licensed vehicles across England, with the English average at 10. Overall, the lower rate of ULEV uptake may improve over time from investments into the technology that enables lower costs and in turn encourages a greater use of electric vehicles.[104]

Figure 9: Average electric vehicles charging devices per thousand total licensed vehicles



Source: ONS and UK government statistics (2020, 2019)

3.2.1. Analysis of interview responses and literature

Interviewees were generally positive about the net zero future for the transport sector in the North East. They saw the transition to electric vehicles in the UK and internationally as having the potential to generate significant economic activity in the region both in terms of the manufacturing of electric vehicles, and the sales of these vehicles to consumers in the UK and

[103] UK Government (2020) *Average electric vehicles charging devices per thousand total licensed vehicles.* Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/882143/veh0105.ods. Accessed 10 March 2021

[104] Committee on Climate Change (2020) *The Sixth Carbon Budget The UK's path to Net Zero*. Available from https://www.theccc.org.uk/uk-action-on-climate-change/reaching-net-zero-in-the-uk/. Accessed 11 February 2021

for export (in 2020 the UK exported 81% of the cars manufactured domestically).[105] Several interviewees also noted there was also the potential to electrify some of the existing railway lines to bring about improvement in both the passenger and freight infrastructure.

Manufacturing of electric vehicles

The increasing uptake of electric vehicles is an important step towards decarbonisation of the transport sector. This is highlighted by the targets set in the Sixth Carbon Budget[106] and the Ten Point Plan for a Green Industrial Revolution, which includes a commitment to phase out the sale of new petrol and diesel cars and vans by 2030 and to provide capital and late-stage R&D funding to build a globally competitive electric vehicle supply chain through the £500m Automotive Transformation Fund.[107]

The North East region has existing expertise in the manufacturing of electric vehicles and related industries. For example, Nissan's plant in Sunderland currently manufactures the Nissan Leaf, a fully electric vehicle, amongst other models. On 1 July 2021, Nissan and battery manufacturer Envision AESC announced a £1bn investment to create a North East electric vehicle manufacturing hub, including the UK's first large-scale gigafactory.[108]

Stakeholders within the automotive sector highlighted the importance of having the supporting supply chain based in the North East. Currently, 80% of all of Nissan's European vehicles are produced in the North East region. If production was to relocate there would be a significant risk to the supply chain, as firms that co-locate nearby production plants would be forced to leave as well. The industry is aware of risks, which include securing people with the right skills and maintaining competitiveness in a global market.

Net zero also offers significant opportunities for the cluster and the region. Stakeholders for example mentioned that the industry is actively engaged in supporting transition for the North East automotive cluster in a similar fashion to the chemical and process manufacturing sectors respectively (see the Industry and carbon capture section below).

Specifically, the challenge for automotive in the North East, according to industry stakeholders, is energy costs. Tackling this issue as part of a net zero transition will not only increase competitiveness but could present an opportunity for the sector to continue to grow. Proposed solutions include the use of digital technology in the manufacturing process, to generate insights from real time data in order to drive energy efficiency in the process.

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[105] SMMT (2020) *Key Exports Data*. Available from https://www.smmt.co.uk/industry-topics/europe-and-international-trade/key-exports-data/. Accessed 22 July 2021

[106] Climate Change Committee (2020) *The Sixth Carbon Budget: The UK's path to Net Zero*. Available from https://www.theccc.org.uk/uk-action-on-climate-change/reaching-net-zero-in-the-uk/. Accessed 19 January 2021 and HM Government (2020) *The Ten Point Plan for a Green Industrial Revolution*. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/936567/10_POINT_PLAN_BOOKLET.pdf. Accessed 21 January 2021

[107] APC UK (2021) *Automotive Transformation Fund*. Available from https://www.apcuk.co.uk/opportunities-for-you/automotive-transformation-fund/. Accessed 7 July 2021

[108] UK Government (2021) *Business Update Statement made on 1 July 2021*. Available from https://questions-statements.parliament.uk/written-statements/detail/2021-07-01/hcws137. Accessed 7 July 2021

Sale of electric vehicles

While the region's overall transport emissions are relatively low on a per person basis compared to other regions of England, a shift towards low emission alternatives is still necessary to achieve a decarbonised transport sector.

One potential barrier mentioned in stakeholder interviews was the high upfront costs of EVs for local consumers. The North East has one of the lowest median incomes in the UK, so despite EVs having lower operating costs, the upfront costs may be difficult to overcome. One solution to this problem that was mentioned was potential government support to help consumers with these upfront costs, which may also help achieve a fair transition.

Another point that was raised by stakeholders was around range anxiety for EVs, given that charging infrastructure in the region is still developing. To overcome this challenge, Transport for the North (TfN) have developed a Strategic Transport Plan with an aim to have a zero-carbon public transport network by 2050 and to increase the number of public charging stations for electric vehicles across the whole of the North East by 2024.[109] TfN is also planning to improve the connectivity between low-carbon energy and research hubs in the North East and North West.

Electric vehicles are not the only means for decarbonising road transport. As mentioned previously in section 3.1 in certain scenarios HGVs and other large vehicles could be better suited to a switch to hydrogen. This view was shared by multiple stakeholders, and there are a number of pilot projects in the pipeline including one in Teesside.[110]

Decarbonisation of personal transport is important for the sector, but an area that has seen considerable focus has been electrification of commercial fleet vehicles. This transition is being driven by running cost savings of between 20% and 25% over internal combustion engine (ICE) vehicles.[111]

Shipping and aviation

Given the volume of port trade in the North East, the decarbonisation of shipping will potentially be important. Stakeholders noted the potential for the region to act as a transit hub, with collocation of hydrogen production, storage, and use as goods transfer from vehicles to shipping in the import/export process. For aviation, the region does have one major international airport in Newcastle, although its exposure to aviation emissions may be relatively low, as the airport accounted for just 2% of total passenger numbers in the UK in 2019.[112]

[109] Transport North East (2020) *North East Transport Plan 2021-2035*. Available from https://www.transportnortheast.gov.uk/wp-content/uploads/2020/11/Full-Transport-Plan.pdf. Accessed 21 January 2021

[110] For example, see: Logan Energy (2020) *Logan Energy gets hydrogen on the road in multi-million pound Teesside project.* Available from https://www.loganenergy.com/logan-energy-gets-hydrogen-on-the-road-in-multi-million-pound-teesside-project/. Accessed 30 March 2021

[111] Automotive World (2021) The top three reasons fleets are electrifying. Available from https://www.automotiveworld.com/articles/comment-the-top-three-reasons-fleets-are-electrifying/. Accessed 22 July 2021

[112] Civil Aviation Authority (2020) *Airport data 2019.* Available from https://www.caa.co.uk/Data-and-analysis/UK-aviation-market/Airports/Datasets/UK-Airport-data/Airport-data-2019/. Accessed 25 March 2021

3.2.2. Localisation approach and decarbonisation tables

The table below outlines the approach taken to adjust national UKTM data on demand, investment (operational and capital costs), and emissions under the Sixth Carbon Budget transport pathways to the North East region. UKTM results grouped in transport include the costs of underlying infrastructure, as well as the cost of the UK's transition to low-carbon vehicles (including the associated costs of operating these new vehicles). Given that much of the cost base relates to the roll out of a new low-carbon fleet across the population, investment and demand changes were for the most part attributed to the North East proportionally based on vehicle registrations, GVA and freight (on the basis that passenger or economic activity would likely determine the level of transition needed).

Table 3: Approach to apply national Sixth Carbon Budget pathways at a regional level for transport

Sector	Localisation principle for UKTM data	Data source
Relatively evenly spread / demand driven		
Light road transport vehicles (e.g. cars and vans)	Proportion of vehicle registrations in the North East	Department for Transport, UK government (2019)
Heavy road transport vehicles	Proportion of total GVA (all sectors) in the North East relative to the UK	ONS (2019) GVA by sector at NUTS1 and NUTS3
Freight trains	Freight train transport jobs	NOMIS (2019) Business Register and Employment Survey
Passenger transport (bus and train)	Population density of the North East relative to the UK	UK government (2018) Local Authority territorial CO2 emissions estimates
Aviation	The total number of passengers at each airport (in 2019) are allocated its local authority and region, as a proportion of the UK total	Civil Aviation Authority (2019) Size of UK Airports
Shipping	The tonnage of cargo at each major port in the UK are allocated to its local authority and region, as a proportion of the UK total	UK government (2019) Major Port Freight Traffic

Source: PwC analysis

3.2.3. Regional exposure estimates and wider analysis - Transport

Based on the results of the analysis, transport could potentially add £500 million net to the GVA of the North East region by 2050 compared to 2020. Road transport drives a significant proportion (90%) of this change. Road transport's net £450m addition to the total GVA would make it the single largest contributor to the total GVA of the sectors and impacts covered.

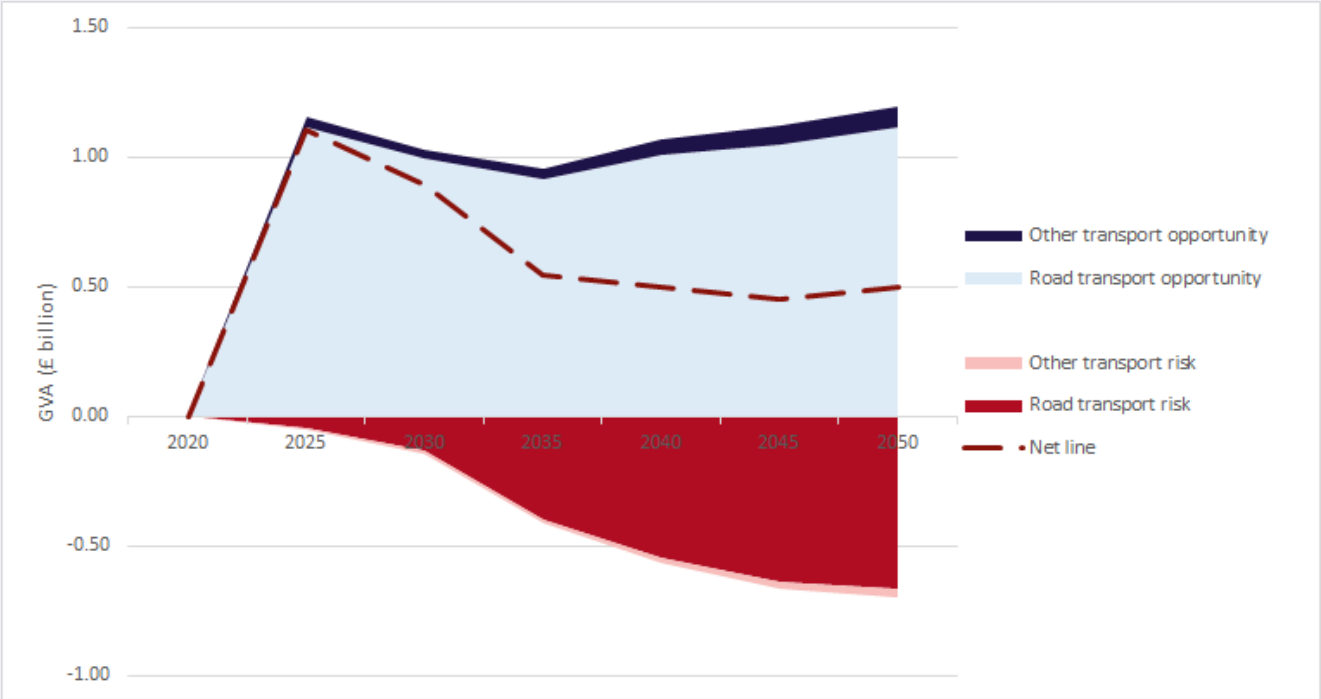
The high opportunity in the road transport sector in the North East reflects the relatively greater national spend in this area, as vehicles across the UK are replaced by low-carbon alternatives.

In this context, it is worth noting that the economic benefit of vehicle purchases falls not only to vehicle manufacturers, but also to associated industries such as wholesale and retail, and repair industries, which are located across the UK.

As the North East has a significant vehicle manufacturing base already, it may also stand to capture additional value from decarbonisation through the supply chains involved in vehicle manufacturing. Vehicles are also highly traded in domestic and international markets, so both international and national decarbonisation pathways will impact the transport sector to a large extent, assuming vehicle manufacturing maintains a strong presence in the region.

While the road transport sector has a greater net benefit by 2050 than other transport due to its greater opportunity from expenditure, it risks losing more GVA (£660 million) by 2050, relative to 2020 numbers as fossil fuel vehicles phase out.

Figure 10: Transport GVA impacts in the North East from 2020 to 2050



Source: PwC analysis of the regional impact tool outputs

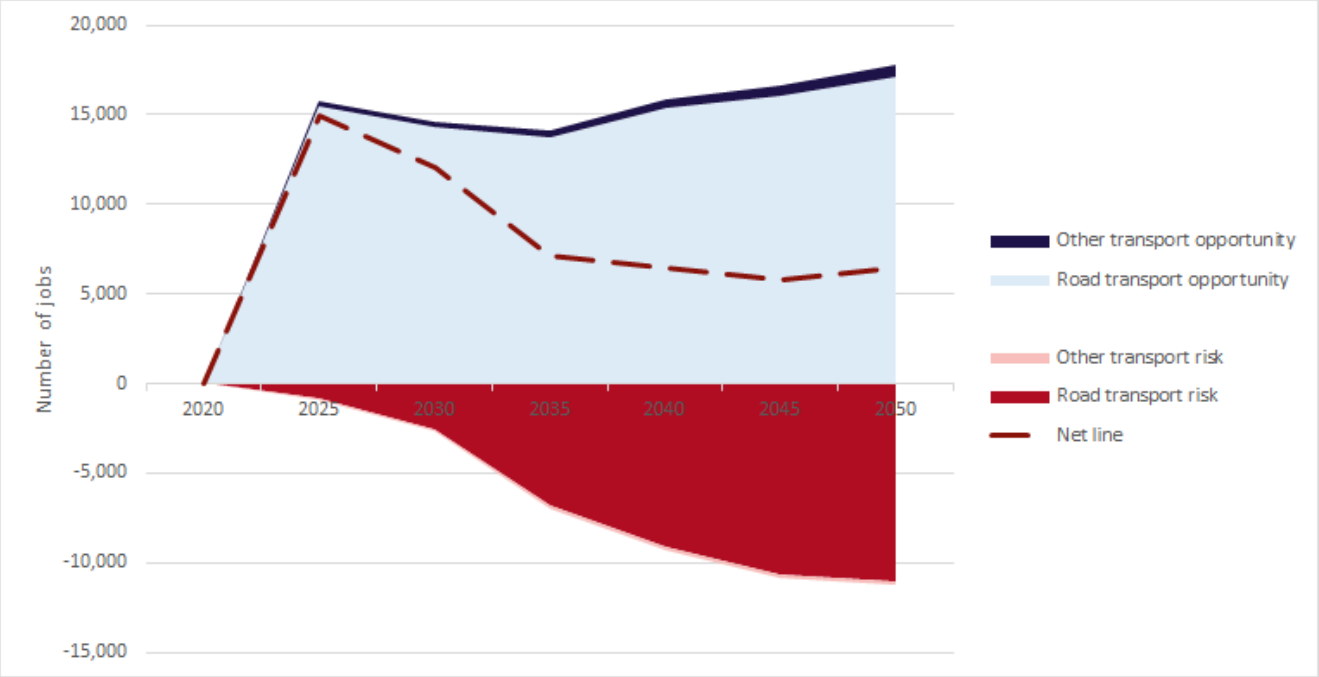
The net zero transition in the transport sector could generate a potential net increase in GVA of £0.5bn by 2050, with a peak in 2025 at £1.1 billion. The economic benefit of vehicle purchases falls not only to vehicle manufacturers, but also to associate industries, such as wholesale and retail, and repair industries. Initial gains are offset to some extent by fossil fuel phase out related transport risks from 2030.

Echoing the potential GVA opportunity, the results of the analysis suggest that there will be significant opportunity for employment from the transport sector (driven mostly by road transport), with around 15,000 direct gross jobs added in the next five years and then increasing slightly more in the period to 2050.

However, over time the opportunity for new jobs is balanced by increasing jobs at risk from the road transport sector, as manufacturing, sales, and associated infrastructure for ICE vehicles decline. In net terms, this means that direct employment from the transport sector could

increase by 15,000 between now and 2025, in the lead up to the ban on sales of new petrol and diesel cars and vans by 2030 and while there is still a significant ICE market. After 2025, the net increase in jobs declines sharply to around 6,500 net additional jobs by 2050 compared to 2020 as ICE vehicles are phased out.

Figure 11: Transport employment impacts in the North East from 2020 to 2050



Source: PwC analysis of the regional impact tool outputs

The transition to net zero in transportation could lead to a potential net increase in jobs of 6,500 by 2050. Net employment gains peak in 2025, prior to the targeted end of sales of new petrol and diesel vehicles in 2030. Over time the opportunity for new jobs is offset to some extent by increasing jobs at risk from the road transport sector, as manufacturing, sales, and associated infrastructure for ICE vehicles decline.

3.3. Buildings

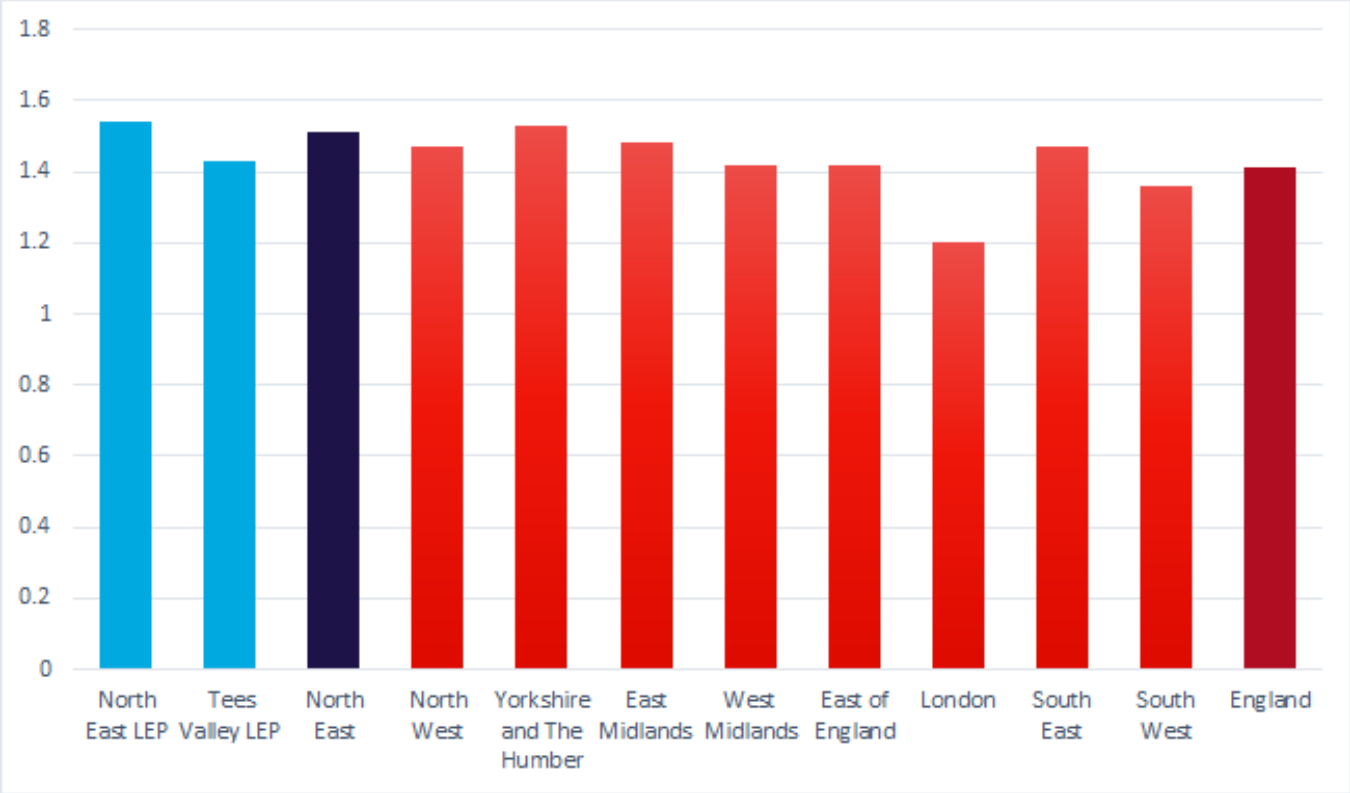
This section covers buildings, including domestic buildings and commercial buildings, as well as appliances.[113] Emissions from the residential sector accounted for 18% of total CO2 per capita in the UK in 2018.[114]

There are two key issues around achieving decarbonisation in this sector: the energy efficiency of buildings, and how to switch to zero carbon heating. As shown in Figure 12, in terms of domestic (household) emissions, the North East produces the second highest domestic CO2 per capita of all English regions at 1.51 tonnes.

[113] Note that energy infrastructure in premises (e.g. meters) is captured under the energy sector in the tool.

[114] Department for Business, Energy and Industrial Strategy (2019) 2018 UK Greenhouse Gas Emissions, Provisional Figures. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/790626/2018-provisional-emissions-statistics-report.pdf
. Accessed 25 January 2021

Within the North East region, the levels of domestic emissions are driven slightly more by the North East LEP where 1.54 tonnes are being emitted per capita, compared to 1.43 tonnes for Tees Valley. This may be partly driven by the rural areas in the North East LEP area: rural buildings are more likely to be off-grid, meaning that fuel sources such as heating oil and diesel generators are more likely to be used.[115]



Source: ONS and UK government Statistics (2018)

3.3.1. Analysis of interview responses and literature

The stakeholder interviews focused on issues around domestic buildings, including fuel poverty and the relative energy inefficiency of the housing stock in the North East, compared to other regions. Another point raised was around retrofitting, and the rate at which retrofitting is needed over the next 10 to 15 years.

Fuel poverty and the energy efficiency of the housing stock

Government statistics show that in 2019, the North East had some of the highest levels of fuel poverty[116] in England, at 14.8%, just behind Yorkshire and the Humber at 16.8% and the West

[115] HM Treasury (2020) Net Zero Review: Interim report. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1004025/210615_NZR_interim_report_Master_v4.pdf Accessed 15 September

[116] A household is considered fuel poor/poverty if fuel costs are higher than the national median average and if they were to spend that amount their residual income will fall below the official poverty line

Midlands at 17.5%.[117] Of those households living in fuel poverty in the North East, 90% are in a property with an Energy Performance Certificate (EPC) rating of band D or below.[118] Therefore, new policies and additional investment may be required in order for the North East to reach the government's goal of all fuel poor households having an EPC[119] rating of at least C by 2030.[120]

Most stakeholders noted fuel poverty as an issue in the region and considered it a key barrier in achieving a fair transition for domestic heating. Stakeholders noted the view that low-carbon energy prices are potentially higher than what consumers are currently used to, and therefore measures to improve efficiency will be necessary to ensure a fair transition.

A push for improvements in thermal efficiency (e.g. through insulation) could help reduce the demand for energy and challenge fuel poverty. Many cited the example of the Green Homes Grant scheme, which has now closed, as a means for helping those that cannot afford the costs of transition, providing the additional benefit of reducing fuel poverty.

Retrofitting and heating

Efficiency improvements will be important for a net zero future. The Sixth Carbon Budget has proposed a target to achieve efficiency rating of C in domestic properties over the next 10 to 15 years, and private rented properties will be required to achieve that even sooner by 2025.[121]

The majority of the current housing stock will still exist in 2050.[122] As a result, retrofitting will play a large part in the transition to net zero, through insulating already built properties, and replacing gas boilers with a low-carbon alternative.

Given the scale of retrofitting required, stakeholders were particularly positive about the employment opportunity that retrofitting homes represented to the region. During the installation process, direct jobs could be created and many of the skills gained would also be applicable for new builds, which will be required to be zero carbon by 2025.[123] Despite the optimism, stakeholders were concerned about the need for a sufficiently large and suitably qualified workforce to deliver this type of work. They highlighted the need for better dialogue

[117] Department for Business, Energy and Industrial Strategy (2021). *Annual fuel poverty statistics report (2019 data)*.Available from https://www.gov.uk/government/statistics/annual-fuel-poverty-statistics-report-2021 Accessed 21 January 2021

[118] North East LEP (2019) *North East: energy for growth*. Available from https://www.nelep.co.uk/wp-content/uploads/2019/08/full-strategy-energy-for-growth-strategy.pdf. Accessed 21 January 2021

[119] The UK Government recently updated its target to achieve Fuel Poverty Energy Efficiency Rating (FPEER) band C by 2030 which is effectively the same as EPC C but includes financial assistance measures such as the Warm Homes Discount (WHD). Reference: UK Government (2021) *Fuel poverty strategy for England*. Available from https://www.gov.uk/government/consultations/fuel-poverty-strategy-for-england. Accessed 22 July 2021

[120] HM Treasury (2017) *The Clean Growth Strategy*. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700496/clean-growth-strategy-correction-april-2018.pdf. Accessed 21 January 2021

[121] Climate Change Committee (2020) *Policies for the sixth carbon budget and net zero*. Available from https://www.theccc.org.uk/wp-content/uploads/2020/12/Policies-for-the-Sixth-Carbon-Budget-and-Net-Zero.pdf. Accessed 20 January 2021

[122] Killip (2008) Transforming the UK's Existing Housing Stock. Available from: https://d7.ciob.org/sites/default/files/FMB%20Building%20A%20Greener%20Britain.pdf Accessed 15 September 2021

[123] Ministry of Housing, Communities & Local Government (2021) Rigorous new targets for green building revolution. Available from: https://www.gov.uk/government/news/rigorous-new-targets-for-green-building-revolution Accessed 15 September 2021

between education and training providers, local government and industry to ensure the workforce required is available and coordinated.

Stakeholders also raised the question around the supply of retrofitters once the initial retrofitting installations are complete, with the Green Jobs Taskforce report highlighting the retrofit sector was expected to grow during the short to medium term.[124] It is possible that there would be too many trained individuals to cover the ongoing maintenance market beyond 2035 after the initial push to install: the Sixth Carbon Budget states that 1.8 million heat pumps will need to be installed each year up until the mid-2030s.[125] While there was no simple solution offered by stakeholders, the consensus was that a balance between training enough people to deliver against ambitious national targets and ensuring they have long term employment opportunities needs to be struck.

Some stakeholders highlighted that retrofitting some properties was currently not cost-effective and that sometimes it is cheaper to demolish and rebuild a property rather than retrofitting it. A substantial portion of a building's lifetime emissions are incurred during construction, which raises issues on what is the best low-carbon approach. Research shows that when considering these factors, there can be a greater CO2 impact from either rebuilding homes or retrofitting, depending on the specific circumstances.[126] Irrespective of the path chosen towards decarbonising buildings, government funding and incentives may be necessary to reach the targets set, as the current uptake falls short of what is required.[127]

3.3.2. Localisation approach and decarbonisation tables

The table below outlines the approach taken to transform the national data on investment, demand and emissions for buildings under the Sixth Carbon Budget net zero pathways to the regional level.

Overall, demand and investments in domestic buildings are assumed to be in line with the number of households across the regions, and in line with GVA for commercial buildings. One exception to this approach pertains to assumptions used in relation to heating. Regional atmospheric conditions may affect the uptake of heat pumps compared to other technologies. Heat pumps are less effective in colder climates which may reduce demand in the region, compared to warmer regions.[128] As a result, a high-level assumption has been used, which

[124] Green Jobs Taskforce (2021) Green Jobs Taskforce report. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1002112/green-jobs-taskforce-report__1_.pdf. Accessed 16 July 2021

[125] Climate Change Committee (2020) *Policies for the Sixth Carbon Budget and Net Zero*. Available from https://www.theccc.org.uk/wp-content/uploads/2020/12/Policies-for-the-Sixth-Carbon-Budget-and-Net-Zero.pdf. Accessed 10 March 2021

[126] Green Gauge (2020) *To Demolish or Not to Demolish*. Available from https://ggbec.co.uk/embodied-carbon-and-building-demolition-the-case-for-retrofit/ Accessed 10 March 2021

[127] Statista (2021) Number of heat pumps in operation in the United Kingdom from (UK) 2013-2019. Available from https://www.statista.com/statistics/740491/heat-pumps-in-operation-uk/#:~:text=In%202019%2C%20the%20UK%20had,thousand%20were%20aerothermal%20heat%20pumps. Accessed 10 March 2021

[128] The Renewable Energy Hub UK (2020) *How do heat pumps work in cold weather?*. Available from https://www.renewableenergyhub.co.uk/main/heat-pumps-information/how-do-heat-pumps-work-in-cold-weather/. Accessed 22 July 2021

adjusts heat pump take-up downwards (by 25%) and hydrogen boiler take-up upwards (by 25%) compared to what would be predicted based on household numbers (residential buildings) and economic activity (non-residential buildings) in the North East region.[129] This is a broad assumption designed to provide illustration of differing regional options in a top down way. In practice, specific locations will be better suited to community heating, hydrogen and heat pumps based on a variety of factors (for example, accessibility/suitability of unit). Other work is currently ongoing on how different local factors could influence the most appropriate local net zero pathways in the housing sector, and could be used in future to further refine the localisation approach.

Table 4: Approach to apply national Sixth Carbon Budget pathways at a regional level for buildings

Sector	Localisation principle for UKTM data	Data source
Relatively evenly spread / demand driven		
Heat pumps (non residential)	A high-level assumption that the North East will experience a 25% lower uptake than the proportion allocated using the region's GVA	PwC analysis, ONS (2019) GVA by sector at NUTS1 and NUTS3
Heat pumps (residential)	A high-level assumption that the North East will experience a 25% lower uptake than the proportion allocated using the region's number of households	PwC analysis, NOMIS (2019) Annual Population Survey ONS (2019) Family and households
Hydrogen boiler (non residential)	A high-level assumption that the North East will experience a 25% higher uptake than the proportion allocated using the region's GVA	PwC analysis, ONS (2019) GVA by sector at NUTS1 and NUTS3
Hydrogen boiler (residential)	A high-level assumption that the North East will experience a 25% higher uptake than the proportion allocated using the region's number of households	PwC analysis, NOMIS (2019) Annual Population Survey ONS (2019) Family and households
Other heat (non residential)	Proportion of total GVA (all sectors) in the North East relative to the UK	ONS (2019) GVA by sector at NUTS1 and NUTS3
Other heat (residential)	Proportionate to the number of households in the region	NOMIS (2019) Annual Population Survey ONS (2019) Family and Households
Retrofitting (non residential)	Proportion of total GVA (all sectors) in the North East relative to the UK	ONS (2019) GVA by sector at NUTS1 and NUTS3
Retrofitting (residential)	Proportionate to the number of households in the region	NOMIS (2019) Annual Population Survey ONS (2019) Family and Households
Appliances (non-residential)	Proportion of total GVA (all sectors) in the North East relative to the UK	ONS (2019) GVA by sector at NUTS1 and NUTS3
Appliances (residential)	Proportionate to the number of households in the region	NOMIS (2019) Annual Population Survey ONS (2019) Family and Households

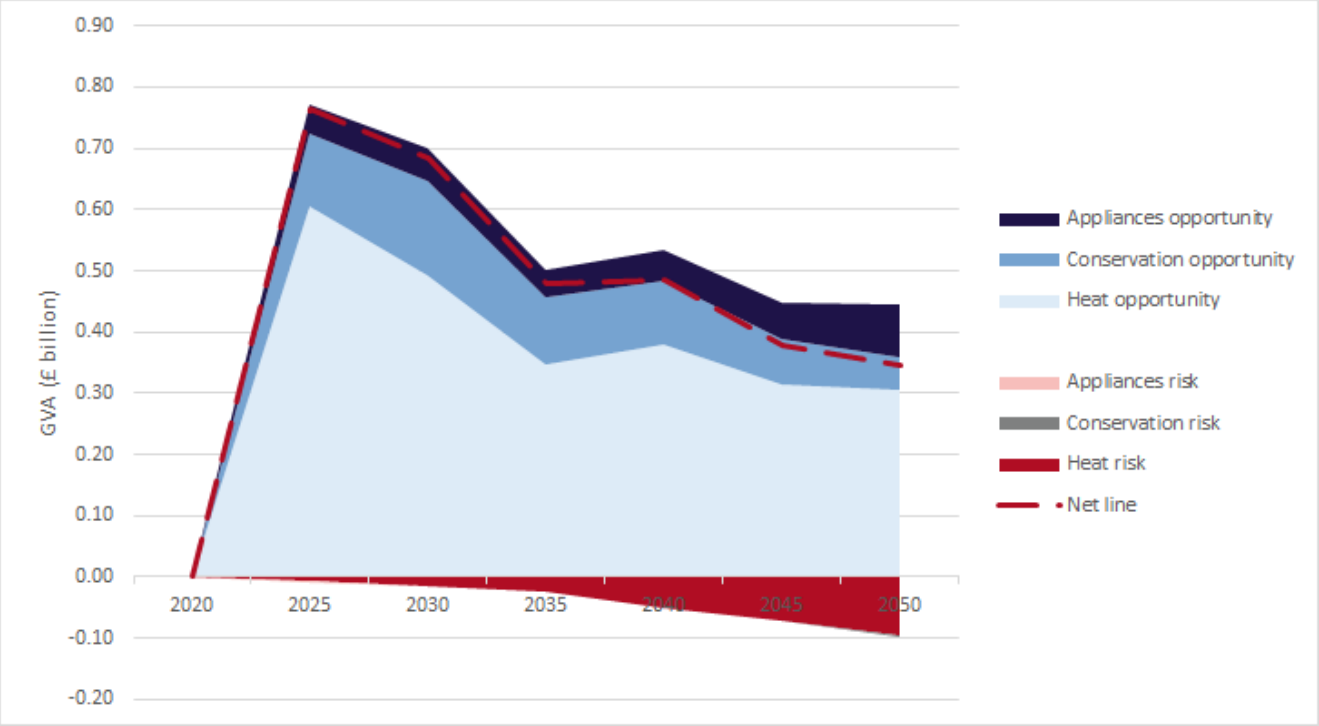
Source: PwC analysis
Note: Other heat includes gas, district heating, electric heaters and others

[129] This is a broad assumption, as other factors such as the number of off-grid homes, space constraints and other factors would also need consideration.

3.3.3. Regional exposure estimates and wider analysis - Buildings

Overall, based on the localisation approach set out above, the regional impact analysis estimates that the core Sixth Carbon Budget scenario for buildings could add £760 million to the North East's GVA by 2025 and £350 million by 2050, both relative to 2020. The early peak is in line with key policy announcements.

Figure 13: Buildings GVA impacts in the North East from 2020 to 2050



Source: PwC analysis of the regional impact tool outputs

The transition to net zero in the building sector could generate a potential net increase of £350 million GVA by 2050. The increase peaks in 2025 at £760 million, in line with the government's target date for all new homes to be zero carbon by 2025, as well as the aim to phase out the installation of high carbon fossil fuel heating during the current decade for all new and existing buildings which are currently off the gas grid.

These announcements include, for example, setting 2025 as the target year for all new homes to be zero carbon ready[130] and the government's aim to phase out the installation of high carbon fossil fuel heating during the 2020s in new and existing buildings in areas beyond the gas grid, as set out in the Clean Growth Strategy.[131] Throughout the transition period, the majority of the GVA generated (60%) comes from heating, with a minority coming from other types of retrofitting and appliances.

The net employment profile estimates broadly align to changes in GVA, with a peak of around 10,000 more net jobs in 2025 than 2020. The net employment then falls to roughly 5,200 more

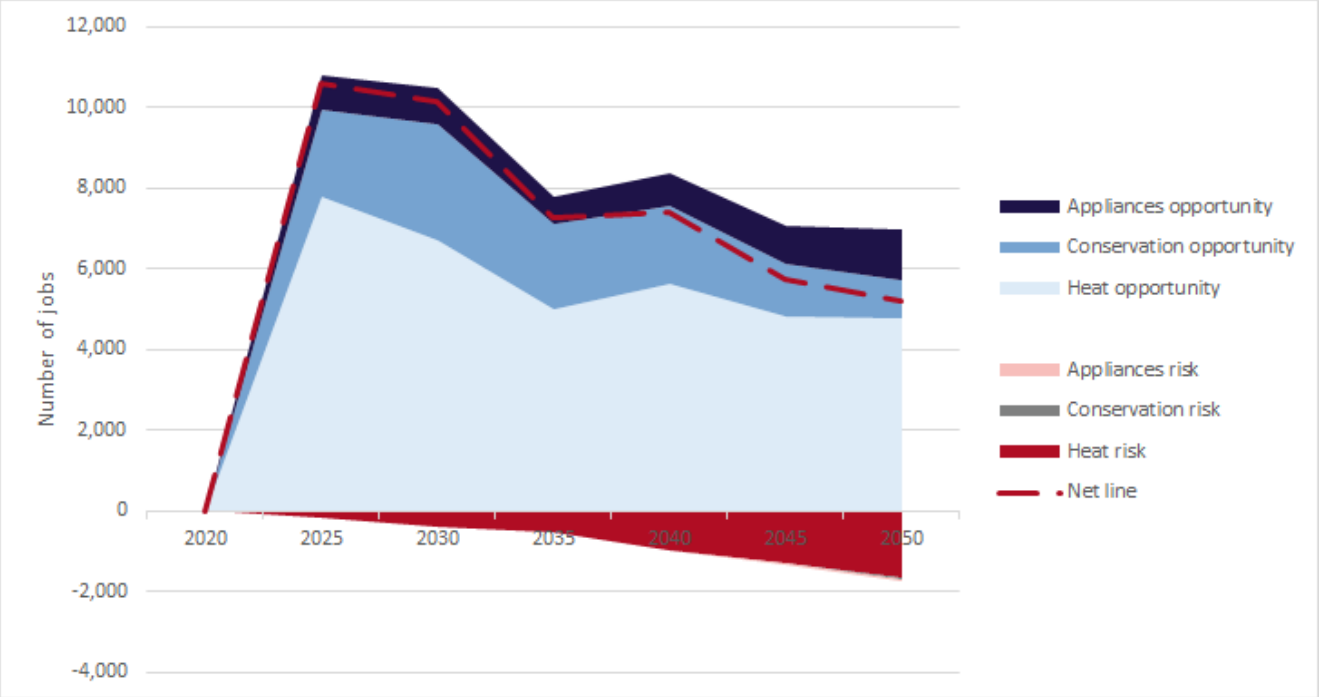
[130] UK Government (2021) *Rigorous new targets for green building revolution*. Available from https://www.gov.uk/government/news/rigorous-new-targets-for-green-building-revolution. Accessed 11 March 2021

[131] HM Government (2017) *The Clean Growth Strategy*. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700496/clean-growth-strategy-correction-april-2018.pdf. Accessed 6 July 2021

jobs in 2050 than 2020. Over the course of the time period, the heating sector remains to be the largest driver of growth at around 60%, with 3,100 more net jobs by 2050.

There is minimal risk of jobs in conservation and appliances across the years, while there are more jobs at risk year on year in the heating sector (by 2050, there may be a loss of 1,600 jobs in heating compared to 2020). This risk may be due to the expected decline in demand for gas and other high-carbon heating. To the extent that tradespeople can adapt skills to low-carbon technologies and the UK develops manufacturing of the underlying low-carbon technologies, these jobs at risk may be offset by the growth potential in the sector.

Figure 14: Buildings employment impacts in the North East from 2020 to 2050



Source: PwC analysis of the regional impact tool outputs

The analysis suggests there could be a potential net increase of 5,200 jobs from net zero transition in the buildings sector compared to 2020, with a peak in potential net additional jobs in 2025. In line with the GVA analysis, the heating sector drives the opportunity for more jobs in the region, but also the risk of losing jobs, as heat pumps and other low-carbon heating systems replace existing higher-carbon technologies.

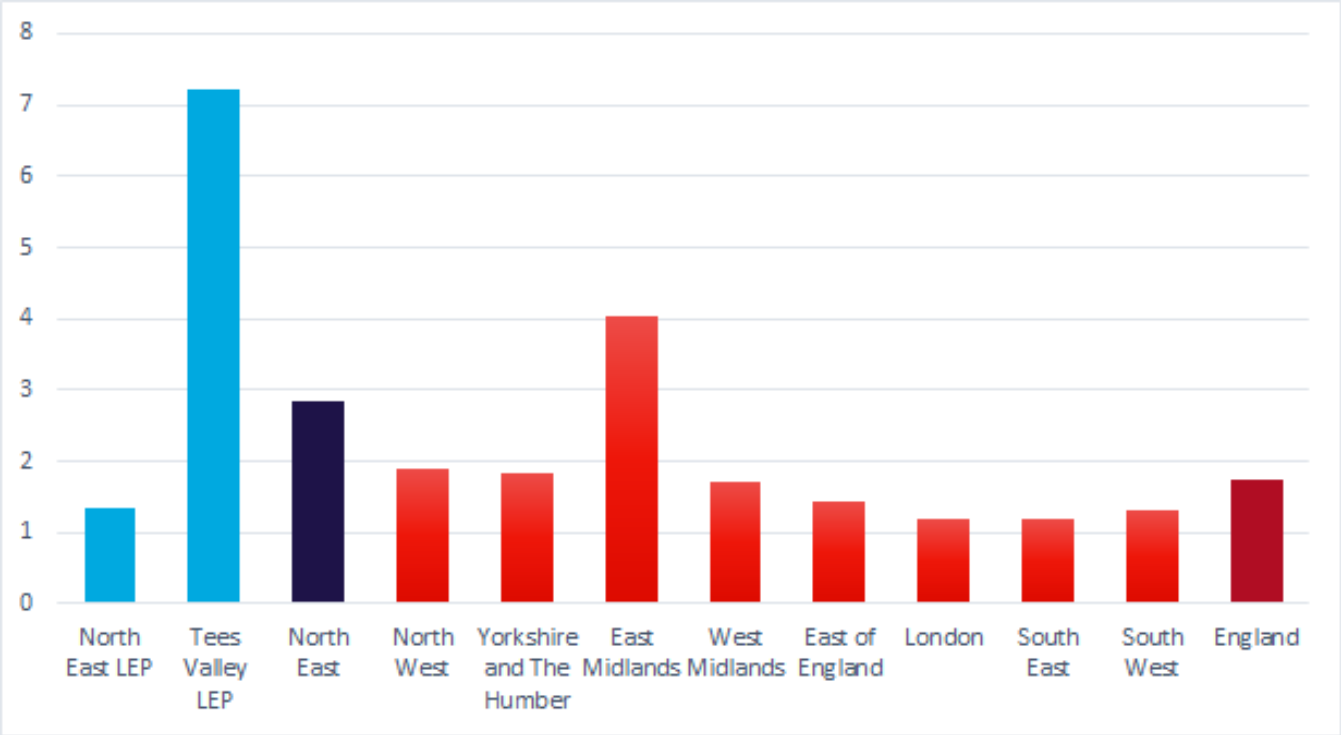
3.4. Industry and carbon capture

This section covers industry and carbon capture, with a focus on chemical and process manufacturing given the existing clusters in the North East region. Manufacturing of vehicles is analysed in the transport section, above. CCUS relates to carbon capture, use, and storage, and is expected to be one of the key technologies in the net zero transition given its role in abating process emissions.[132]

[132] Hydrogen fuel switching and electrification are also expected to be highly crucial.
Element Energy (2020) *Deep-decarbonisation pathways for UK industry. Climate Change Committee*. Available from https://www.theccc.org.uk/publication/deep-decarbonisation-pathways-for-uk-industry-element-energy/. Accessed 19 January 2021

The North East region is the second highest industrial and commercial emitter across the UK, at 2.85 tonnes per capita. This is driven by the Tees Valley LEP area, which emits 7.2 tonnes per capita, and which is where carbon intensive clusters such as chemical and steel production are currently located. These emissions are also more than five times higher than that of the North East LEP area (at 1.2 tonnes per capita).

Figure 15: Industry CO2 emissions per capita



Source: ONS and UK government Statistics (2018)

3.4.1. Analysis of interview responses and literature

The industrial sector is an important sector with significant employment in the North East. Despite being highly exposed to a net zero transition through its high-emitting processes, the majority of stakeholders were optimistic about the potential for the sector. Many felt that the sector can continue to grow as transition progresses but were also aware of the supply chain risks if any industry is left behind and fails to transition. The solution that was most commonly mentioned to support the clusters in the North East, in particular chemical and process manufacturing, was CCUS.

Chemical and process manufacturing

The Tees Valley LEP area contains a large and well-integrated chemical complex[133] which has the potential for advancement of low-carbon biobased feedstocks and chemical recycling centres which could minimise plastic waste. Despite the industry's high emissions, the sector has improved on emissions performance, with the past 30 years seeing an 80% direct

[133] Tees Valley Combined Authority (2020) *Chemicals and Process*. Available from https://teesvalley-ca.gov.uk/business/key-sectors/chemicals-and-process/. Accessed 25 March 2021

emissions reduction (compared to 43% for the UK total).[134] It is also seen as strategically important to a national low-carbon economy as it is needed to build and recycle electric vehicle parts and batteries for storing electricity. This was a view shared by industry stakeholders during the interviews, who noted that alongside chemicals manufacturing, process manufacturing for base industries is necessary to allow the UK to establish an independent industrial base.

However, to capture the opportunity, carbon intensive industries will need to reduce their net emissions. CCUS technologies are seen to be a vital method to reduce emissions. In addition, the high levels of waste-heat produced by the steel and chemical industries could be reused if there is development of industrial waste heat capabilities.

There was consensus amongst stakeholders that government support is needed to achieve transition in the sectors highlighted above. Stakeholders were in agreement that emerging technologies such as CCUS and hydrogen will require a national strategy to articulate how the government sees these contributing towards achieving net zero. There have been steps in this direction, with £1 billion announced in the November 2020 Spending Review for the Carbon Capture and Storage Infrastructure Fund.

This announcement of the fund was followed by the CCUS Cluster Sequencing Process, which will be launched in 2021, with the first phase aiming to identify a natural sequence of clusters, balancing clusters' own deployment schedules with their ability to deliver wider benefits such as cost reduction, learning and economic benefits.[135] Stakeholders within the sector have raised concerns about the sequencing process to BEIS officials through the department's own industry engagement. They highlighted the risk of carbon leakage and offshoring if a region is selected as one of the first clusters as part of the sequencing process. This is because firms within this cluster will have to put on hold existing decarbonisation and clustering plans while the new cluster is established, leaving them at a competitive disadvantage in the interim period, when carbon policy costs (e.g. Emissions Trading Scheme) will be high.

The second phase of the sequencing process will allocate the £1 billion to the selected clusters as well as provide revenue support to individual projects within clusters, in line with the UK government Industrial Decarbonisation Strategy.[136]

Carbon capture

While CCUS is critical to existing high-emitting industries in the North East, the development of CCUS also represents an opportunity for a new industry to emerge in the North East. CCUS technologies offer the ability to decarbonise existing industrial facilities, to produce low-carbon hydrogen for use in transport and heat, as well as to generate negative emissions using

[134] Department for Business, Energy & Industrial Strategy (2020) Final UK greenhouse gas emissions national statistics: 1990 to 2018. Available from https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2018 Accessed 15 September 2021

[135] UK Government (2020) *Carbon Capture Usage and Storage: Market Engagement on Cluster Sequencing.* Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/959729/ccus-cluster-sequencing-consultation-document.pdf. Accessed 10 March 2021

[136] UK government (2021) *Industrial Decarbonisation Strategy*. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/970229/Industrial_Decarbonisation_Strategy_March_2021.pdf. Accessed 7 July 2021

bioenergy with CCUS.[137] The concentration of carbon-intensive industries in the North East and its location next to the North Sea makes the area well suited to industrial CCUS sites. The North Sea and existing mines offer significant potential to store and transport CO2 from carbon-intensive industries.[138] In addition, CCUS can be provided at a lower cost if developed in regional industry clusters, due to economies of scale.

The broad optimism around CCUS was shared by most stakeholders. However, one stakeholder cited a concern that not enough preparation has gone into mitigating the risk of CCUS failure, in other words questioning what are the implications of CCUS not being as effective as originally expected. The concern was that this would slow the transition in industries such as process manufacturing, while alternative measures were developed, while existing industries would become uncompetitive due to carbon taxes and other pressures.

3.4.2. Localisation approach and decarbonisation tables

National UKTM estimates of the demand changes, investment, and carbon reductions needed in industry under the core net zero pathway were apportioned to the region proportionately based on sectoral employment figures. This is on the basis that those areas with existing industrial activity will need to change the most, but the approach does not take into consideration potential growth or decline of sectors.

Given that CCUS is currently in the early stages of development, the approach to applying national level estimates for this technology to the North East has been based on the simplifying assumption of the North East being one of five region-clusters mentioned in the Ten Point Plan.[139] To localise UKTM results relating to CUS, the approach used was to divide the impact equally between the five regions mentioned as potential clusters in the Ten Point Plan. In practice, both private and public investment is likely to follow a different pattern, but in the absence of further data this broad and equalised approach was adopted. The CCUS sequencing process itself was still live as of summer 2021 with results due in October 2021. The assumptions used here are purely illustrative, and do not reflect any expected outcome for the cluster sequencing process.

[137] Vivid Economics (2020) *Net Zero Teesside Economic Benefits. Net Zero Teesside.* Available from https://www.netzeroteesside.co.uk/wp-content/uploads/2020/06/20200508_NZT_Economic_Benefits_Report_Edited_Clean_web.pdf. Accessed 19 January 2021

[138] D. Baxter, J. Emden, L. Laybourn-Langton and H. Lloyd (2017) *Net-Zero North: Delivering the decarbonisation mission in the north of England*. Available from https://www.ippr.org/publications/net-zero-north. Accessed 19 January 2021

[139] HM Government (2020) *The Ten Point Plan for a Green Industrial Revolution*. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/936567/10_POINT_PLAN_BOOKLET.pdf. Accessed 21 January 2021

Table 5: Approach to apply national Sixth Carbon Budget pathways at a regional level for industry and carbon capture

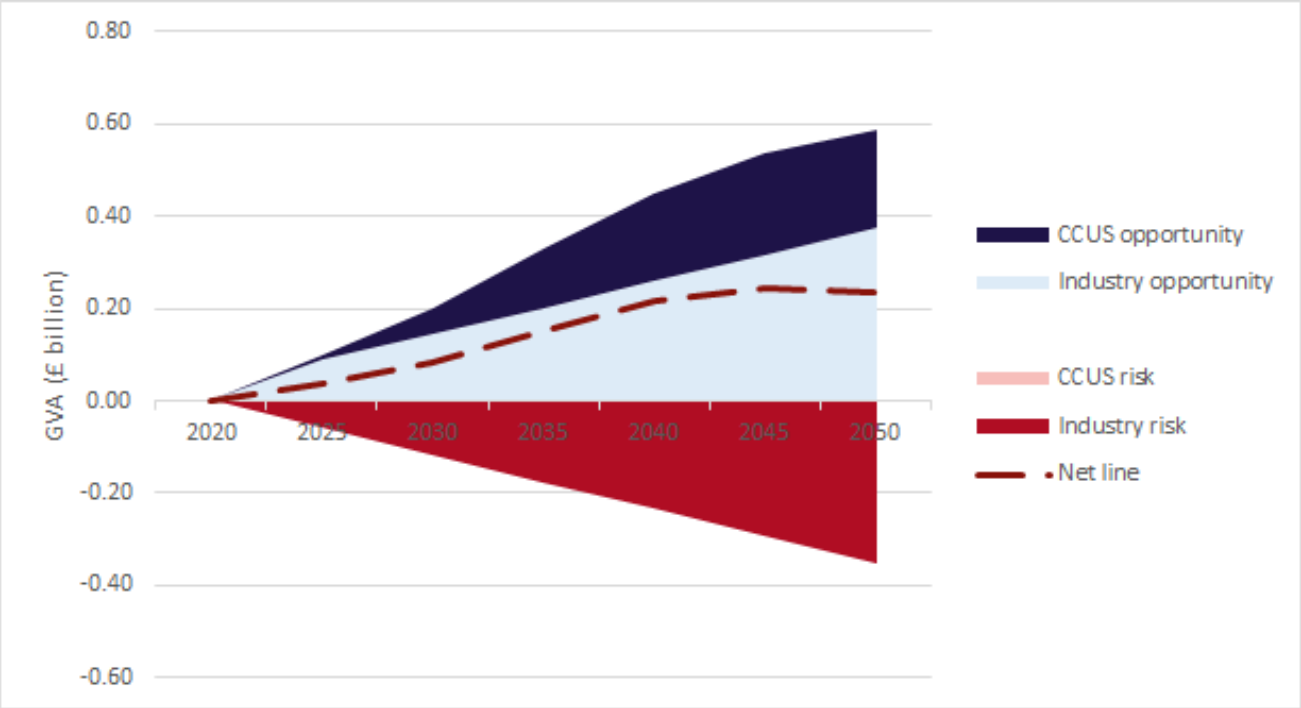
Sector	Localisation principle UKTM data	Data source
Concentrated impacts due to industry mix		
Industry	Proportion of employment in the region compared to UK in each sector incorporated in to the model	NOMIS (2019) Business Register and Employment Survey
Emerging sector		
CCUS storage	Equally divided between the five possible regions mentioned in the Ten Point Plan for a Green Industrial Revolution.	UK government (2020) The Ten Point Plan for a Green Industrial Revolution
CCUS capture and power	Equally divided between the five possible regions mentioned in the Ten Point Plan for a Green Industrial Revolution.	UK government (2020) The Ten Point Plan for a Green Industrial Revolution

Source: PwC analysis

3.4.3. Regional exposure estimates and wider analysis - Industry and Carbon Capture

Based on the regional impact analysis and localisation approach above, the industry and carbon capture sectors could generate together net £230 million in GVA to the North East economy by 2050 compared to 2020.

Figure 16: CCUS and industry GVA impacts in the North East from 2020 to 2050

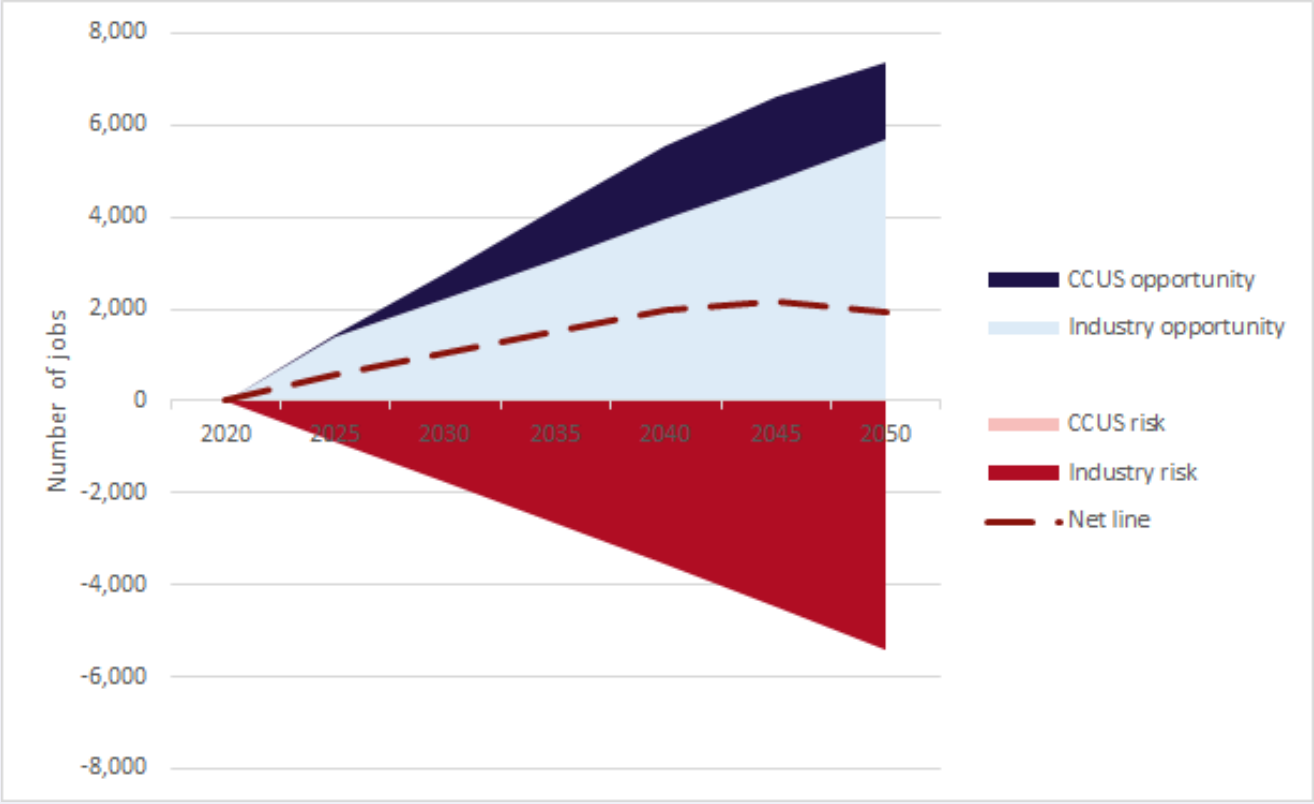


Source: PwC analysis of the regional impact tool outputs

The transition to net zero could lead to a steady increase in net GVA relative to 2020, leading to £230 million more in GVA by 2050 largely driven by CCUS and the potential for the North East to be a CCUS cluster site. While CCUS investments present opportunity in a new sector, the opportunity for industry will require effective investment in decarbonisation to avoid downside risks.

The regional impact analysis suggests that by 2050, there could potentially be 2,000 more net jobs in CCUS and industry, with changes to job levels in wider industry dependent on the success of the carbon transition. While there are minimal net changes in the industry sector,[140] CCUS offers increasing GVA opportunities over the period, with the potential for £210 million more GVA in the region by 2050. This opportunity is driven by the potential for a CCUS cluster site in the North East and CCUS developing as planned; however, there is uncertainty around the underlying technology and hence the impacts. Uncertainty underscores the importance of government support. The minimal net changes in the industry sector are based on the potential for continued steady growth if decarbonisation is achieved, but also the downside exposure to carbon pricing and competition if net emissions are not reduced.

Figure 17: CCUS and industry employment impacts in the North East from 2020 to 2050



Source: PwC analysis of the regional impact tool outputs

The direct employment impacts of decarbonisation from industry and CCUS mirror the GVA impacts, over time. There is the potential for growth in employment if the North East becomes a CCUS cluster site and the absence of the risk of job losses, as there is currently no CCUS in the region.

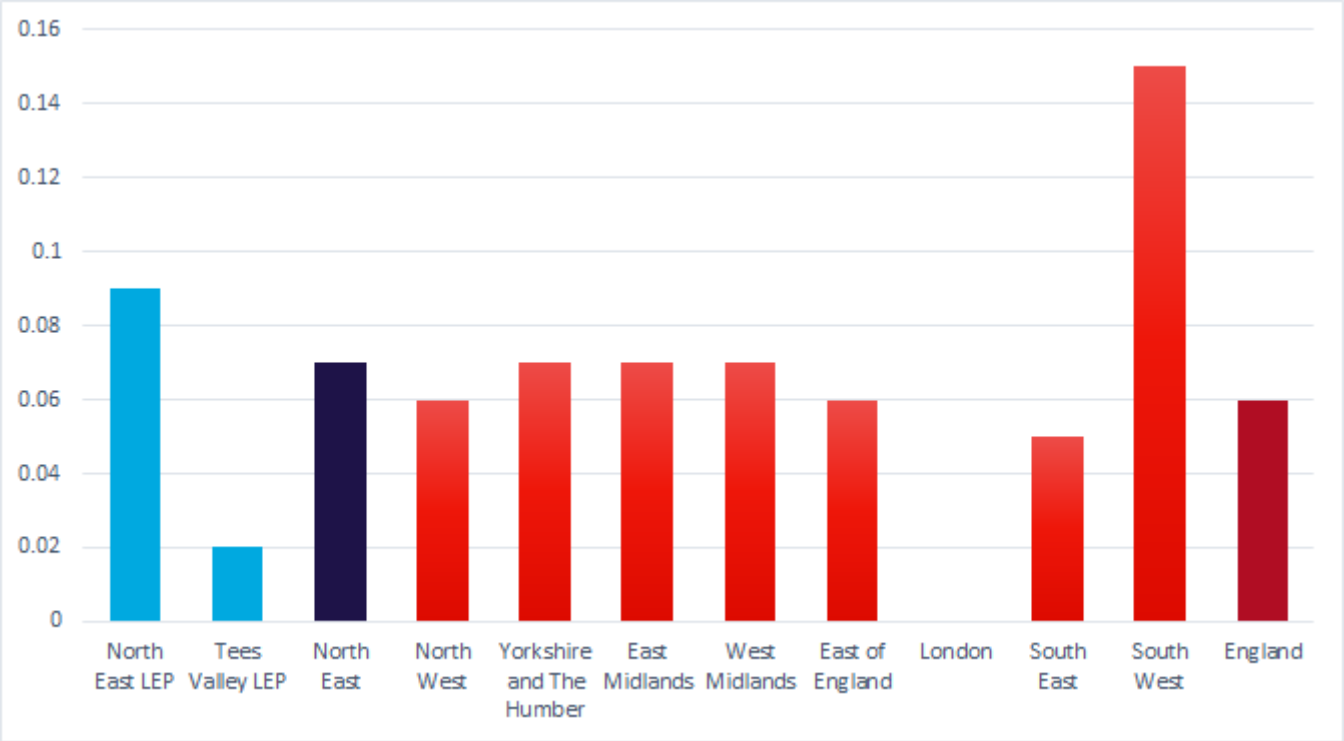
[140] Note that some industry related costs of CCUS are included within figures on industry.

3.5. Land use and agriculture

This section covers land use and agriculture. Land use includes tree planting and restoring peatlands.

In comparison to other sectors, CO2 emissions per capita from agriculture are far lower across all regions in the UK, which may reflect the UK importing nearly 50% of its food.[141] However, the North East has the joint second highest emissions per capita at 0.07 tonnes per capita from agriculture with emissions per capita highest in the South West at 0.15 tonnes per capita. In 2018, 92.9% of land in the North East was non-developed, slightly higher than the average across England of 91.5%.[142] Forest, land and water made up 39.4% of this non-developed land in the North East, which was 18.4% higher than the average across England.[143]

Figure 18: Agricultural CO2 per capita



Source: ONS and UK government Statistics (2018)

[141] UK Government (2020) *Food Statistics in your pocket: Global and UK supply*. Available from https://www.gov.uk/government/statistics/food-statistics-pocketbook/food-statistics-in-your-pocket-global-and-uk-supply. Accessed 10 March 2021. Imports not included in territorial emissions.

[142] Ministry of Housing, Communities & Local Government (2020) *Land Use in England, 2018*. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/900910/Land_Use_in_England__2018_-_Statistical_Release.pdf. Accessed 21 July 2021

[143] Ministry of Housing, Communities & Local Government (2020) *Land use in England interactive report*. Available from https://www.gov.uk/government/collections/land-use-in-england. Accessed 21 July 2021

3.5.1. Analysis of interview responses and literature

Land use and agriculture were not widely mentioned in the stakeholder interviews. One stakeholder did report the need to change the use of land, with a suggestion of linking land use payments to achieving environmental benefits through tree planting, hedgerow planting and peatland restoration by farmers and private landowners. This is expected to be partly delivered through Defra's Environmental Land Management Schemes, replacing the existing Basic Payment Scheme (BPS) in England.[144] Another mentioned that cattle farmers were at risk from a net zero transition, given the changes that may potentially be needed in reducing consumption of meat and dairy.

3.5.2. Regional exposure estimates

For the land use and agriculture sector, the regional impact tool and available data proved unsuitable to produce appropriate estimates of the potential net economic impacts on the North East of the transition to net zero. Further details are set out in Annex D. Further analysis is required of the potential regional impacts of net zero on agriculture and land use.

[144] UK Government (2021) *Environmental land management schemes: overview*. Available from https://www.gov.uk/government/publications/environmental-land-management-schemes-overview. Accessed 30 March 2021

4. Governance, Infrastructure and Skills in the North East

The impact of net zero transition will have wider implications beyond the five key sectors explored in Chapter 3. Governance, infrastructure and the existing skills in the North East will affect and help enable a successful transition. This chapter sets out the findings on the risks and opportunities for each area based on our interviews with both national and local stakeholders.

4.1. Governance in the North East

Strong governance will support a transition to net zero in the region, given the scale of change required. In this respect, the North East has an opportunity to address some concerns that were raised by stakeholders during the interviews. Two points in particular were raised: firstly, the challenges of working across multiple layers of governance across the North East and secondly, the cluster competition approach adopted by central government, which can lead to barriers to knowledge between clusters.

Working across multiple organisations

Government stakeholders said that they generally felt they were able to deliver the region's priorities at pace when needed. However, the view from across other stakeholders was that there are still some challenges working around the multiple layers of governance in the region, although it was accepted that this is not unique to the region. Despite these challenges many stakeholders shared that they are able to make the current arrangement work in order to bring about meaningful change. Stakeholders cited that CAs and LEPs worked well in delivering on the mandate and that they had good relationships with industry, but felt that there are more opportunities for LAs to work more closely together in the future.

In particular, stakeholders were positive about local leadership and strategic thinking on region wide issues such as net zero, adult education and the metro transport system. Some stakeholders also pointed to a need for the region to have a more joined up approach, especially when it came to developing a regional climate strategy and aligning this with the national Net Zero Strategy. Stakeholders believed that if the region is able to come together to tackle this issue, then the likelihood of gaps emerging would be much less, and resources can be allocated more efficiently.

Beyond this, it was mentioned that there was a need for more coordinated action between the public, private and third sectors. However, stakeholders highlighted organisations such as Voluntary Organisations' Network North East (VONNE) and the Materials Processing Institute (MPI) are already engaging stakeholders across academia, industry, public and civil society in order to build better coordination between organisations in the region. The former in particular was praised for creating the North East England Climate Coalition (NEECCo) as a regional response to the climate crisis, with the aim of addressing this issue and ensuring a fair

transition for the region by bringing together representatives from the public, private and Voluntary, Community and Social Enterprise (VCSE) sectors.

Cluster competition

Stakeholders raised a number of challenges around cluster competitions and the current structure used to allocate funding. Some noted that, while competitions amongst regions and clusters can be good to drive efficiency and innovation, they also create a barrier to knowledge sharing. Another challenge that was raised was the level of administrative process involved with competitions and seeking government funding, which can make the process difficult.

A key challenge that was raised on cluster competition was the uncertainty it creates and its effect on industry. Multiple stakeholders noted difficulties with the last CCUS funding programme and the knock-on impact it had on industry confidence and investment in new technologies. More broadly, it was felt that more certainty is needed from the government, in particular in relation to new technologies, and that it is vital that the risk of future projects falling through is minimised.

4.2. Infrastructure in the North East

Stakeholders generally said less about physical infrastructure compared with other areas, such as social infrastructure (for example education and housing), and the net zero transition. This may be a result of net zero scenarios for the future still being unclear, therefore making judgements about physical infrastructure needs somewhat difficult. On education, stakeholders discussed the universities and colleges in the region in some detail, along with the courses that they provide and how they work with industry. Housing has also been covered as part of section 3.3 - Buildings so this section will not discuss housing.

Physical infrastructure

Looking at physical infrastructure, stakeholders generally agreed that the road system was fit for purpose but that further electrification of the rail network was necessary to ensure a better service and as a way of transitioning the sector to net zero. However, in order to secure the investment required, research has highlighted that, historically, infrastructure projects in the North East needed to demonstrate stronger business cases compared to comparable projects in the south.[145] This has often been difficult to achieve given differences in population density and geography, the latest version of the Green Book sets out procedures for place based analysis for policy appraisal to help overcome this challenge.[146]

Beyond this, stakeholders were positive about the region's industrial infrastructure, specifically existing gas infrastructure and the ability to repurpose it to suit transport of hydrogen fuel. More

[145] University of Cambridge (2018) *The Imperial Treasury: appraisal methodology and regional economic performance in the UK.* Available from https://www.bennettinstitute.cam.ac.uk/media/uploads/files/The_Imperial_Treasury_appraisal_methodology_and_regional_economic_performance_in_the_UK.pdf. Accessed 29 March 2021

[146] UK Government (2020) The Green Book (2020). Available from https://www.google.com/url?q=https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent/the-green-book-2020%23a2-place-based-analysis&sa=D&source=editors&ust=1631781280458000&usg=AOvVaw3SJ54un66GVxzho9p9aJ0- Accessed 16 September 2021

recently, Tees Valley was successful in securing funding for a freeport for the region in the March 2021 UK budget, however the North East LEP's bid for a freeport[147] was not successful.[148]

Social infrastructure

Stakeholders were positive about the social infrastructure[149] in the North East, in particular the universities and the further education capabilities in the region, and how these educational institutions work with industry. A number of examples were given of the work being done on the low-carbon economy. These included:

- The National Centre for Energy Systems Integration (CESI). A £20 million multi-institutional, multi-discipline industrial research consortium investigating the future energy challenges for the UK, led by Newcastle University and with partners such as Durham University. The aim is to undertake research into the whole energy system, including heating, cooling, electricity and transport, taking into account generation, distribution and demand as well as policy, economics and regulation;
- Net Zero North. A collaboration of eight research intensive universities[150] in the north of England working to support green economic growth in the region through partnerships with industries. The collaboration commits to addressing the long-term skills gap challenge through co-produced research programmes based on business need, delivering a comprehensive programme of skills and learning, as well as university to business and business to business collaboration and knowledge sharing[151]; and
- Durham Energy Institute. A multidisciplinary research institute based out of Durham University. Its research focuses on decarbonisation of the energy sector and is involved in a number of key low-carbon initiatives including for example CESI mentioned above and the North East Centre for Energy Materials (NECEM).[152]

Industry stakeholders noted that the partnerships between industry and universities are allowing the North East to tackle some of the challenges of a net zero transition. However, they mentioned that one of the areas that the government could support is the commercialisation of new technologies. Stakeholders mentioned that while the quality of research in the region is high, it is sometimes not possible to take new technology or innovations to market as the risk is too high. Bridging this gap between research and commercialisation could present opportunities for the region and the country as a whole. Commercialisation is also recognised

[147] A freeport is a secure customs zone at a port where different customs rules apply. To find out more, please visit: https://www.gov.uk/government/consultations/freeports-consultation/freeports-consultation

[148] Chronicle Live (2021) *'Bitter disappointment' as North East loses out on freeport bid.* Available from https://www.chroniclelive.co.uk/news/north-east-news/bitter-disappointment-north-east-loses-19957741. Accessed 22 July 2021

[149] Social infrastructure in this context covers a range of social services and assets which contribute towards a good quality of life. For example hospitals, universities, parks and prisons.

[150] The eight universities are: Durham University, Lancaster University, University of Leeds, University of Liverpool, University of Manchester, Newcastle University, University of Sheffield and University of York.

[151] N8 Research Partnership (2021) *Net Zero North*. Available from https://www.n8research.org.uk/net-zero-north. Accessed 20 January 2021

[152] Durham University (2021) *Durham Energy Institute*. Available from https://www.durham.ac.uk/research/institutes-and-centres/durham-energy-institute/. Accessed 22 July 2021

in the UK Innovation Strategy, which includes plans to establish a Commercialisation Funding Framework and strengthen support for commercialisation capability.[153]

Collaborations have yielded some tangible results more recently. An example is the partnership between Newcastle University and industrial partners in the Northern Powergrid and Siemens, which resulted in the UK's largest smart grid project, the Smart Grid Lab. The project provides a simulation demonstrating the impacts on distribution networks under future scenarios, to provide guidance on how smart grids will be needed to mitigate future energy challenges.[154]

Stakeholders were also positive about the further education opportunities available in the region. They felt that colleges and other further education institutions were responsive to changes in the labour market and would offer new courses if there is demand for them from prospective students and employers. Stakeholders noted that there can be a challenge around ensuring that enough skilled workers are available in the labour market, due to timing issues around supply moving quickly to keep up with demand. Stakeholders mentioned that given the pace at which the transition may progress, universities and colleges may sometimes find it difficult to know which courses to provide. In particular, if there is not enough clarity on the technologies that the UK will adopt going forward. Despite this, climate change degrees are already being offered at some universities in the UK.[155] Further, the Green Jobs Taskforce report published this year sets out recommendations for building better pathways to green careers that include ensuring green jobs are open to all, improving the teaching of climate change knowledge and skills, and reviewing green training pathways.[156]

4.3. Impact of net zero on skills in the North East

The impact of the net zero transition on skills will depend on the current skills base in the region, the level of skills needed during the transition and the quality of jobs created as a result of the transition. Stakeholders were overall positive about the potential for the North East to benefit from the transition, through new jobs being created in emerging low-carbon sectors, and expressed that sectors which face significant exposure to net zero would successfully transition. The consensus from stakeholders was that much of the skills base within the North East is transferable to a net zero economy. While some retraining will be necessary, it is unlikely that many will need to undergo full retraining. To illustrate this point, stakeholders gave examples of some of the skills in offshore oil and gas, which can be applied to offshore wind, and skills in the manufacture of ICE vehicles can be applied to electric vehicle manufacturing.

[153] Department for Business, Energy & Industrial Strategy (2021) UK Innovation Strategy: leading the future by creating it. Available from https://www.gov.uk/government/publications/uk-innovation-strategy-leading-the-future-by-creating-it Accessed 15 September 2021

[154] Newcastle City Council (2020) *Our Newcastle, Our Future, Net Zero Newcastle - 2030 Action Plan*. Available from https://www.newcastle.gov.uk/sites/default/files/Climate%20Change/Net%20Zero/Net%20Zero%20Newcastle%20-%202030%20Action%20Plan_0.pdf. Accessed 21 January 2021

[155] For example the University of Greenwich (https://www.gre.ac.uk/undergraduate-courses/engsci/climate-change-bsc) and Liverpool John Moores University (https://www.ljmu.ac.uk/study/courses/undergraduates/2021/climate-change)

[156] Green Jobs Taskforce (2021) Green Jobs Taskforce report. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1002112/green-jobs-taskforce-report__1_.pdf. Accessed 16 July 2021

One stakeholder also noted that the CAs in the region have devolved powers over the adult training budget and could support the skills base transition.[157]

A concern that was raised was around issues with the current skills training from some colleges and private providers. Industry stakeholders mentioned that some courses were proprietary to certain companies and could act as a barrier to entry or prohibit employees from moving between jobs in the same sector without requiring additional training. This issue was also recognised in the Green Jobs Taskforce report which recommended "passporting" arrangements between course providers to allow for standardisation of requirements.[158]

Stakeholders were nevertheless positive about the quality of jobs being created during the transition, with almost all stakeholders expecting new jobs of equal or greater quality compared to those jobs lost or replaced. This will be important to ensure a fair transition, providing workers with similar or better opportunities as the economy transitions to net zero.

Skills gaps were cited as a potential issue, in particular for new technologies. As an example, stakeholders mentioned CCUS construction, given that the technology and processes are new, the retrofitting skills required and the number of people needed with this skill to meet transition targets. The skills gap could also be exacerbated by the high rates of out-migration of students who attend the region's universities.[159] Stakeholders did also note several aspects that worked in favour of the region when it came to retaining skills, such as the lower cost of living, access to outdoor sites or national parks and the attractiveness of living in areas such as Newcastle.

The Green Jobs Taskforce report highlighted the employment opportunities and skills needs for the North East, which were primarily in line with stakeholders views mentioned above.[160] Specifically the taskforce noted CCUS, onshore wind, offshore wind, nature conservation and restoration, nuclear and automotive were key areas for the region.

[157] MHCLG (2019) *Devolution: A Mayor for the North of Tyne. What does it mean?* Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/789556/North_of_Tyne_Brochure_A4.pdf. Accessed 10 March 2021
DCLG (2017) *Devolution: A Mayor for the Tees Valley. What does it mean?* Available from https://www.lepnetwork.net/media/1483/plain_english_guides_to_devolution_tees_valley.pdf. Accessed 10 March 2021

[158] Green Jobs Taskforce (2021) Green Jobs Taskforce report. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1002112/green-jobs-taskforce-report__1_.pdf. Accessed 16 July 2021

[159] See for instance: Savage, M. (2018) Brain drain of graduates to London leaves cities facing skills shortage. Available from: https://www.theguardian.com/money/2018/mar/18/regions-london-brain-drain-graduates-metro-mayors Accessed 15 September 2021

[160] Green Jobs Taskforce (2021) *Green Jobs Taskforce report*. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1002112/green-jobs-taskforce-report__1_.pdf. Accessed 16 July 2021

5. Overall assessment

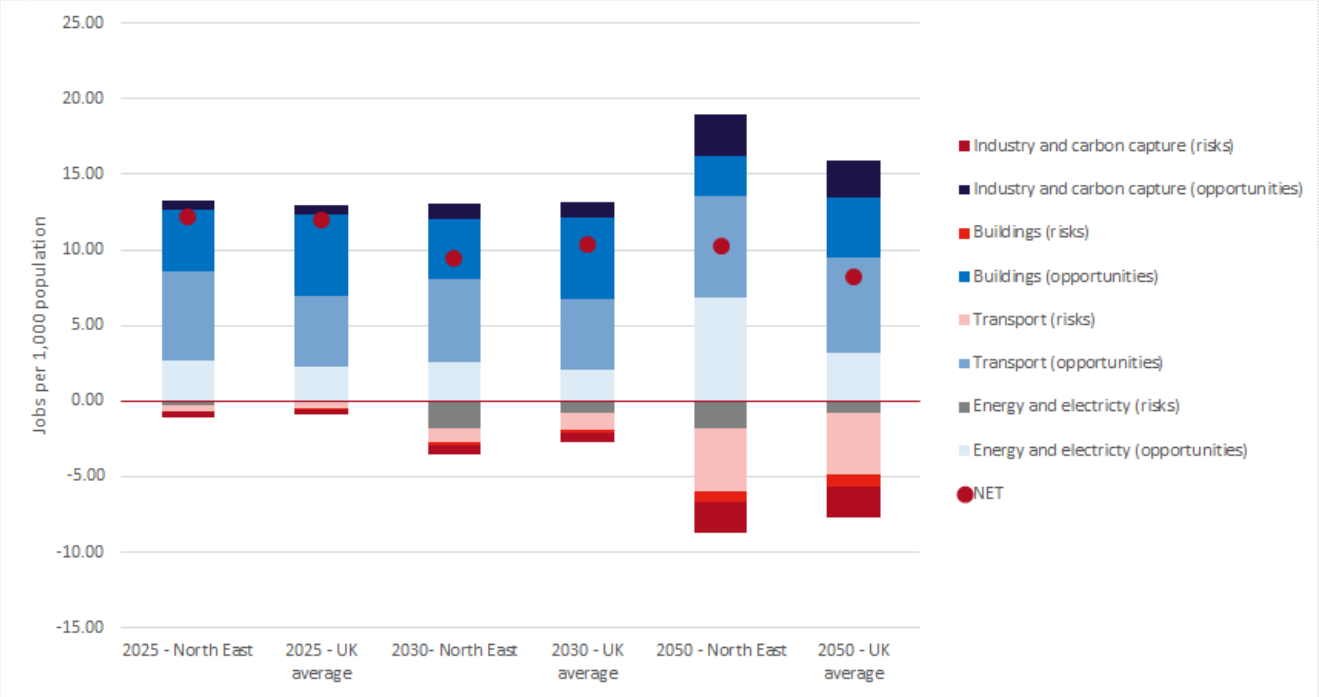
The North East has the potential to benefit from the transition to net zero, over and above the benefits that may accrue at a national level. However, steps need to be taken across key sectors to realise opportunities and mitigate risks. The opportunity is driven in part by the region's potential to attract high investments in hydrogen, offshore wind, and other low-carbon energy generation. Investment in these technologies could be enabled by both the North East's geography and industrial history and infrastructure. For instance, the region has sites suitable for hydrogen storage and existing hydrogen distribution and production capacity; it also has ports located in proximity to offshore wind infrastructure and resources. There is also a significant opportunity in decarbonising buildings and transport, which is in line with other regions. Investment in these technologies nationally will be supported by policy commitments included in the Ten Point Plan for a Green Industrial Revolution and further policy announcements made by the UK government ahead of hosting COP26.

Figure 19 below shows the comparison of the potential risks and opportunities in the North East region and the UK in 2025, 2030 and 2050. The opportunities grow over time, outpacing potential risks, and they grow relatively more for the North East.

By 2025, the North East opportunity is around the same level as the UK average in terms of direct jobs gained compared to 2020. The importance of net zero activities in buildings and transport - which will need to take place across the UK - help explain the relative similarities, and demonstrate the potential role of decarbonisation in enabling a green recovery from the Covid-19 pandemic. After another five years the region's opportunity is again broadly in line with the UK average, but may experience slightly higher risks from decarbonisation in the energy sector. By 2050, the North East again sees a greater than average increase in opportunity, based primarily on the energy and electricity and industry and carbon capture sectors. It also experiences higher downside risk than the UK average due to the phase out of fossil fuels and biomass over time, but overall the net opportunity less risk is higher than average. Given the importance of energy, electricity, and CCUS in the longer term opportunity, the ability of the North East to capture opportunities in these sectors (through for example, acting as clusters), will be important to realising gains. Adoption of low-emissions vehicles in the region also helps drive the overall opportunity.[161]

[161] See Annex D for sensitivities of the absence of any investment in key areas such as hydrogen and CCUS.

Figure 19: Overall national scenario compared to the North East, per 1,000 population in 2018



Source: PwC analysis of the regional impact tool outputs
Note: This is standardised per thousand population (2018)

The stronger and larger relative economic impact in 2050 (compared to 2020) for the North East compared to the UK is driven by opportunities in the energy and electricity (offshore wind, hydrogen, nuclear and biomass) sector and industry carbon capture sectors. The net increase in the number of direct jobs for the North East compared to 2020 remains relatively flat after 2030 as gains in the energy sector are offset by rising risks in the transport sector. For the UK as a whole, net additional direct job opportunities from the net zero transition decline as there is a less pronounced increase in the energy sector. Given the potential risks across sectors mitigation, measures will need to be carefully considered to ensure that the individuals affected are able to transition to sectors of new investment. .

The analysis of net opportunity and risk is intended to highlight the possibility that individuals who are displaced from some industries are able to enter others. As a result, consideration will need to be given to the potential downside risks, which grow over time, and how these can be mitigated. High level analysis performed of occupation codes suggested that the relative distribution of occupations would not dramatically alter by 2050 compared to 2020 under the core pathway. However, labour mobility will be key to enabling a smooth transition, as highlighted in the Green Jobs Taskforce report.[162]

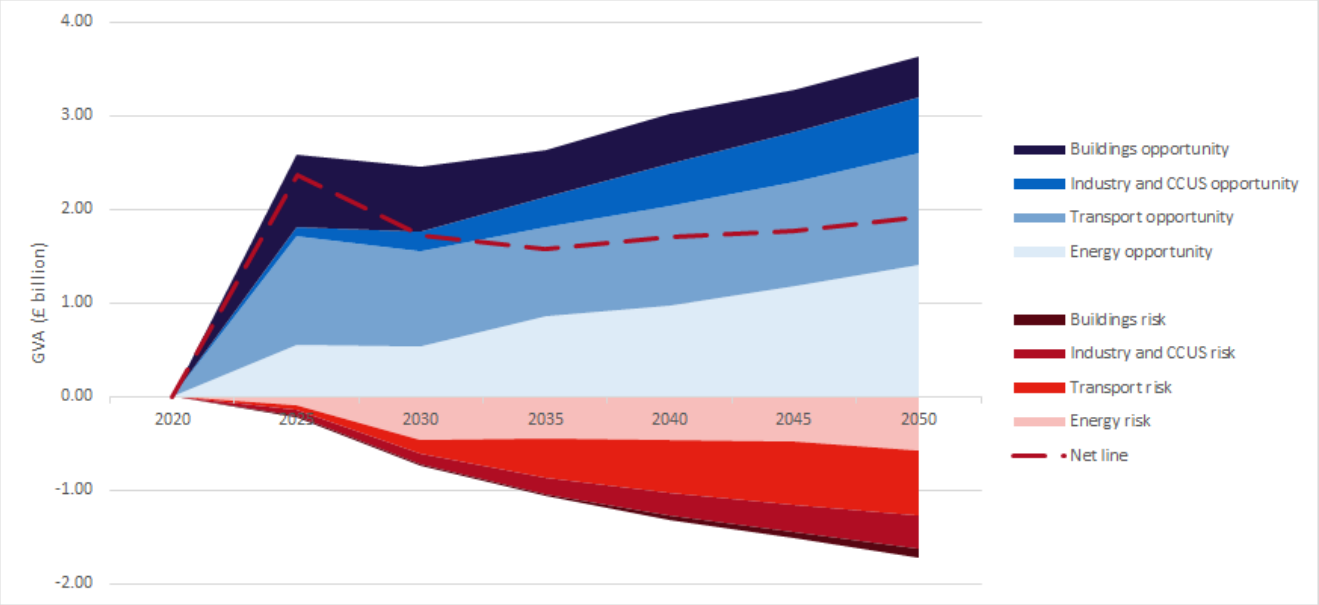
While these results are intended to demonstrate the temporal aspect and relative impacts of transition, it should also be noted that these are illustrative only. Results do not, for instance, take into account situations where investment and development costs for assets need to be

[162] Green Jobs Taskforce (2021) Green Jobs Taskforce report. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1002112/green-jobs-taskforce-report__1_.pdf. Accessed 16 July 2021

incurred earlier in reality,[163] and they are based on 'in-year' cost profiles and assumptions from several sources. This means some of the potential impacts may in fact be felt in other time periods.

The analysis shows that, in real terms, an additional £1.9 billion could be added to annual direct GVA in the North East under the core net zero pathway by 2050 (as compared to 2020). This is equal to around 4% of current GVA in the North East. The initial increase in GVA by 2025 will be driven by the transport and building sectors. It will then decline slightly as gains in the energy and electricity sector will be counterbalanced by a phase out of fossil fuels and related transportation.

Figure 20: Overall GVA impacts in the North East from 2020 to 2050



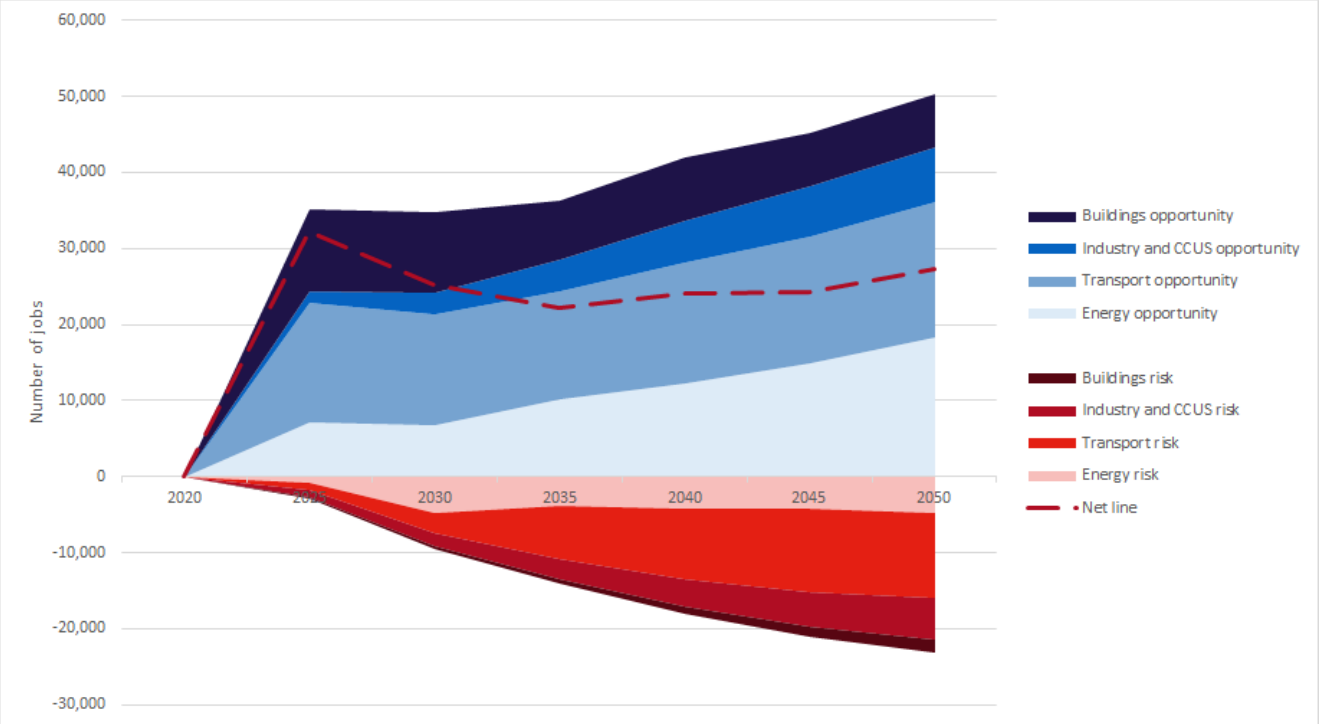
Source: PwC analysis of the regional impact tool outputs

Under the localisation approach used to apply the Sixth Carbon Budget Core scenario to the North East, the peak increase in GVA (as compared to 2020) occurs in 2025 (at £2.4bn) and is driven by the early transition in the transport and buildings sectors, as well as in certain low-carbon energy technologies. Further gains in GVA in following decades are made largely due to the development of the energy and electricity sector, including across a wider range of technologies. However, this increase is partially offset by the phase out in fossil fuels and related transportation, as well as a diminished opportunity from buildings and biomass.

The potential impacts in terms of jobs follow a broadly similar pattern to those of GVA. By 2050, there could be a net additional 27,000 direct jobs in the North East across the sectors above compared to 2020 under the core decarbonisation pathway. The greatest opportunity is in the energy and electricity sector (13,500 jobs), followed by transport and buildings (6,500 and around 5,000 jobs, respectively).

[163] See page 29 of this report for more: Climate Change Committee (2020) The Sixth Carbon Budget Methodology Report. Available from https://www.theccc.org.uk/wp-content/uploads/2020/12/The-Sixth-Carbon-Budget-Methodology-Report.pdf Accessed 17 September 2021

Figure 21: Overall employment impacts in the North East from 2020 to 2050



Source: PwC analysis of the regional impact tool outputs

Under the localisation approach used to apply the Sixth Carbon Budget Core scenario to the North East, the peak increase in employment from 2020 levels occurs in 2025, which is accommodated by the increase in transport and buildings sectors and certain low-carbon energy technologies. Gains in employment in following decades are made largely due to the development in the energy and electricity, and opportunity in the industry and carbon capture sectors. However, over time the opportunity for new jobs is offset by increasing jobs at risk in the road transport sector, as manufacturing, sales, and associated infrastructure for ICE vehicles decline.

Based on the localisation approach used, the overall net picture is relatively robust to alternate national decarbonisation pathways that were modelled as part of the Sixth Carbon Budget Impact Assessment (see Annex E for further details). As set out in Figure 22 below, with the exception of the 'no net zero' pathway (counterfactual), which assumes the UK does not aim for net zero in 2050, the net jobs impact varies between net zero pathways from around 26,000 (high CCUS scenario) and 31,000 (low CCUS scenario). This is driven by the relative similarity of impacts from sectors such as buildings and transport, and the presence of several low-carbon energy industries (offshore, nuclear, hydrogen, biomass) in the North East, which creates some resilience to the exact energy pathway that the UK follows. For instance, under the localisation assumptions used:

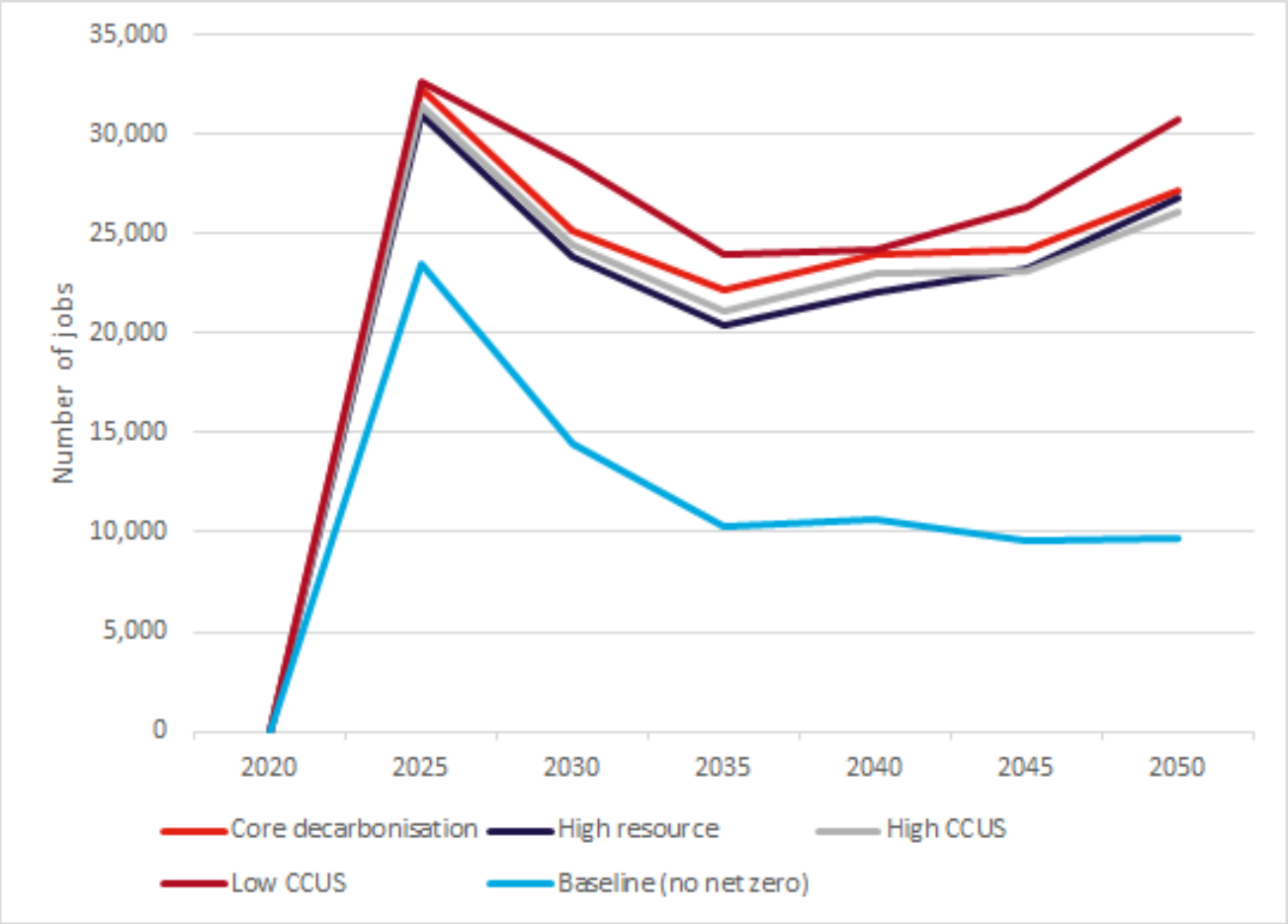
- Under the 'High resource' UKTM scenario[164] (which is based on more reliance on hydrogen), the North East stands to benefit as one of the hydrogen clusters. However, the lower spend in nuclear cancels out some of the additional gains from hydrogen investment; and
- In contrast, under the Low CCUS scenario, there is more investment in nuclear nationally, as well as in other sectors. As 13% of nuclear and offshore investment is centred in the North East under the localisation assumptions, this leads to higher

[164] Descriptions of the Sixth Carbon Budget scenarios used above are provided in Annex E, Box E1.

general impacts . Under High CCUS, the impacts in the Low CCUS are reversed, meaning that the North East's net gain in jobs is lower.

Additional sensitivity analysis under different scenarios is covered in more detail in the Annex D.

Figure 22: Net jobs exposure in the North East under different UKTM pathways



Source: PwC analysis of the regional impact tool outputs.
Descriptions of the Sixth Carbon Budget scenarios used above are provided in Annex E

Figure 21 shows the impacts to net jobs exposure in the North East overall as the UK transitions to net zero under different UKTM Sixth Carbon Budget pathways, compared to 2020 levels. Under the Baseline scenario (no net zero/counterfactual) slightly over 10,000 net jobs are created by 2050. In comparison, the range of net zero pathways estimate number of jobs created from around 26,000 (high CCUS scenario) to 31,000 (low CCUS scenario).

Looking beyond the sectors, the wider governance, infrastructure and skills present in the North East will also affect exposure to net zero transition.

On governance, stakeholders reported two key challenges for the region. The first was around having to work across multiple layers of governance and the need to often work across multiple organisations, a challenge which is not unique to the North East. Despite this, stakeholders noted that, where a priority was identified for the region, they are able to pull together and deliver at pace, with a number highlighting the positive impact metro mayors have had pushing the agenda. Many stakeholders also expressed the view that more work can be done to engage further with the third sector. Organisations such as VONNE and the MPI are already engaging across academia, industry, public and civil society in order to build better

coordination between organisations in the region, however, this can be expanded and built upon.

The second challenge focused on how central government can best deliver and incentivise funding for emerging technologies such as CCUS and hydrogen. While they acknowledged the benefits of having competition between clusters in driving value for money and efficiency, they felt the barrier to communication and knowledge sharing was of a greater concern as well as the uncertainty the competition itself creates.

On infrastructure, stakeholders said little regarding precise physical infrastructure needs under the net zero transition, which may be a reflection of net zero scenarios remaining unclear at this point in time. Stakeholders were more confident about repurposing and leveraging existing industrial infrastructure in the region, citing specifically the potential to convert some of the existing gas infrastructure to transport hydrogen fuel, and the potential as a transport hub. Multiple stakeholders highlighted the strength of other infrastructure in the region, which included the road network and the number of internationally connected ports in the region. The latter in particular was recognised in 2021 as Teesport in Tees Valley secured funding for freeport status.

Regarding social infrastructure, stakeholders highlighted the strength of universities and further education institutions, noting how many had formed meaningful partnerships with industry. They also felt further education institutions were responsive to changes in the labour market, offering new courses if there was sufficient demand for them. However, there were concerns raised around ensuring there were enough skilled workers available to meet demand in emerging industries, noting that responsiveness and flexibility by providers would need to be maintained.

The impact of net zero on skills depends on the current skills base, the skills needed during the transition and the quality of jobs created as a result of the transition. Stakeholders were positive about the potential for the North East to benefit from the transition, through new jobs being created in emerging low-carbon sectors, and expressed that sectors which face significant exposure to net zero would successfully transition. The main potential issue cited by stakeholders was skills gaps developing, especially in new and emerging technologies such as hydrogen, CCUS and electric vehicles manufacturing. The issue could also be exacerbated by the high rates of out-migration of students who attend the region’s universities.

Annex A: The North East region

This annex provides an overview of the economic composition of the North East, including the industries it is home to and the jobs and skills those industries support.

Economic output

The unique characteristics of the North East region ensures it has a key role in UK strategy, however, the same characteristics pose unique challenges to achieving net zero transition. In this context, the North East's economy was valued at £52.6 billion in 2018, accounting for roughly 2.9% of the UK GVA, the latest year where data is available (at the time of writing) on a regional basis.[165] The North East LEP contributed £39.4 billion and the Tees Valley £13.2 billion,[166] broadly in line with differences in population. In the same year, the North East region had a GVA per capita of £19,800, around 71% of the UK average of £27,700.[167]

The North East LEP has noted that there has traditionally been a focus on the mining and manufacturing sectors. With manufacturing in particular still being a key focus in the area, with clusters in automotive and medicine manufacturing.[168] These sectors in particular face a greater exposure to transition. However, Invest North East England[169] has also highlighted the growing IT and software industry cluster, and noted that the region had the highest growth rate of any other UK region in these sectors (excluding London) in the period between 2013 to 2017.[170] As a result these growing sectors may help insulate the region overall from some net zero transition compared to other regions.

The Tees Valley LEP has highlighted that the area has a significant presence of the chemical and process sectors compared to the rest of the UK, with 30% of total UK output from the chemicals and processing industry produced in the region.[171] In the Tees Valley Strategic Economic Plan, it is reported that employment levels in these two sectors are more than double that of the national average, and that in advanced manufacturing, employment levels are at least one and a half times the national average.[172] In a similar regard to the

[165] ONS (2019) *Regional gross value added (balanced) by industry: local authorities by NUTS1 region*. Available from https://www.ons.gov.uk/economy/grossvalueaddedgva/datasets/regionalgrossvalueaddedbalancedlocalauthoritiesbynuts1region. Accessed 9 March 2021

[166] ONS (2019) *Regional gross value added (balanced) by industry: city and enterprise regions*. Available from https://www.ons.gov.uk/economy/grossvalueaddedgva/datasets/regionalgrossvalueaddedbalancedbycombinedauthoritycityregionsandothereconomicandenterpriseregionsoftheuk. Accessed 9 March 2021

[167] GVA per capita of £19,900 for the North East LEP. GVA per capita of £19,500 for the Tees Valley LEP.

[168] North East LEP (2019) *North East Energy for growth*. Available from https://www.nelep.co.uk/wp-content/uploads/2019/08/full-strategy-energy-for-growth-strategy.pdf. Accessed 8 March

[169] This organisation works alongside the region's seven local authorities aiming to support new inward investment and promote the region as prime location for businesses to locate, grow and prosper. Available from https://investnortheastengland.co.uk/. Accessed 8 March

[170] Invest North East England (2020) *Why North East England works*. Available from https://investnortheastengland.co.uk/north-east-england-works/#:~:text=North%20East%20England%20is%20one,to%20call%20our%20region%20home. Accessed 8 March

[171] Tees Valley Combined Authority (2016) *Tees Valley Strategic Economic Plan: The Industrial Strategy for Tees Valley*. Available from https://teesvalley-ca.gov.uk/wp-content/uploads/2016/03/TVCA-Strategic-Economic-Plan-2016-26.pdf Accessed 8 March 2021

[172] Tees Valley Combined Authority (2016) *Tees Valley Strategic Economic Plan: The Industrial Strategy for Tees Valley*. Available from https://teesvalley-ca.gov.uk/wp-content/uploads/2016/03/TVCA-Strategic-Economic-Plan-2016-26.pdf Accessed 8 March 2021

manufacturing clusters mentioned above, the chemical, process and advanced manufacturing sectors face exposure to net zero transition given their relative size compared to the other UK regions.

The North East region is also closely linked to the rest of the UK through business operations and supply chains operating across the country. The low-carbon economy reflects these linkages, with businesses in the offshore energy industry having links with Scotland, the Humber, Liverpool and Cumbria, as an example.[173] The region is connected with other regions through partnerships such as the Northern Powerhouse, NP11 and Transport for North (TfN). The region also has well established international trade links, with the Institute for Public Policy Research (IPPR) reporting that the region has the highest proportion of its exports going to non-EU countries, at 62%.[174] These linkages have implications for how net zero transition will be governed and the role the North East could potentially play in transport decarbonisation.

Across the North East LEP there are five ports in total which are globally connected and provide key access for businesses to supply chains, such as the Port of Tyne and Sunderland Port.[175] In 2018, the North East LEP region exported £4.4 billion worth of goods, equivalent to 1.4% of total UK export value.[176] In the same year, the Tees Valley LEP region exported £2.5 billion worth of goods, 0.8% of total UK export value.[177] The Tees Valley LEP area exports relatively more as a proportion of GVA than the North East LEP and the national average. Its export value was 19.0% of GVA, compared to 11.2% in the North East LEP area and 16.7% for the UK as a whole. Given the high proportion of international trade being conducted in the region this creates additional exposure for businesses not just from UK transition but abroad as well.

Labour market

The labour market in the North East performs slightly lower than the UK average across a number of key indicators and statistics. In the North East LEP and Tees Valley LEP, 75.3% and 74.0% of the working age population were economically active in the third quarter of 2020, compared to 78.3% in the UK as a whole.[178] Tees Valley LEP had a slightly lower unemployment rate of 6.1% compared to 6.3% in the North East LEP, both of which were above the 2020 UK average of 4.2%.[179] Since 1992 (the earliest year for which regional figures

[173] North East Local Enterprise Partnership (2019) *The North East Strategic Economic Plan*. Available from https://www.nelep.co.uk/wp-content/uploads/2019/02/north-east-strategic-economic-plan-jan-2019-final.pdf. Accessed 19 January 2021.

[174] HMRC (2017) *UK Regional Trade in Goods Statistics* in D. Baxter, J. Emden, L. Laybourne-Langton and H. Lloyd (2017) *Net-Zero North: Delivering the decarbonisation mission in the north of England* (reference) Available from https://www.ippr.org/files/2017-12/net-zero-north-report-1712.pdf. Accessed 19 January 2021.

[175] North East LEP (2019) *The North East Strategic Economic Plan*. Available from https://www.nelep.co.uk/wp-content/uploads/2019/02/north-east-strategic-economic-plan-jan-2019-final.pdf. Accessed 19 January 2021

[176] ONS (2020) *International trade in services by subnational areas of the UK*. Available from https://www.ons.gov.uk/businessindustryandtrade/internationaltrade/datasets/internationaltradeinservicesbysubnationalareasoftheuk. Accessed 10 March 2021

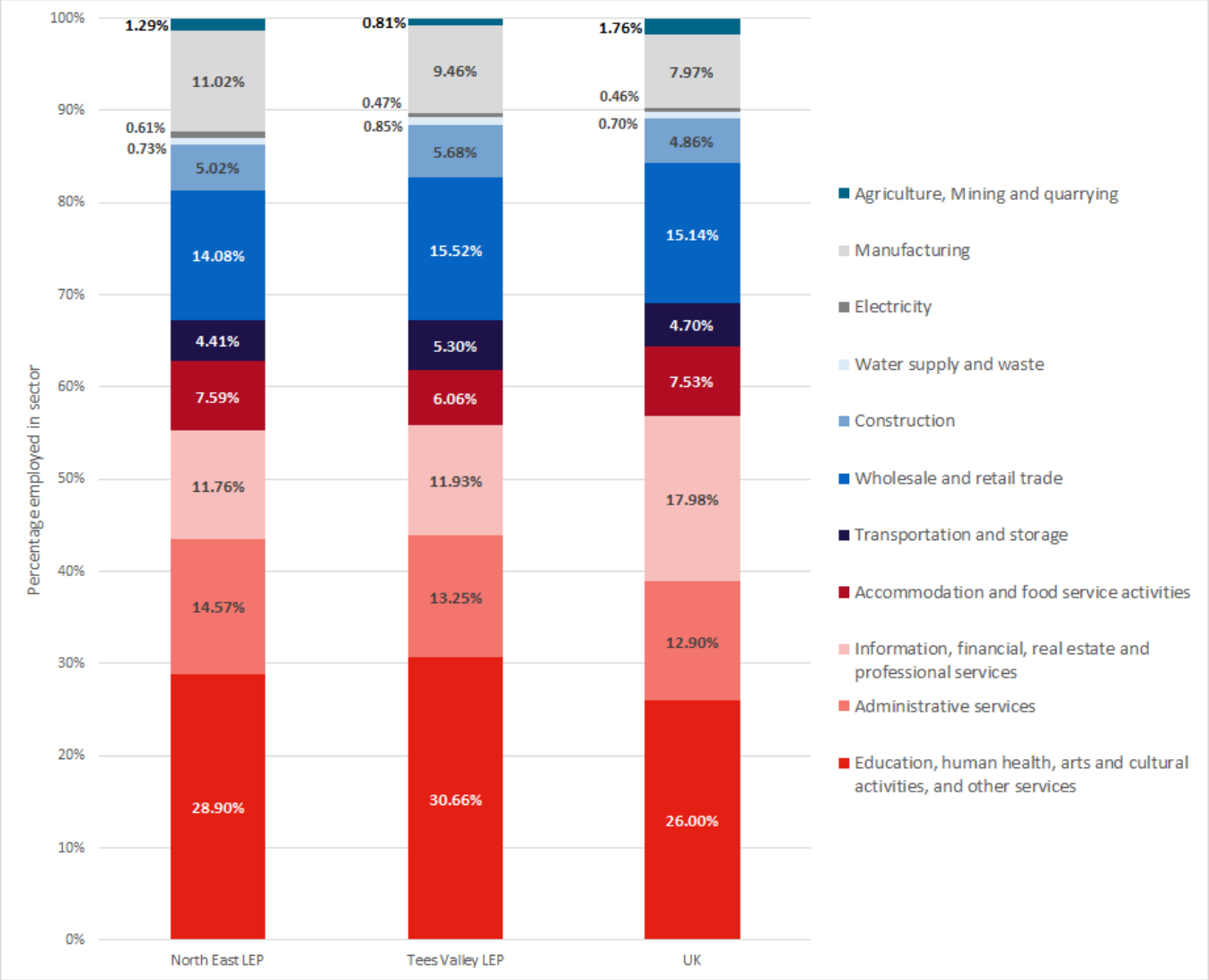
[177] ONS (2020) *International trade in services by subnational areas of the UK*. Available from https://www.ons.gov.uk/businessindustryandtrade/internationaltrade/datasets/internationaltradeinservicesbysubnationalareasoftheuk. Accessed 10 March 2021

[178] NOMIS (2019) *Annual Population Survey*. Available from https://www.nomisweb.co.uk/. Accessed 16 March 2021
ONS (2021) *LI05 Regional labour market: Local indicators for Local Enterprise Partnerships*. Available from https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/datasets/locallabourmarketindicatorsforlocalenterpriseparternshipsli05. Accessed 16 March 2021

[179] NOMIS (2019) *Annual Population Survey*. Available from https://www.nomisweb.co.uk/. Accessed 9 March 2021

are available), the unemployment rate in the North East region has been consistently higher compared to the UK.[180] The challenges in the underlying labour market would suggest the region faces greater exposure to net zero transition.

Figure A1: Employment distribution across sectors



Source: *NOMIS (2018), PwC Analysis*[181]

The employment distribution in the two LEPs follows similar patterns to that of the UK with some small variances. The professional, scientific and technical activities sector sees the lowest proportion of employment in the two LEPs compared to the UK. The sector employs 9% in the UK, but only 4% and 5% in the North East LEP and Tees Valley LEP respectively. However, the manufacturing sector represents a greater proportion of employment in the North

[180] ONS (2021) *LFS: ILO unemployment rate: North East: All: %: SA*. Available from https://www.ons.gov.uk/employmentandlabourmarket/peoplenotinwork/unemployment/timeseries/ycnc/lms. Accessed 23 March 2021

[181] NOMIS (2018) *Annual Population Survey*. Available from https://www.nomisweb.co.uk/. Accessed 9 March 2021
NOMIS (2018) *Business Register and Employment Survey*. Available from https://www.nomisweb.co.uk/. Accessed 9 March 2021
PwC analysis

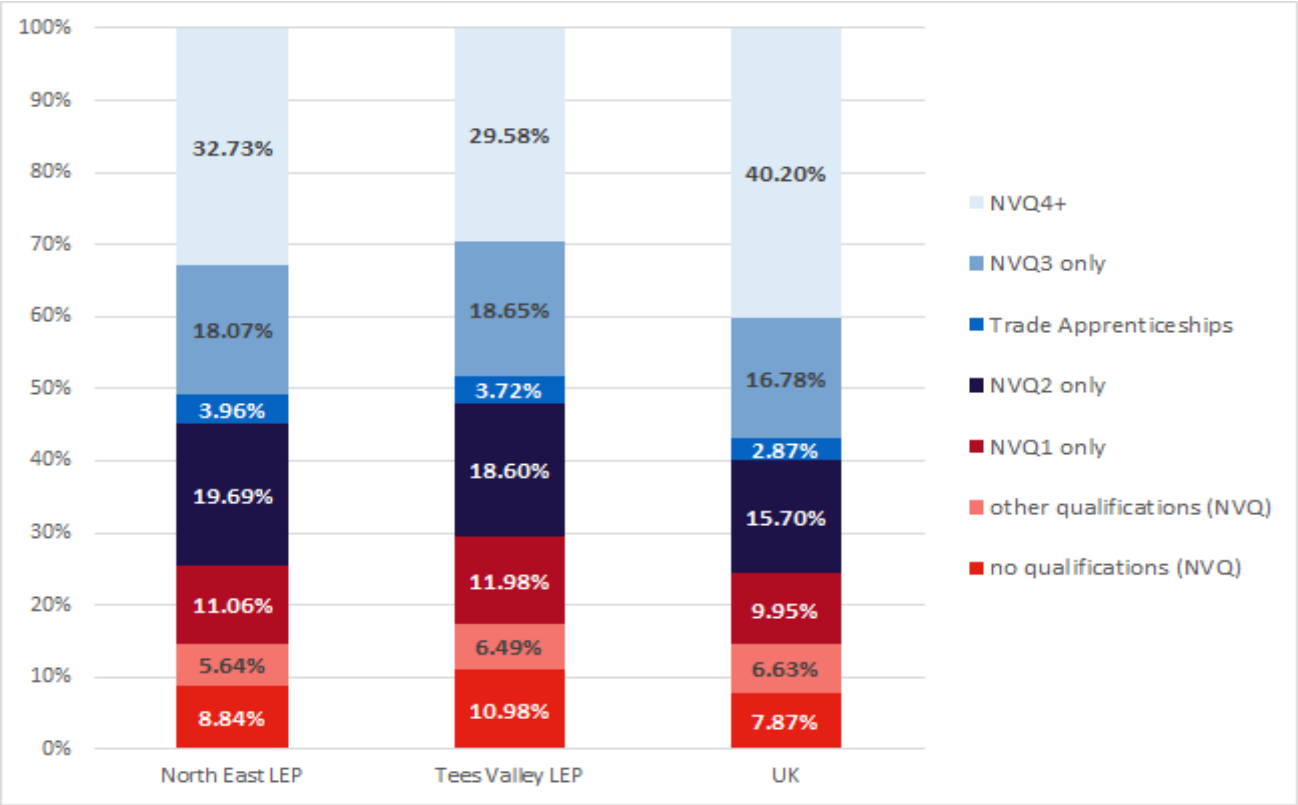
East. The sector reflects 8% of employment across the UK, with 11% in the North East LEP and 9% in the Tees Valley LEP. These are important differences, as mentioned previously manufacturing in general has a greater exposure to transition compared to other sectors.

The biggest relative differences between the two LEPs are in the agriculture and mining and quarrying sectors. The agricultural sector is 2.5 times larger relatively by employment in the North East LEP compared to the Tees Valley LEP (reflecting that it predominantly covers and urban area), while the mining and quarrying sector is nearly 5 times larger in the Tees Valley LEP.[182] In absolute terms however, these differences are small, as shown by Figure A1.

Skills

The North East region is home to several leading academic and research institutions such as Newcastle University, the University of Sunderland, Northumbria University, Teesside University and Durham University. The region has a high intake of students studying higher education relative to its population size, and it awards a significant number of research degrees related to the low-carbon energy sector, but graduate retention has been identified as an issue,[183] as a result increasing the exposure of the region to large skills gaps forming as transition to net zero gets underway.

Figure A2: Qualification differences between the LEPs and the UK



Source: *NOMIS (2019)*

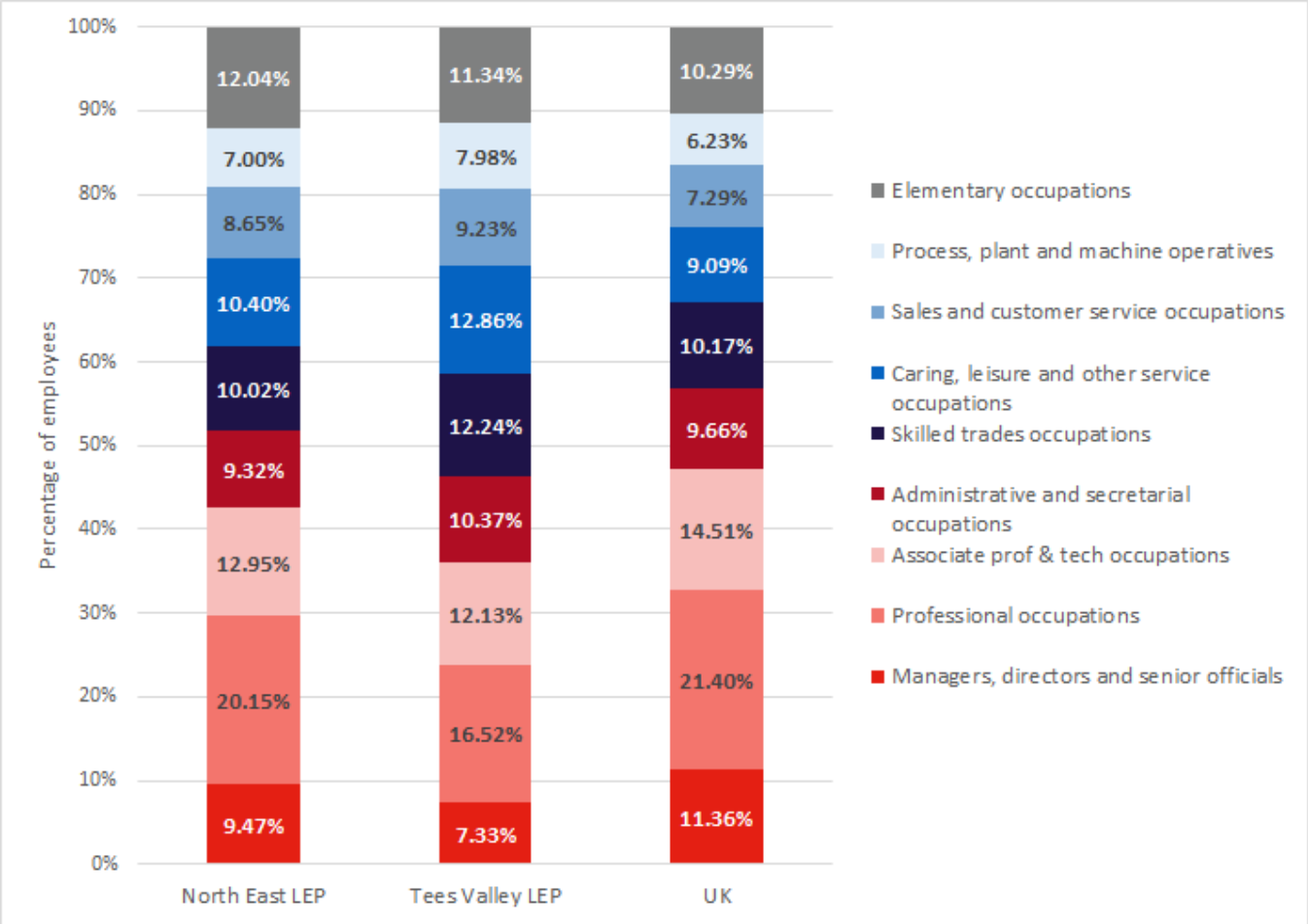
[182] NOMIS (2018) *Annual Population Survey*. Available from https://www.nomisweb.co.uk/. Accessed 9 March 2021 NOMIS (2018) *Business Register and Employment Survey*. Available from https://www.nomisweb.co.uk/. Accessed 9 March 2021 PwC analysis

[183] Joshua Emden and Luke Murphy (2019) *A just transition - realising the opportunities of decarbonisation in the north of England*. Available from https://www.ippr.org/files/2019-03/energy-skills-march19.pdf. Accessed 21 January 2021.

At the same time, higher qualifications rates are lower in the North East and Tees Valley LEPs compared to the UK. Only 33% of the working population are qualified to National Vocational Qualification (NVQ) Level 4 (degree level) or above in the North East LEP and 30% in the Tees Valley LEP, compared to 40% nationally.[184] In contrast, the LEPs have relatively more people qualified with trade apprenticeships. Both LEPs have a relatively higher proportion of people with no qualifications, compared to the UK (7.9%), with this being higher for Tees Valley LEP (11.0%) than the North East LEP (8.8%).

The occupation distribution in the LEPs follows a similar pattern to that of the UK, with some differences. There are relatively fewer people in managerial, directorial and senior official positions in the two LEPs. Similarly, the Tees Valley LEP area has relatively fewer workers in professional occupations when compared to the national average and the North East LEP area. In contrast, Tees Valley has relatively more workers in skilled trades occupations compared to the North East LEP and to the UK as a whole. Both LEPs also have a slightly larger proportion of the workforce in process, plant and machine operative roles compared to the UK, with the Tees Valley LEP having a larger proportion out of the two LEPs.

Figure A3: Occupation distribution differences between the LEPs and the UK



Source: *NOMIS (2019)*

[184] NOMIS (2019) *Qualifications (NVQ) by age. Annual Population Survey*. Available from https://www.nomisweb.co.uk/query/select/getdatasetbytheme.asp?opt=3&theme=&subgrp=. Accessed 21 January 2021

Annex B: Regional benchmarking

Figure B1: Benchmarking at UK Level

	Overall				Transport				Domestic				Industry & Commercial				Agriculture & Land use			Energy
Metric	CO2 emissions per capita	CO2 emissions £ GVA	Per capita GVA	Skills of workforce	Transport CO2 emissions per capita	Population density	E- infrastructure	Vehicle mix	Domestic CO2 per capita	Energy mix	Home energy efficiency		Business CO2 per capita	Business mix	Business energy mix	Business 'efficiency' component	Agricultural CO2 per capita	Agricultural 'efficiency' component	Land use change CO2 per capita	Renewable energy
Description	*Total estimated CO2 by final use divided by the number of inhabitants*	*CO2 per GVA based on regional CO2 estimates, divided by predicted CO2 using national intensities*	*Total regional GVA divided by the number of inhabitants*	*Proportion of economically active workforce with NVQ 3 and above**	*Total estimated transportation CO2 by final use divided by the number of inhabitants*	*Total population divided by area (km2)*	*Average electric vehicles charging devices per thousand total licensed vehicles*	*Number of ultra low emission vehicles per thousand total licenced vehicles*	*Total estimated industrial/commercial CO2 by final use divided by the number of inhabitants*	*Domestic electricity consumption (GwH) / total domestic energy consumption*	*Average of median energy efficiency score for Energy Performance Certificate (1-100) by dwelling*	*Social housing as a % of total dwellings*	*Total estimated industrial/commercial CO2 by final use divided by the number of inhabitants*	*Predicted CO2 based on local industry mix, relative to England*	*Industrial/commercial electricity consumption (GwH) / total energy consumption*	*CO2 per GVA based on regional CO2 estimates, divided by predicted CO2 using national intensities*	*Total estimated agricultural CO2 by final use divided by the number of inhabitants*	*CO2 per GVA based on regional CO2 estimates, divided by predicted CO2 using national intensities*	*Total estimated agricultural CO2 by final use divided by the number of inhabitants*	*Electrical generating capacity from renewable sources*
Units	Tonnes of CO2 per capita	Indexed, CO2/GVA (England = 1)	GVA (£) per capita	% of economically active	Tonnes of CO2 per capita	Persons per km2			Tonnes of CO2 per capita	% GwH electricity consumed as a proportion of total domestic energy consumed	Score from 1-100*****	% of social housing	Tonnes of CO2 per capita	Indexed, tonnes of CO2 per GVA (England = 1)	% GwH consumed	Indexed, CO2/GVA regional estimates compared to predicted based on SIC codes	Tonnes of CO2 per population	Indexed, CO2/GVA regional estimates compared to predicted based on SIC codes	Tonnes of CO2 per capita	% of the England's renewable energy generated in the region
Local Enterprise Partnership																				
North East LEP	4.06	1.19	£20,616	56%	1.69	252	0.68	4.50	1.54	18%	.76	23%	1.36	1.31	39%	0.88	0.09	2.18	-0.61	3%
Tees Valley LEP	10.42	3.10	£20,372	55%	1.75	828	0.43	2.61	1.43	18%	.75	19%	7.23	1.16	17%	5.39	0.02	0.61	-0.02	1%
Region																				
North East	5.67	1.67	£20,554	56%	1.71	306	0.61	3.96	1.51	18%	.75	22%	2.85	1.03	28%	1.85	0.07	1.79	-0.46	4%
North West	5.25	1.27	£25,119	59%	1.87	489	0.36	11.21	1.47	20%	.76	17%	1.89	1.11	30%	1.17	0.06	1.13	-0.03	12%
Yorkshire and The Humber	5.41	1.31	£25,033	58%	2.04	342	0.33	8.40	1.53	18%	.74	17%	1.83	1.28	34%	1.15	0.07	1.57	-0.07	24%
East Midlands	7.50	2.41	£18,813	59%	1.95	318	0.34	5.36	1.48	21%	.73	15%	4.03	1.49	21%	1.74	0.07	1.37	-0.04	11%
West Midlands	5.25	1.33	£23,963	56%	2.10	454	0.30	6.66	1.42	21%	.75	18%	1.70	1.35	37%	0.93	0.07	1.51	-0.05	3%
East of England	5.11	1.06	£29,134	57%	2.28	349	0.32	10.61	1.42	23%	.76	15%	1.43	1.01	41%	1.33	0.06	1.60	-0.08	31%
London	3.26	0.38	£51,780	72%	0.88	5,652	1.92	16.94	1.20	23%	.77	22%	1.19	0.56	52%	0.66	0.00	0.01	-0.01	1%
South East	4.65	0.87	£32,210	66%	2.13	506	0.44	12.39	1.47	22%	.76	13%	1.19	0.35	35%	0.47	0.05	0.60	-0.19	6%
South West	4.79	1.05	£27,496	62%	2.08	245	0.33	10.59	1.36	25%	.76	13%	1.32	1.07	42%	0.80	0.15	2.70	-0.12	9%
England	5.00	1.00	£30,241	61%	1.87	433	0.50	10.16	1.41	22%	.75	17%	1.74	1.00	35%	1.00	0.06	1.00	-0.09	1.00
Year	2018	2018	2018	2019	2018	2018	2019, 2020**	2019, 2020***	2018	2018	2019****	2019	2018	2018	2018	2018	2018	2018	2018	2019
Dataset	(1)	(1) (2)	(1) (2)	(3)	(1)	(1)	(4) (5)	(5) (6)	(1)	(7)	(8)	(9) (10)	(1)	(2) (11)	(7)	(1) (2)	(1)	(1) (2)	(1)	(12)

Source Datasets

(1) Local Authority territorial CO2 emissions estimates 2005-2018 (kt CO2), UK government
(2) Regional gross value added (balanced) by industry: all NUTS level regions, ONS
(3) Annual Population Survey, NOMIS
(4) Electric Vehicle Charging Device Statistics
(5) Licensed vehicles at the end of the year by body type and upper and lower tier local authority 1 , including diesel cars and vans, United Kingdom, 2019
(6) Ultra low emission vehicles (ULEVs) 1 licensed at the end of the quarter by upper and lower tier local authority 2, United Kingdom from 2011 Q4
(7) Total sub-national final energy consumption, 2018 from Sub-national total final energy consumption in the United Kingdom (2005 - 2018)
(8) Energy Performance Certificate statistics for new and existing flats and houses
(9) Number of dwellings by tenure and district, England, UK government, 2019

(10) Number of dwellings by tenure and region, from 1991, UK government, 2019
(11) Atmospheric emissions: greenhouse gases by industry and gas (kt CO2), ONS
(12) Renewable electricity generation: (MWh) at Local Authority Level - 2019, UK government

Figure B2: Employment (direct) carbon exposure score (page 1)

Direct exposure by SIC Section			England		North East		North East LEP		Tees Valley LEP		North East relative exposure	
Section Code	Section Name	CO2/ GVA	% jobs in the region	Direct exposure	% jobs in the region	Direct exposure	% jobs in the region	Direct exposure	% jobs in the region	Direct exposure	North East LEP	Tees Valley LEP
		Kt CO2 per £ million GVA	%		%		%		%		Region exposure - England exposure	
		A	B	A*B*100	C	A*C*100	D	A*D*100	E	A*E*100		
A01	Crop and animal production, hunting and related service activities	0.73	0.50%	0.36	0.33%	0.24	0.38%	0.28	0.15%	0.11	-0.08	-0.25
A02	Forestry and logging	0.16	0.03%	0.00	0.03%	0.01	0.04%	0.01	0.01%	0.00	0.00	0.00
A03	Fishing and aquaculture	1.51	0.01%	0.01	0.01%	0.01	0.01%	0.01	0.01%	0.01	0.00	0.00
B	Mining and quarrying	1.73	0.15%	0.26	0.24%	0.42	0.16%	0.27	0.47%	0.82	0.01	0.56
C10T12	Manufacture of food products, beverages and tobacco products	0.00	1.18%	0.00	0.99%	0.00	0.85%	0.00	1.27%	0.00	0.00	0.00
C13T15	Manufacture of textiles, wearing apparel and leather products	0.01	0.28%	0.00	0.09%	0.00	0.11%	0.00	0.05%	0.00	0.00	0.00
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of article	0.60	0.22%	0.13	0.37%	0.22	0.44%	0.26	0.30%	0.18	0.13	0.05
C17	Manufacture of paper and paper products	0.48	0.15%	0.07	0.17%	0.08	0.16%	0.08	0.14%	0.06	0.01	-0.01
C18	Printing and reproduction of recorded media	0.08	0.28%	0.02	0.33%	0.03	0.38%	0.03	0.12%	0.01	0.01	-0.01
C19	Manufacture of coke and refined petroleum products	8.02	0.02%	0.16	0.05%	0.40	0.02%	0.15	0.14%	1.08	-0.01	0.92
C20	Manufacture of chemicals and chemical products	1.05	0.27%	0.28	0.66%	0.69	0.38%	0.40	1.35%	1.42	0.12	1.13
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	0.05	0.11%	0.01	0.25%	0.01	0.33%	0.02	0.02%	0.00	0.01	0.00
C22	Manufacture of rubber and plastic products	0.41	0.46%	0.19	0.58%	0.24	0.66%	0.27	0.51%	0.21	0.08	0.02
C23	Manufacture of other non-metallic mineral products	2.31	0.24%	0.56	0.29%	0.67	0.33%	0.76	0.17%	0.39	0.19	-0.17
C24	Manufacture of basic metals	2.80	0.18%	0.51	0.29%	0.81	0.16%	0.46	0.68%	1.89	-0.05	1.39
C25	Manufacture of fabricated metal products, except machinery and equipment	0.20	0.83%	0.17	1.32%	0.27	1.42%	0.29	1.18%	0.24	0.12	0.07
C26	Manufacture of computer, electronic and optical products	0.04	0.32%	0.01	0.19%	0.01	0.22%	0.01	0.08%	0.00	0.00	-0.01
C27	Manufacture of electrical equipment	0.14	0.20%	0.03	0.29%	0.04	0.38%	0.05	0.08%	0.01	0.03	-0.02
C28	Manufacture of machinery and equipment n.e.c.	0.13	0.53%	0.07	0.99%	0.13	1.09%	0.14	0.59%	0.08	0.07	0.01
C29	Manufacture of motor vehicles, trailers and semi-trailers	0.08	0.48%	0.04	1.24%	0.10	1.42%	0.12	0.68%	0.06	0.08	0.02
C30	Manufacture of other transport equipment	0.09	0.39%	0.03	0.25%	0.02	0.22%	0.02	0.27%	0.02	-0.01	-0.01
C31_32	Manufacture of furniture; other manufacturing	0.16	0.49%	0.08	0.45%	0.07	0.44%	0.07	0.46%	0.07	-0.01	-0.01
C33	Repair and installation of machinery and equipment	0.04	0.37%	0.02	0.17%	0.01	0.14%	0.01	0.30%	0.01	-0.01	0.00

Figure B3: Employment (direct) carbon exposure score (page 2)

Direct exposure by SIC Section			England		North East		North East LEP		Tees Valley LEP		North East relative exposure	
Section Code	Section Name	CO2/ GVA	% jobs in the region	Direct exposure	% jobs in the region	Direct exposure	% jobs in the region	Direct exposure	% jobs in the region	Direct exposure	North East LEP	Tees Valley LEP
		Kt CO2 per £ million GVA	%		%		%		%			
		A	B	A*B*100	C	A*C*100	D	A*D*100	E	A*E*100	Region exposure - England exposure	
D35	Electricity, gas, steam and air conditioning supply	3.43	0.36%	1.24	0.91%	3.12	0.98%	3.38	0.68%	2.32	2.14	1.08
E36	Water collection, treatment and supply	0.11	0.12%	0.01	0.21%	0.02	0.22%	0.02	0.14%	0.01	0.01	0.00
E37T39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation ac	0.26	0.45%	0.12	0.34%	0.09	0.31%	0.08	0.42%	0.11	-0.04	-0.01
F	Construction	0.12	8.51%	1.06	7.93%	0.98	7.87%	0.98	8.20%	1.02	-0.08	-0.04
G	Wholesale and retail trade; repair of motor vehicles	0.07	13.31%	0.94	12.81%	0.91	12.68%	0.90	13.52%	0.96	-0.04	0.02
H49	Land transport and transport via pipelines	0.01	1.76%	0.01	2.07%	0.01	1.97%	0.01	2.37%	0.01	0.00	0.00
H50	Water transport	1.99	0.04%	0.07	0.00%	0.00	0.00%	0.00	0.00%	0.00	-0.07	-0.07
H51	Air transport	9.26	0.24%	2.20	0.12%	1.15	0.16%	1.52	0.00%	0.03	-0.68	-2.17
H52	Warehousing and support activities for transportation	0.05	1.66%	0.08	1.24%	0.06	1.09%	0.06	1.69%	0.09	-0.03	0.00
H53	Postal and courier activities	0.16	0.74%	0.12	0.58%	0.09	0.66%	0.11	0.51%	0.08	-0.01	-0.04
I	Accommodation and food service activities	0.07	13.23%	0.89	13.22%	0.89	13.78%	0.93	11.07%	0.75	0.04	-0.15
J	Information and communication	0.01	3.95%	0.03	2.73%	0.02	2.95%	0.02	1.69%	0.01	-0.01	-0.02
K	Financial and insurance activities	0.00	3.12%	0.01	1.98%	0.00	1.86%	0.00	2.37%	0.00	0.00	0.00
L	Real estate activities	0.00	1.56%	0.01	1.57%	0.01	1.64%	0.01	1.52%	0.01	0.00	0.00
M	Professional, scientific and technical activities	0.01	7.99%	0.10	5.29%	0.07	4.92%	0.06	6.42%	0.08	-0.04	-0.02
N	Administrative and support service activities	0.04	7.95%	0.29	6.78%	0.24	6.67%	0.24	7.10%	0.25	-0.05	-0.03
O	Public administration and defence; compulsory social security	0.05	3.56%	0.19	5.70%	0.30	5.90%	0.31	5.07%	0.27	0.12	0.08
P	Education	0.03	7.64%	0.20	8.18%	0.21	8.31%	0.22	7.78%	0.20	0.02	0.00
Q	Human health and social work activities	0.04	11.15%	0.39	14.13%	0.50	13.45%	0.47	16.23%	0.57	0.08	0.18
R	Arts, entertainment and recreation	0.03	2.16%	0.07	2.15%	0.07	2.19%	0.07	2.03%	0.06	0.00	0.00
S	Other service activities	0.03	1.84%	0.06	1.65%	0.05	1.75%	0.06	1.35%	0.04	0.00	-0.02
T	Activities of households	0.01	0.96%	0.01	0.83%	0.01	0.87%	0.01	0.85%	0.01	0.00	0.00
	Total		**100.00%**	**11.11**	**100.00%**	**13.28**	**100.00%**	**13.14**	**100.00%**	**13.58**	**2.04**	**2.47**
Year		2016, 2018*	2019		2019		2019		2019			
Dataset		(1) (2)	(3)		(3)		(3)		(3)			

(1) Atmospheric emissions: greenhouse gases by industry and gas (kt CO2), ONS
(2) 2016 Input-Output Analytical Tables
(3) Business Register and Employment Survey, NOMIS

Figure B4: Occupation type CO2 exposure[185]

Occupation type by highest ranking SIC 07 Section ranking						England		North East		North East LEP		Tees Valley LEP			
Occupation Type		Sector that is the top employer of the occupation		% of individuals of the occupation employed in top employing sector	CO2/GVA in highest employing sector Kt CO2 per £ million GVA	% employed in occupation	Index of exposure	% employed in occupation	Index of exposure	% employed in occupation	Index of exposure	% employed in occupation	Index of exposure	North East LEP	Tees Valley LEP
Code	Name	Code	Name	A	B	C	A*B*C*100	D	A*B*D*100	F	A*B*F*100	G	A*B*G*100	Region exposure - England exposure	
11	Corporate Managers And Directors	G	Wholesale, retail, repair of vehicles	17%	0.07	8.51%	0.99	5.90%	0.69	6.23%	0.73	4.90%	0.57	-0.27	-0.42
12	Other Managers And Proprietors	I	Accommodation and food services	23%	0.07	3.24%	0.48	3.05%	0.45	3.24%	0.48	2.45%	0.36	0.00	-0.12
21	Science, Engineering, Tech Professionals	J	Information and communication	27%	0.01	6.01%	0.11	5.13%	0.09	5.63%	0.10	3.56%	0.06	-0.01	-0.04
22	Health Professionals	Q	Health and social work	82%	0.03	4.53%	1.28	5.31%	1.50	5.43%	1.54	4.90%	1.39	0.25	0.10
23	Teaching And Educational Professionals	P	Education	94%	0.03	4.98%	1.20	4.93%	1.18	5.19%	1.25	4.07%	0.98	0.05	-0.22
24	Business, Media And Public Service Professionals	M	Prof, scientific, technical activ.	29%	0.01	6.04%	0.22	3.91%	0.14	3.88%	0.14	3.97%	0.14	-0.08	-0.08
31	Science, Engineering ,Tech Associate Professiona	C	Manufacturing	24%	0.44	1.86%	1.97	2.18%	2.31	2.18%	2.31	2.18%	2.30	0.34	0.34
32	Health And Social Care Associate Professionals	Q	Health and social work	82%	0.03	1.53%	0.43	1.55%	0.44	1.47%	0.42	1.80%	0.51	-0.02	0.08
33	Protective Service Occupations	O	Public admin and defence	85%	0.05	1.09%	0.48	1.23%	0.54	1.29%	0.57	1.04%	0.45	0.09	-0.03
34	Culture, Media And Sports Occupations	R	Arts, entertainment and recreation	32%	0.03	2.59%	0.26	1.96%	0.20	2.10%	0.21	1.52%	0.15	-0.05	-0.11
35	Business, Public Service Associate Professionals	K	Financial and insurance activities	16%	0.00	7.69%	0.02	5.83%	0.01	5.91%	0.01	5.59%	0.01	0.00	-0.01
41	Administrative Occupations	O	Public admin and defence	85%	0.05	7.59%	3.33	7.97%	3.50	7.82%	3.43	8.39%	3.68	0.10	0.35
42	Secretarial And Related Occupations	Q	Health and social work	82%	0.03	2.05%	0.58	1.60%	0.45	1.49%	0.42	1.97%	0.56	-0.16	-0.02
51	Skilled Agricultural And Related Trades	A	Agriculture, forestry and fishing	43%	0.74	1.06%	3.39	0.82%	2.63	0.76%	2.44	0.97%	3.09	-0.95	-0.30
52	Skilled Metal, Electrical, Electronic Trades	C	Manufacturing	24%	0.44	3.54%	3.75	4.28%	4.53	3.86%	4.09	5.59%	5.92	0.34	2.17
53	Skilled Construction And Building Trades	F	Construction	79%	0.12	3.37%	3.16	3.49%	3.28	3.34%	3.14	3.97%	3.73	-0.03	0.56
54	Textiles, Printing And Other Skilled Trades	I	Accommodation and food services	23%	0.07	1.94%	0.29	1.97%	0.29	2.05%	0.30	1.73%	0.26	0.02	-0.03
61	Caring Personal Service Occupations	Q	Health and social work	82%	0.03	6.95%	1.96	8.77%	2.48	8.17%	2.31	10.64%	3.01	0.35	1.04
62	Leisure, Travel And Related Personal Services	S	Other service activities	40%	0.03	1.99%	0.25	2.23%	0.28	2.24%	0.28	2.21%	0.27	0.03	0.03
71	Sales Occupations	G	Wholesale, retail, repair of vehicles	17%	0.07	5.13%	0.60	5.54%	0.64	5.27%	0.61	6.35%	0.74	0.02	0.14
72	Customer Service Occupations	G	Wholesale, retail, repair of vehicles	17%	0.07	1.92%	0.22	3.25%	0.38	3.38%	0.39	2.87%	0.33	0.17	0.11
81	Process, Plant And Machine Operatives	C	Manufacturing	24%	0.44	2.42%	2.56	3.55%	3.76	3.59%	3.80	3.49%	3.69	1.23	1.13
82	Transport And Drivers And Operatives	H	Transport and storage	54%	1.10	3.77%	22.19	3.69%	21.73	3.42%	20.15	4.52%	26.66	-2.04	4.47
91	Elementary Trades And Related Occupations	F	Construction	79%	0.12	1.47%	1.38	1.84%	1.73	2.01%	1.89	1.31%	1.23	0.51	-0.14
92	Elementary Administration And Service Occupation	I	Accommodation and food services	23%	0.07	8.73%	1.29	10.02%	1.48	10.03%	1.48	10.01%	1.48	0.19	0.19
Year				2019	2016, 2018	2019		2019		2019		2019			
Dataset				(1)	(2) (3)	(4)		(4)		(4)		(4)			

(1) Occupation at UK level by sector, industry, age and ethnicity, ONS
(2) 2016 Input-Output Analytical Tables
(3) Atmospheric emissions: greenhouse gases by industry and gas (kt CO2), ONS
(4) Occupation (SOC2010) sub-major group of employment, NOMIS

[185] The CO2 emissions exposure (at a UK level) is calculated for the top employing sector for each occupation type across the regions studied to highlight which occupations, and in which sectors, are most exposed to the net zero transition. Relative exposure of the North East is then approached by examining the relative share of employment (by occupation code) that is both highly concentrated in one industry, and concentrated in an industry that is relatively carbon intensive.

Annex C: Key stakeholders in North East

The list of stakeholders that were interviewed are set out below. We conducted 17 interviews in total, with two interviews conducted with two distinct BEIS sector teams.

Table C1: Key stakeholders in the North East

# Reference	Organisation/Stakeholder	Area/Sector
1	North East Process Industry Cluster	Chemical
2	Voluntary Organisations' Network North East (VONNE)	Citizens
3	ORE Catapult, Blyth	Energy
4	Durham Energy Institute	Energy
5	North East LEP	Governance / Overall
6	Tees Valley LEP / CA	Governance / Overall
7	North East of England Climate Coalition	Governance / Overall
8	North of Tyne MCA	Governance / Overall
9	Newcastle University	Governance / Transport
10	BEIS sector teams	Industry, energy
11	Materials Processing Institute (MPI)	Manufacturing
12	North East Automotive Alliance	Manufacturing
13	Climate Change Committee (CCC)	Overall
14	Engineering Construction Industry Training Board	Skills/Construction
15	Northern Powerhouse	Spatial / places
16	Tees Valley Area Lead	Overall

Source: PwC, others' and BEIS research

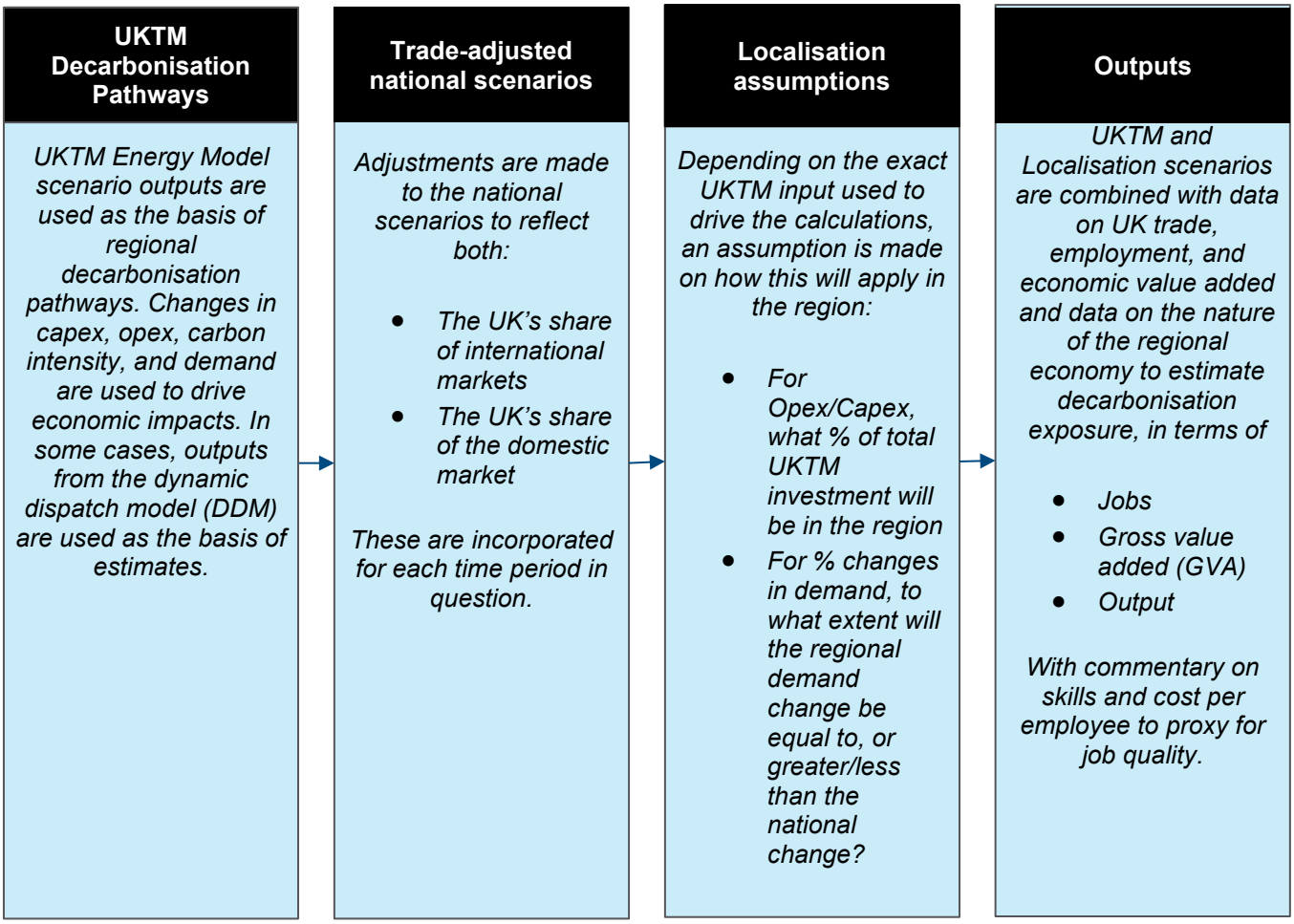
Annex D: Technical annex - regional impact tool

One key element of the approach used to arrive at the experimental estimates set out within this report is the Regional Impact Tool. The purpose of the Regional Impact Tool is to illustrate the potential exposure of a region to different UKTM decarbonisation pathway scenarios, based on different assumptions about where investment is made and technologies taken up. Outputs are expressed in terms of jobs, output, and gross value added (GVA). The tool is designed to illustrate potential direct exposure in terms of 'risk' (output, GVA, jobs that may be lost) and opportunity (output, GVA, jobs that may be gained).

The tool was designed to be adapted to any UK region, and this report pilots the tool with respect to the North East region.

Overall, there the Regional Impact Tool follows the below approach, which will be described further in this technical annex.

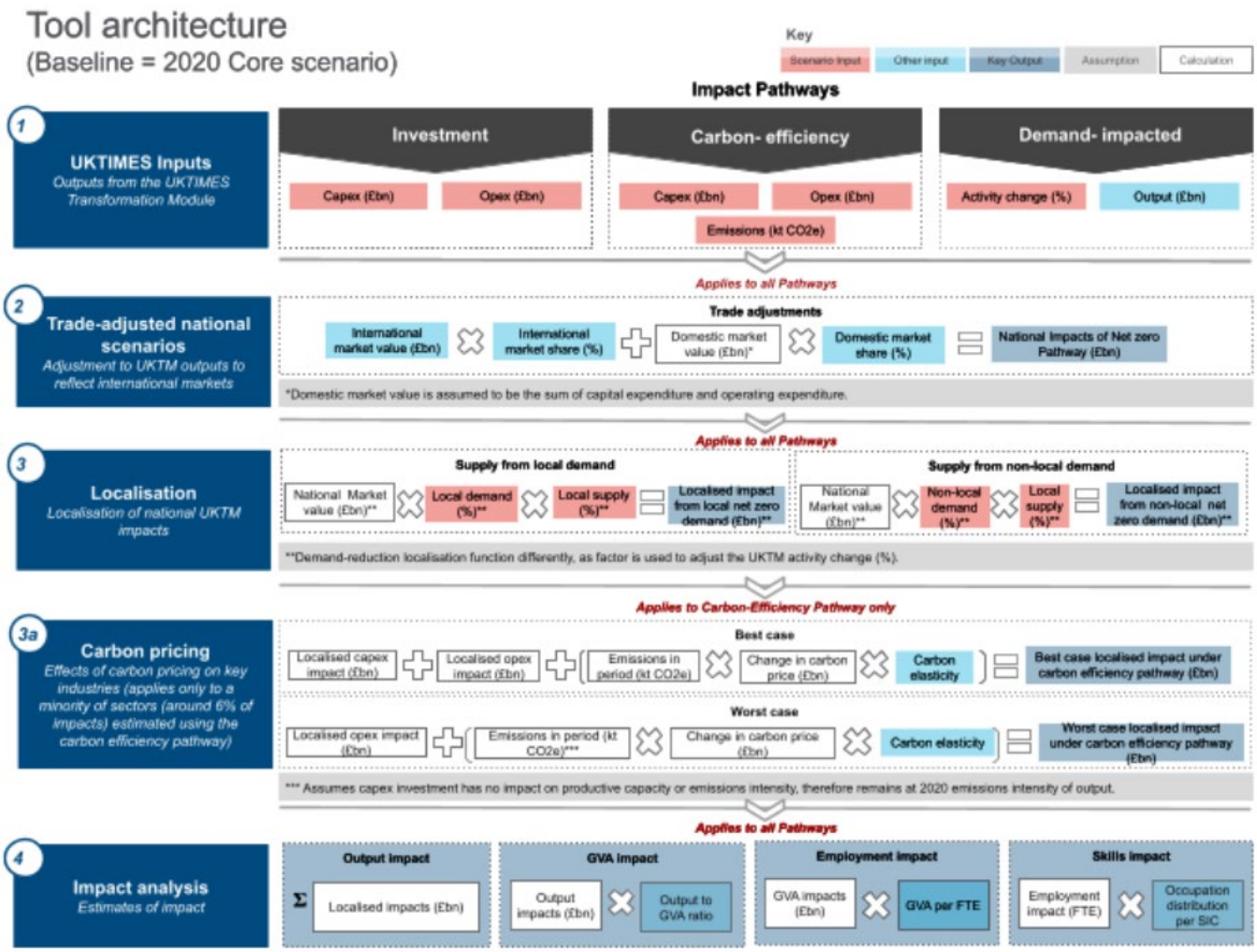
Figure D1: Overall approach of the regional impact tool



Source: PwC illustrations

Figure D2 presents a more detailed approach of the impact pathways and data sources used in the tool.

Figure D2: Tool architecture



Source: PwC illustrations

In terms of its structure, the tool is designed to produce outputs at a LEP or regional level, but data and calculations are undertaken at the LA level in order to be able to aggregate to the LEP level (not all data is available at LEP level). Note that a maximum of 33 LAs can be included in the tool at one time.

Overall, the illustrative tool exposure outputs should be seen in the following context:

- The tool is experimental. It was designed to integrate with UKTM outputs, and to present high level potential exposure analysis. It is therefore not a whole economy or dynamic model.
- The figures provide estimated local impacts for a set of key sectors directly impacted (relating closely to the green economy or at risk carbon-intensive industry) and outputs do not therefore show all job changes in the economy, including those driven by indirect, induced or catalytic impacts. They are also based on NOMIS jobs data, and so do not include economic activity by individuals outside of that data.

- Most notably, a key sector excluded from the analysis is financial services, the costs of which cannot be distinguished in UKTM outputs, and which is not included in the Annual Business Survey data on which analysis is based. This may overestimate changes in other sectors, and underestimate changes related to the finance industry. The agricultural and land use sector is also excluded from the results as the regional impact tool and available data proved unsuitable to produce appropriate estimates of the potential net economic impacts on the North East of the transition to net zero.
- All figures shown are in comparison to 2020 for the UKTM scenario to which they relate. Some charts show the UKTM baseline for comparative purposes, however figures (all in real terms) should be interpreted as including growth.
- The figures include key direct supply chain considerations for capex, but do not include all sectors or encompass the full set of indirect and wider impacts.
- The tool provides outputs in terms of jobs, output, and GVA in specific sectors, and does not consider any household sector or distributional impacts. In estimating the job impacts, the tool does not speculate on changes in wages, unemployment or the wider welfare impacts of net zero.
- The tool was designed to take UKTM output data as its primary input, as well as some information for the Energy Innovation Needs assessment (EINA) calculators and from the Dynamic Dispatch Model (DDM) . Apart from this, it was designed using publicly available datasets.
- In the main, spend data is interpreted as productive economic output, from which GVA and employment changes are then estimated in a linear way. This may overestimate the impact in some cases.
- Note that while the UKTM estimates are used as the basis of estimates for the majority of sectors, results from the Dynamic Dispatch Model (DDM) are used as the primary basis for estimated impacts in the energy sector.

The remainder of this technical annex presents the approach used to generate exposure estimates, along with specific assumptions made as part of that approach.

UKTM Inputs

UKTM is the foundation of the analysis. UKTM is an energy system model of the UK that has been developed by UCL and BEIS, using the International Energy Agency (IEA) Energy Technology Systems Analysis Program (ETSAP) TIMES modelling framework. UKTM provides decarbonisation pathways for the UK through bottom-up, technology rich cost optimisation.

The Regional Impact Tool draws on three scenarios from UKTM. The scenarios are based on different assumptions such as the [pending].[186] The key outputs of UKTM that are used in the regional impact tool are:

- Capital and operational expenditure outputs;
- Emissions levels; and,
- ‘Activity levels’ (ie. level of energy required, kilometres driven).

These inputs are used in different ways depending on the impact pathway (see below).

[186] H.E.Daly and B. Fais (2014) *UK TIMES Model overview*. Available from https://www.ucl.ac.uk/drupal/site_energy-models/sites/energy-models/files/uk-times-overview.pdf. Accessed 25 March 2021

The analysis uses the UKTM outputs relating to the Sixth Carbon Budget. It thus reflects decarbonisation pathway assessments that are consistent with the 2050 net zero target, and aligns to BEIS Sixth Carbon Budget impact assessment. The 'Core' pathway is used as the basis for results in this report. Other decarbonisation pathways are presented at points as sensitivities or for comparative purposes.

The following are other key features of UKTM outputs that are of import to the regional impact tool:

- Figures are in real terms (base year 2010 £), and are updated to 2018 £ using GDP deflator (Source: HM Treasury);
- Outputs are generated at five year intervals (for 2020, 2025, etc.). UKTM output data from 2010 to 2050 are used for the purposes of the regional impact tool.
- Figures relate to decarbonisation pathways for the UK as a whole;
- UKTM outputs incorporate economic and population growth, consistent with the Energy and Emission Projections (EEP) Covid Central scenario 2019 and the OBR long-term forecasts;[187]
- Cost outputs (capital and operating expenditure) are presented in annualised terms. As a result, an adjustment is made in the regional impact tool to proxy for the cash flow profile associated with different technologies.

The DDM and UKTM models as used to produce the Impact Assessment of the Sixth Carbon budget also noted the following limitations (Box D1). Please refer to the Impact Assessment for a fuller discussion of these models.

Box D1: Limitations of the UKTM and DDM models as used to estimate the impacts of the Sixth Carbon Budget (Extracted from the Impact Assessment for the sixth carbon budget)

UKTM has a number of limitations:

- The model only takes account of a subset of the full costs and benefits of meeting a given carbon budget level. In addition, only technical factors are taken into account in the roll out choices (costs, maximum build rates etc.). Behavioural or other practical considerations that might make certain pathways undesirable or difficult to achieve are not accounted for. In addition, the modelled solution will delay roll out of the more expensive options required for as long as is technically possible, given the assumed maximum deployment rate and overarching emissions constraint. This result is due to the discounting of future costs and because costs are then incurred for a shorter time period, as the modelling ends in 2060.
- The results for each run of the model take no account of risk or uncertainty. The pathways modelled by UKTM are therefore only least-cost and achievable if all of the underpinning assumptions turn out to be correct over the whole period. It is unlikely in practice that all technologies would achieve the costs and performance assumed and that the availability and maximum build rate assumptions could all be achieved. This aspect also contributes to the model delaying the roll out of more expensive options,

[187] OBR (2020) *Economic and fiscal outlook*. Available from https://obr.uk/efo/economic-and-fiscal-outlook-march-2020/. Accessed 29th March 2021

as it does not factor in the risk that some of these options may not be fully viable, and the impact this could have on achieving the UK's 2050 emissions target.

- The level of detail in UKTM varies across different sectors and, as with any model, is a simplified representation of the real world. Because it does not fully reflect the diversity in technology options and user choices it may understate the diversity of technologies that could contribute to achieving meeting targets at least-cost. UKTM does not include behavioural measures, such as transport modal shifts or increased household recycling.
- Sectors where the majority of emissions are not related to energy use, such as agriculture, are modelled in less detail in UKTM than in sector-specific models. Other sectors are generally more granular in UKTM in terms of the number of technology options but less detailed in terms of the factors that affect variation in costs. For instance, UKTM takes no account of variation in heat network costs due to geospatial factors, instead applying an average cost per unit of capacity. Competition for use of land, including diverting it from other uses such as agriculture, is also likely to be an issue in the higher biomass availability scenarios but these interactions are not taken into account within UKTM. It is important to note that UKTM does not price risk, or directly factor in uncertainty. Therefore, each solution that UKTM finds is dependent on every assumption about each technology (e.g., cost, maximum build rate, maximum availability) coming true. UKTM effectively states the latest decision points to start mitigation actions, in a deterministic world under perfect foresight.

The DDM has several limitations, the most important of which are:

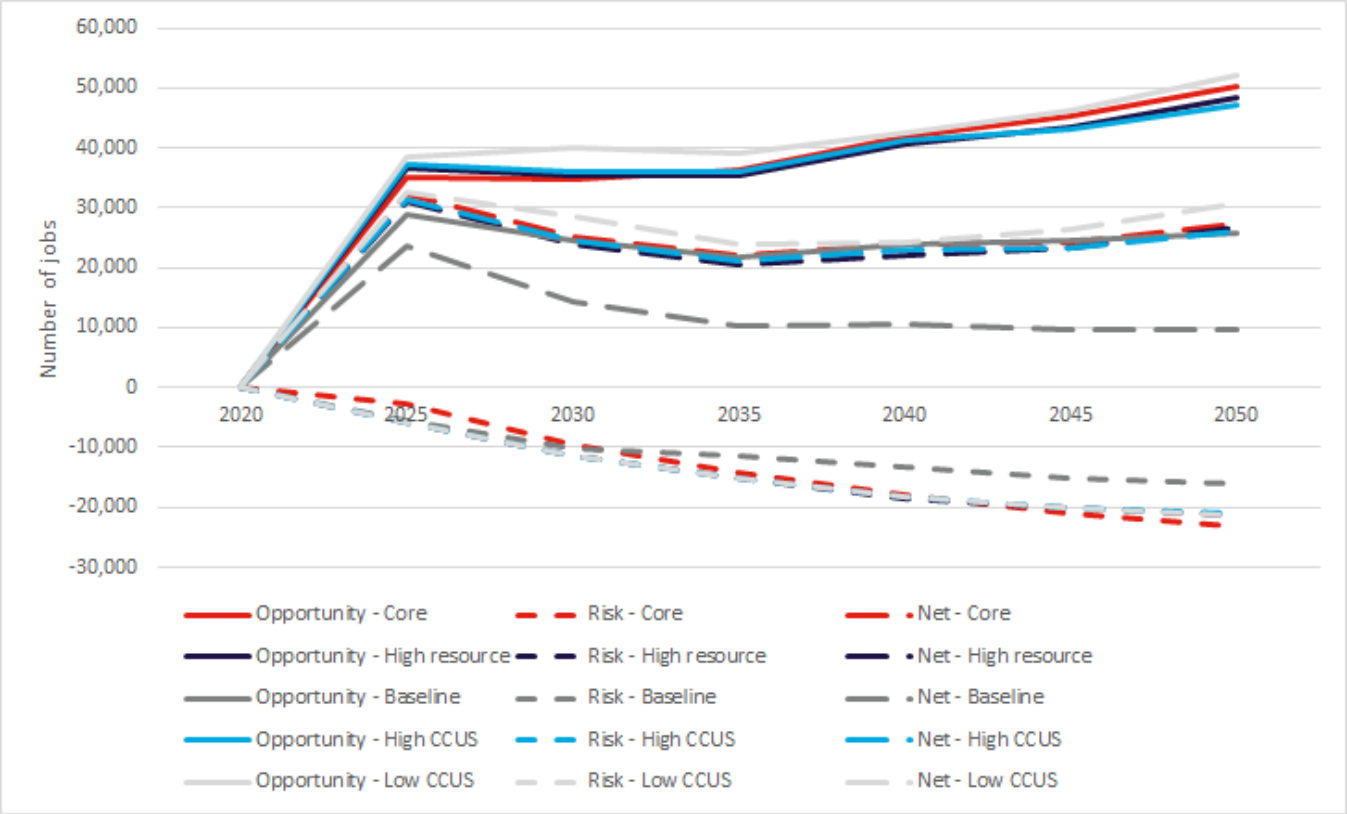
- It is deterministic, in that a given set of inputs will always produce the same outputs.
- Plants are assumed to be profit maximising, and act according to economic rationality.
- The DDM does not tell us the optimal mix of technologies to ensure security of supply or decarbonise. The mix is defined by user inputs (for the purposes of this analysis these have been informed by the Modelling 2050: electricity system analysis paper76 that was published with the Energy White paper).

Source: Extracted from the Impact Assessment for the sixth carbon budget[188]

The net results in the North East vary based on the underlying decarbonisation pathway. As shown in Figure D3 below, with the exception of the 'no net zero' pathway, the net jobs impact varies between net zero pathways from around 27,000 (high CCUS scenario) and 31,000 (low CCUS scenario).

[188] Department for Business, Energy and Industrial Strategy (2021) *Impact Assessment for the sixth carbon budget*. Available from https://www.legislation.gov.uk/ukia/2021/18/pdfs/ukia_20210018_en.pdf. Accessed 29 June 2021

Figure D3: Net jobs exposure in the North East under different UKTM pathways



Source: PwC analysis

The overall illustrative impacts are specific to the North East, and in large part are driven by the presence of a variety of energy industries (offshore, nuclear, hydrogen) and the localisation assumptions that mean that future investment in these technologies will be channelled into the North East. In particular:

- Under the 'High resource' UKTM pathway (which is based on more reliance on hydrogen), the North East stands to benefit as one of the hydrogen clusters (net jobs of 6,500 compared to around 5,000 in the core scenario; and 200 additional jobs from CCUS). However, the lower spend from nuclear somewhat counteracts this effect (with around 1,400 net jobs compared to 2,500 in the Core scenario. .
- Under the Low CCUS UKTM pathway , there is more investment in nuclear and offshore. As 13% of nuclear and offshore investment is centred in the North East in the core set of localisation assumptions, this dominates other impacts. For example under the Low CCUS pathway 2,000 net jobs are added by 2030 from offshore wind, compared to around 1,000 in the Core pathway in that year. 1,000 net jobs from nuclear are added by 2050 under the Low CCUS pathway as well. Under High CCUS, these impacts are reversed, meaning that the North East's net gain in jobs is lower.

Across pathways, the net impact on other sectors is relatively similar. Note that the underlying pathways data was sourced from UKTM for most sectors, but some energy technologies rely on DDM data. While these sources are consistent with the Sixth Carbon Budget Impact Assessment, there is a risk of inconsistency once these are transformed using the regional impact tool,

Impact pathways in the regional impact tool

The tool uses three primary impact pathways to transform UKTM outputs into decarbonisation exposure estimates. These pathways are used for different types of sectors. Each pathway is summarised in Table D1, with further details on approach below:

Table D1: Impact pathways used in the regional impact tool

Pathway	Approach to estimation	Sectors affected
Investment pathway (£) (primary pathway - used for c. 90% of 2050 UKTM core pathway cost outputs)	Opex/Capex is used as a proxy for economic outputs (e.g. capex on petrol cars)	New sectors where investment is expected (e.g. EVs, Renewable energy), OR sectors where there will be disinvestment (non-low emissions vehicles)
Carbon efficiency pathway (used for c. 6% of 2050 UKTM core pathway cost outputs)	Emissions, opex and capex are used to assess current carbon intensity of output and assess the costs of reducing carbon intensity	Sectors where the production process is carbon intensive, and will need transformation (risk) in processes or technology for the net-zero economy, but can also grow (opportunity)
Demand-impacted pathway (%) (used for c. 4% of 2050 UKTM core pathway cost outputs)	Change in activity/final demand is used as a proxy for change in demand	Primarily used for sectors where the underlying product is high carbon and will itself decrease in demand, for example coal mining, oil extraction, or for complementary industries e.g. (HGV haulage)

Source: PwC analysis

Investment pathway

The investment pathway is applied to estimate the impact of most outputs from UKTM. Under this pathway, the following approach is used to translate UKTM outputs into exposure impacts, at a national level, before local assumptions are applied. All impacts are presented as compared to 2020 values (for the scenario to which they relate), and so include an element of growth.

1. UKTM capex and opex are mapped to SIC codes.
2. Figures are adjusted to the chosen base year (£ 2018) and a cash flow capital expenditure profile is applied to capex outputs from UKTM.
3. Changes in capex / opex compared to 2020 values are interpreted as changes in economic output, for the industry to which they are assigned.
4. Exposure impacts in terms of jobs and gross value added are then estimated based on industry level ratios.

SIC code assignment for investment pathways sectors

In order to estimate output, GVA, and jobs exposure, UKTM outputs were aggregated and mapped to SIC codes. This enabled the use of the Annual Business Survey's data at SIC Level 4 to be used to estimate GVA and jobs exposure.

For the majority of sectors (covering around 90% of 2050 (annualised) spend under the core UKTM scenario), the UKTM data on capex and opex was allocated to SIC codes based on the existing energy innovation needs assessment (EINA) assumption. This approach was use

where UKTM could reasonably be associated with a technology included within the EINA dataset.

Where EINA data was not available, SIC allocations were made upon examination of the UKTM output data descriptions, alongside the 2007 SIC industry descriptions. EINA data was used as a point of reference where there were some similarities in the economic product or activity described.

For vehicles, capex and opex was assigned to SIC codes based on value added and the most material direct supply chain input sectors for auto manufacturing as set out in the most recent UK input-output tables. This approach was taken on the basis that the output cost figures from UKTM most closely aligned with wholesale values of vehicles, and may not have aligned fully with data in the EINA technology breakdown (in particular, no EINA was available for cars specifically, which is the largest category of vehicle by far in UKTM).

Investment assumptions

- Both opex and capex are considered to generate economic activity, and therefore increases in spend are linked to increases in both GVA and employment based on industry ratios (see below for more in the section **Jobs, output and GVA ratios**).
- Capex and opex from the UKTM model are annualised figures, which are less relevant for estimating economic activity at a point in time than the capex figures expressed on a cash flow basis. As a result the CCC's Sixth Carbon Budget assumptions on capex cash flow are used to adjust UKTM outputs to a cash flow basis. The section '**Capital expenditure cash flow profiles'** below sets out more on this topic. These profiles are not applied to dis-investment industries.
- Note that in the energy sector, some capex and opex estimates are sourced from the DDM instead of UKTM, in line with the approach taken to produce estimates underpinning the Sixth Carbon Budget Impact Assessment. Where DDM outputs were provided on a non-annualised basis, these were used directly instead of applying CCC capex cash flow profiles.
- Annualised costs (which are the basis of analysis for areas experiencing dis-investment) may over or underestimate actual economic impact, depending on the extent to which opex and annualised capex reflect ongoing economic activity in the sector.
- Investment is assumed to take place in the year in which it is reported in UKTM, after applying the CCC capex profile. No time adjustment to account for earlier investment in the upstream supply chain

Carbon efficiency pathway

The carbon efficiency pathway is applied to estimate the impact of a subset of UKTM industry impacts. This pathway is primarily used for industries with high Scope 1 emissions, which may be particularly and directly sensitive to changes in carbon pricing.

Under this pathway, the following approach is used to translate UKTM outputs into illustrative exposure impacts, at a national level, before local assumptions are applied. All impacts are presented as compared to 2020 values (for the scenario to which they relate), and so include an element of growth.

1. UKTM outputs emissions, capex and opex are mapped to a SIC code.

2. Figures are adjusted to the chosen base year (£ 2018) and a cash flow capital expenditure profile is applied to capex outputs from UKTM.
3. A 'best case' and 'worst case' output impacts are estimated for each industry. The approach to these estimates is described below.
4. Exposure impacts in terms of jobs and gross value added are then estimated based on industry level ratios.

Best case impacts

The approach to estimating best case impacts aligns closely with the approach taken in the investment-led pathway. Namely, all capital and operating expenditure is treated as productive investment that generates economic output. In addition, it is assumed that any reduction in emissions intensity (expressed in terms of emissions per £ of capex or opex) suggested by the UKTM outputs is achieved. If there is not an improvement suggested in UKTM, it is assumed that emissions intensity stays at 2020 levels as per the 2020 Core Sixth Carbon Budget UKTM outputs. Best case impacts are subtracted from worse case impacts to illustrate the decarbonisation pathway's net opportunity.

Worst case impacts

Under the worst case scenario, it is assumed that capital expenditure does not generate additional economic output. In addition, it is assumed that any reduction in emissions intensity (expressed in terms of emissions per £ of capex or opex) suggested by the UKTM outputs is *not* achieved despite expenditure. If UKTM outputs imply that carbon intensity may increase in future, future carbon intensity levels are used in the tool. Worse case impacts represent the decarbonisation pathway risk.

Best case impacts and worst case impacts

Estimates of both best and worst case impacts are subject the following methodological features that distinguish them from the investment pathway:

Carbon pricing[189]*.* One of the policy areas that may impact the exposure of a region is carbon pricing. As a static and supply focused tool, carbon pricing is included as an input in relation to Scope 1 emissions intensive industries, which applies to the efficiency-led pathway.

Carbon pricing is considered when determining output. CO2 emissions are calculated for each year in the model, by multiplying the new emissions intensity estimate (based on UKTM outputs and the worst/best case assumptions) by total estimated output in that year (before considering the impact of carbon pricing).

An adjustment to output is then made based on the change in carbon price. It is assumed that output will be reduced by the following factor:

$$Output\ reduction = Carbon\ emissions \times Change\ in\ Carbon\ price \times Price\ elasticity$$

For the purposes of the estimates in this tool, carbon prices are fixed at £40 per tonne of CO2e of emissions, rising to £160 per tonne CO2e in 2050. This interpretation is based on a

[189] These assumptions are illustrative, and apply to a minority of areas in the tool.

combination of the documentation surrounding the UKTM model and the analysis presented in How to price carbon to reach net-zero emissions in the UK.[190] This price can be adjusted by users. Increases in carbon price between 2020 and 2050 increase the exposure (risk and opportunity) associated with Scope 1 industries. Net figures are relatively robust to changes in price, but the potential downside (failure to adapt) and upside (with adaptation) are sensitive to changes. Changes of £120 per tonne CO2e, for instance, lead the exposure to go from a couple hundred (no changes in carbon price) to almost 5,000 of risk/opportunity with a change in price of £120 per tonne CO2e.

A constant carbon price elasticity of -0.18 is used for all sectors and time periods to understand the strength that a change in carbon pricing will have on demand. This elasticity is based on the work of Rafaty et al. (2020) *Carbon Pricing and the Elasticity of CO2 Emissions*.[191] While lower than the energy demand elasticities typically assumed in energy models, Rafety (2020) deploys novel and sophisticated techniques to estimate an economy wide energy demand elasticity. As CO2e emissions are exogenous in the Regional Impact Tool, this implies a deterministic relationship between output and CO2e emissions for each time period based on the carbon intensity of output and the carbon price elasticity.

Single SIC mapping. Unlike investment pathway impacts, a single SIC code is mapped to an industry. This approach is taken because the primary interest in the carbon efficiency pathway is adaptation in heavy industry, aviation and agriculture. By focusing on the industries themselves, rather than their supply chains, the analysis generates estimates of risk and opportunity in these industries. While this analysis does not speculate on the distribution of these impacts throughout the supply chain, further insight could be generated by doing so.

Demand-impacted pathway (%)

The demand-impacted pathway (%) is applied to estimate the impact of a small subset of UKTM industry outputs. This pathway is primarily used for sectors where the underlying product is high carbon and will itself decrease in demand, for example coal mining, oil extraction, or for complementary industries e.g. (HGV haulage).

Under this pathway, the following approach is used to translate UKTM outputs into exposure impacts, at a national level, before local assumptions are applied. All impacts are presented as compared to 2020 values (for the scenario to which they relate), and so include an element of growth.

1. Changes in activity or demand are estimated from UKTM outputs. These are expressed as a percentage change in demand/ activity compared to 2020 levels.
2. Changes are mapped to affected SIC codes.
3. Percentage changes are applied to 2020 baseline output values for the industry (SIC) in question to estimate output in a particular year.
4. Exposure impacts in terms of jobs and gross value added are then estimated based on industry level ratios and the output figures estimated in step 3.

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[190] Burke, J., Byrnes, R., Fankhauser S (2019) *How to price carbon to reach net-zero emissions in the UK*. Available from https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2019/05/GRI_POLICY-REPORT_How-to-price-carbon-to-reach-net-zero-emissions-in-the-UK.pdf. Accessed 29 March 2021

[191] Rafaty, R., Geoffroy, D., Felix, P. (2020) *Carbon Pricing and the Elasticity of CO2 Emissions*. Available from https://www.eprg.group.cam.ac.uk/wp-content/uploads/2020/11/2035-Text.pdf. Accessed 25 March.2021

Capital expenditure cash flow profiles

One of the limitations of using the UKTM cost outputs for this economic analysis is that they are annualised in order to select the most cost efficient pathway. For the purposes of the economic estimates in this report, this may under or over estimate the economic activity occurring in a particular year, which is more closely related to the cash flow rather than annualised cost of investment (e.g. jobs in construction occur at the beginning of the project, and are not equally distributed throughout the assets life).

To address this issue, capital expenditure profiles (which relate total investment on a cash flow basis) from the Climate Change Committee 6CB are applied to the annualised capital expenditure figures output from UKTM (and, annualised figures output from DDM in the energy sector, in instances where non-annualised data is not available). The following assumptions and limitations are:

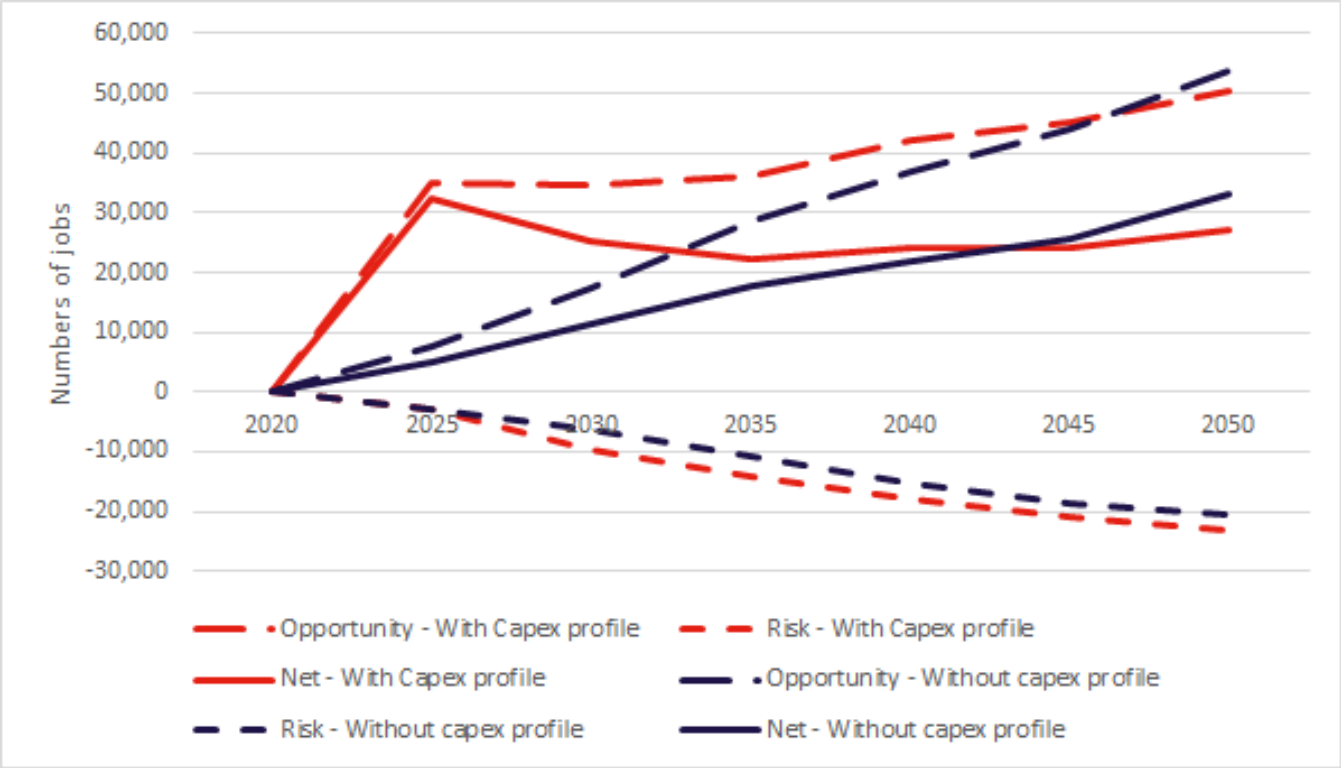
- Estimates are applied at a sector, rather than technology level, and so may not capture differences in deployment timeframes for specific technologies. Some limited exceptions were made where the sector level capex profile did not appear appropriate for all technologies (notably electronic appliances in the residential and non-residential setting did not have a capex profile applied);
- In order to apply the profiles to UKTM data, a fixed point of comparison is required. It is therefore assumed that by 2050, the UK reaches a steady state in terms of investment, in which the annualised capex is equal to the cash flow. It is also assumed that there is no impact of cash flow in 2020 itself. While this is the most appropriate point of triangulation (as it is the latest date of comparison between the two datasets, and so the most probable point at which the decarbonised transition will take place), it may mean that cash flow profiles are over or under estimates;
- UKTM and CCC do not use identical assumptions and so the capex cash flow profile can only be treated as a proxy (in particular, a baseline that includes no additional climate action); and
- CCC 6CB Methodology report sets out that capital investment figures relate to additional spend (compared to the baseline with no further climate action).[192] Disinvestment in existing industries is to some extent captured in the UKTM, but would not be reflected in these figures. This may limit the level of alignment. CCC capex profiles were not applied to disinvestment sectors in the regional impact tool on the basis that large amounts of new capex implied by the CCC profiles for new technologies would not be seen in areas in decline.
- Non-annualised capex data is available for some energy sectors within the DDM outputs. Where this data is available, non-annualised DDM capex data is used in preference to applying CCC profiles to the annualised UKTM or DDM data;
- As set out above, a variety of sources were used to produce non-annualised estimates, introducing the potential for differences in outputs to arise based on underlying assumptions. In reflection of this, calibration was undertaken in energy sectors

[192] Committee on Climate Change (2020) *Sixth Carbon Budget - Methodology Report*, *Page 29*. Available from https://www.theccc.org.uk/wp-content/uploads/2020/12/The-Sixth-Carbon-Budget-Methodology-Report.pdf. Accessed 29 March 2021

hydrogen and biomass processing to reconcile differences between spending and spending profiles across sources.

Figure D4 below illustrates the impact of applying the capex profile. As can be seen, once the capex profile is applied, the jobs impact comes much more quickly, reaching a net of around 30,000 total jobs added by 2025 and dipping at around that level until 2050. Without applying the capex profile, the net jobs added rises slowly over time.

Figure D4: Comparison on employment exposure impact with and without capex profile*



Source: PwC analysis

*Note that figures without the capex profile apply UKTM rather than DDM outputs for certain energy sectors

The overall difference in outputs is largely driven by front-loaded capex profiles of buildings (residential and non-residential) , road transport and certain technologies in the energy sector (in particular, wind energy, biomass and infrastructure). For example, when the capex profile is applied to buildings, net jobs generated from the net zero transition peak at around 11,000 in 2025, before dropping to c. 5,000 net in 2050. In comparison, if the capex profile is not applied, the net employment impact gain is estimated at 1,000 by 2025 rising to 5,000 by 2050. A similar profile is in evidence in road transport, with energy having a capex profile that much more closely resembles the annualised profile.[193]

[193] Note that for road transport, the CCC profile does not show a peak, but rather a continuous increase in total capital investment from 2020 to 2050. The peak present in the output data is a result of the negative jobs impact of dis-investment in non-net zero technology.

Trade-adjusted national scenario

The UKTM outputs provide insight into the UK's potential decarbonisation pathway. However, the UK is integrated in international markets. As a consequence, changes in UK demand for low-carbon may only have a modest impact on local suppliers (in highly trade dependent sectors). Similarly, changes in the international decarbonisation pathway may be highly relevant to certain UK suppliers that are trade exposed.

To account for trade and the importance of international markets, the following approach was taken to arrive at the UK impact on suppliers of decarbonisation

$$\textit{Change for UK suppliers} = \textit{UK Market value} \times \textit{UK share of domestic market} + \textit{International market value change} \times \textit{UK share of international market}$$

The exact data and approach used depended on the impact pathway and data availability, and is described below.

UK market value change. Data on the change in economic activity due to demand changes related to decarbonisation are sourced from the UKTM and DDM outputs using the approach set out above.

UK share of domestic market. Where UKTM data could be directly mapped to a technology covered by the energy innovation needs assessment (EINA), EINA estimates of domestic market share were used. Where data did not map directly, data from the world input output tables on the share of final demand that was not accounted for by imports was used in most cases. Sector specific assumptions on market share were used in some instances based on industry-statistics.

International market. Where UKTM data could be directly mapped to a technology covered by the energy innovation needs assessment (EINA), EINA estimates of international market value (tradeable turnover) were used. In some cases, more than one UKTM technology mapped to a single EINA. In such cases, the international market value was divided between UKTM sectors to prevent double counting. This was primarily the case in heating and carbon capture.

Where no EINA technology data was available, a high level approach was used to estimate the potential change in the international market following decarbonisation. This approach was based on:

1. The current share of UK emissions within global emissions (to understand the size of the UK decarbonisation challenge (and therefore potential market) compared to the world challenge (market), before taking into account climate action)
2. The level of international climate action ambition as compared to the UK ambition. The level of ambition is used to 'scale back' the potential size of the decarbonisation market worldwide (see (1)) based on what countries may achieve. The % change in international emissions from 2020 under a 2 degree Paris Agreement pathway, as it compares to the UKTM % emissions change under the Core Sixth Carbon Budget pathway, is used as a proxy for the level to which the international pathway mirrors the

UK. Using figures from UNEP (2019) *Emissions Gap Report* [194], this suggests a global level of ambition at around 60% of the UK's (ambition varies by year) by 2035.

3. The level of UK ambition. The level of UK decarbonisation ambition is used as a anchor point for making International market value estimates. The UKTM Core scenario for this purpose.

Overall, the following represents the approach that is used to estimate international market value where EINA data is not available:

$$\textit{International market value in sector X} = \textit{UK ambition (UKTM Core CB6)} \div \textit{UK share of International emissions} \times \textit{International ambition as a \% of the UK ambition}$$

Where the demand-impacted pathway (%) was used, the use of data differs. For this pathway, impacts are presented as a % change in demand, which is applied to supply. The relevant question for this pathway with regards to the international market is therefore 'How closely does the international market decarbonisation pathway mirror the UK pathway'. The approach to arriving at this estimate is set out in (2) in the list above.

UK share of international market. Where UKTM data could be directly mapped to a technology covered by the energy innovation needs assessment (EINA), EINA estimates of international market share were used. Where data did not map directly, data from the world input output tables on the share of world final use (demand), excluding the UK, which is supplied by UK suppliers was used as a proxy for UK market share.

Where the demand-impacted pathway (%) was used, the use of data differs. For this pathway, impacts are presented as a % change in demand, which is applied to supply. The relevant question for this pathway is therefore the % of UK supply that is exported. This data is sourced from the UK input output tables at SIC division level.

Trade assumptions. The approach is subject to the following key assumptions and limitations.

- EINA estimates included changes in UK market share (domestic and international over time). Where EINA data was not available, it is assumed that UK market share is constant over time. This assumption could be tested further in subsequent work;
- World input-output data is available at SIC Division level, rather than at the more granular SIC Class level which is often used when mapping UKTM data. As a result, market share and market value estimates are at a much higher level of aggregation, and may not reflect market shares of highly specific sectors;
- Where EINAs were not available, input output data is used. Input output data reflects the market shares in the current economic structure, rather than the potential for the UK to capture market share in emerging technologies; and,
- Where international market share is estimated based on the level of the UK compared to international ambition, this is relatively sensitive to the pathway chosen and therefore the level of emissions each year.

[194] UNEP (2019) *Emissions Gap Report*. Available from https://wedocs.unep.org/bitstream/handle/20.500.11822/30798/EGR19ESEN.pdf?sequence=13. Accessed 25 March 2021

Local demand

In addition to national and international demand, it is important to understand the potential local demand shifts (in terms of investment, efficiency, and demand-impacted pathways), as they may have disproportionate impacts on local suppliers.

In order to estimate local demand a set of different localisation scenarios were arrived at. For investment and efficiency pathways, these 'localisation' assumptions were used to determine how much headline expenditure (as estimated using the UKTM cost outputs) would go to the local economy. For demand-impacted sectors, the localisation assumptions are designed to estimate how much demand will change in the region, as compared to the national average (for instance if the regional shift in demand is exactly equal to the national shift, the local impact would be 100% (e.g. 100% of the national shift)).

It is important to note that for the investment and emissions pathway in particular, localisation assumptions relate to headline spend. For capex, a set of local supply chain assumptions are applied to account for the potential that parts are sourced from outside the region. This is described in the section on local supply chain below.

Localisation assumptions are applied to national estimates of the decarbonisation market after adjusting for leakage from trade. They are also applied to international market value, after adjusting for the UK's share of international markets. This is on the basis that areas receiving domestic investment in a particular technology may be more likely that the average UK region to be linked into global markets in that technology.

Core localisation assumptions. In the first instance, existing data is used to anchor the assumptions to a relevant metric (such as the number of households). However, for areas with a greater degree of uncertainty, like an emerging sector, high-level assumptions are based on stakeholder consultations and literature, or alternative data-driven assumptions are available. These assumptions can then be refined in line with additional information.

The assumptions to localise from the national level to the regional under the core scenario, are outlined below.

Table D2: Localisation assumptions under the core scenario

Sector	Localisation principle UKTM data	Rationale	Data source
Transport			
Light road transport vehicles	Proportion of vehicle registrations in the North East	Assumed in line with the number of current vehicle registrations, with the demand of low-carbon alternative vehicles increasing and the demand for fossil fuel vehicles falling, given the ban on the sale of new petrol and diesel cars in 2030	Department for Transport, UK government (2019)
Heavy road transport vehicles	Proportion of total GVA (all sectors) in the North East relative to the UK	Commercial sector, therefore aligned with regional GVA	ONS (2019) GVA by sector at NUTS1 and NUTS3

Freight trains	Freight train transport jobs	Relevant existing data used as proxy	NOMIS (2019) Business Register and Employment Survey
Passenger transport (bus and train)	Population density of the North East relative to the UK	Population density was used as a proxy for proportion of public passenger transport available in the region.	UK government (2018) Local Authority territorial CO2 emissions estimates
Aviation	The total number of passengers at each airport (in 2019) are allocated its local authority and region, and made as a proportion of the UK total	Relevant existing data used as proxy	Civil Aviation Authority (2019) Size of UK Airports
Shipping	The tonnage of cargo at each major port in the UK are allocated to its local authority and region, and made as a proportion of the UK total	Relevant existing data used as proxy	UK government (2019) Major Port Freight Traffic
Buildings			
Heat pumps (non residential)	A high-level assumption that the North East will experience a 25% less uptake than the proportion allocated using the region's GVA	Regional climatic factors in particular may affect the use of heat pumps compared to other technologies. Heat pumps have been found to not be as effective in colder climates which may reduce demand in the region. As such, a high-level assumption based on stakeholder consultations and literature has been used in which hydrogen boiler take-up is higher and heat pump take-up is lower than would be predicted based on the economic activity (non-residential) or household numbers (residential) in the North East region.	PwC analysis, ONS (2019) GVA by sector at NUTS1 and NUTS3
Heat pumps (residential)	A high-level assumption that the North East will experience a 25% less uptake than the proportion allocated using the region's number of households		PwC analysis, NOMIS (2019) Annual Population Survey ONS (2019) Family and households
Hydrogen boiler (non residential)	A high-level assumption that the North East will experience a 25% more uptake than the proportion allocated using the region's GVA		PwC analysis, ONS (2019) GVA by sector at NUTS1 and NUTS3
Hydrogen boiler (residential)	A high-level assumption that the North East will experience a 25% more uptake than the proportion allocated using the region's number of households		PwC analysis, NOMIS (2019) Annual Population Survey ONS (2019) Family and households
Other heat (non residential)	Proportion of total GVA (all sectors) in the North East relative to the UK	Commercial sector, therefore aligned with regional GVA	ONS (2019) GVA by sector at NUTS1 and NUTS3
Other heat (residential)	Proportionate to the number of households in the region	Relevant existing data used as proxy	NOMIS (2019) Annual Population Survey ONS (2019) Family and Households
Retrofitting (non residential)	Proportion of total GVA (all sectors) in the North East relative to the UK	Commercial sector, therefore aligned with regional GVA	ONS (2019) GVA by sector at NUTS1 and NUTS3
Retrofitting (residential)	Proportionate to the number of households in the region	Relevant existing data used as proxy	NOMIS (2019) Annual Population Survey ONS (2019) Family and Households

Appliances (non-residential)	Proportion of total GVA (all sectors) in the North East relative to the UK	Relevant existing data used as proxy	ONS (2019) GVA by sector at NUTS1 and NUTS3
Appliances (residential)	Proportionate to the number of households in the region	Relevant existing data used as proxy	NOMIS (2019) Annual Population Survey ONS (2019) Family and Households
Industry			
Industry	Proportion of employment in the region compared to UK in each sector incorporated to the model	Relevant existing data used as proxy	NOMIS (2019) Business Register and Employment Survey
CCUS			
CCUS storage	Equally divided between the five possible regions mentioned in the Ten Point Plan for a Green Industrial Revolution.	CCUS is expected to become a key new industry, with investment in place to develop four industrial clusters in regions such as the North East, Yorkshire and the Humber, the North West, Scotland and Wales. Given that CCUS is currently in the early stages of development, the localisation approach has assumed an equal likelihood of becoming one of the four clusters among the five regions.	UK government (2020) The Ten Point Plan for a Green Industrial Revolution
CCUS capture	Equally divided between the five possible regions mentioned in the Ten Point Plan for a Green Industrial Revolution.		UK government (2020) The Ten Point Plan for a Green Industrial Revolution
Energy			
Offshore wind	Estimated offshore wind employment growth in the region by 2032	Offshore wind uses employment growth to overcome the difficulty of assigning postcodes to an offshore region in the renewable plans database	Energy and Utility Skills - UK Offshore wind employment growth by region in 2032 (2018)
Onshore wind	Proportionate to the installed capacity from onshore wind in the region (allocated using postcodes)	Uses renewable energy plans to proxy for the location of growth in the sector	UK government Renewable Energy Planning Database (2020 Q3 quarterly extract)
Nuclear	Proportionate to the capacity of existing reactors in the region	Relevant existing reactors used as proxy	UK Parliament (2021) Existing Reactors in the UK by Capacity
Solar	Proportionate to the installed capacity from solar energy in the region (allocated using postcodes)	Uses renewable energy plans to proxy for the location of growth in the sector	UK government Renewable Energy Planning Database (2020 Q3 quarterly extract)
Other renewables	Proportionate to the installed capacity from other renewables in the region (allocated using postcodes)	Uses renewable energy plans to proxy for the location of growth in the sector	UK government Renewable Energy Planning Database (2020 Q3 quarterly extract)
Hydrogen	In line with the CCUS assumptions as part of a 'SuperPlace' which are equally divided between the	The approach for hydrogen follows that of CCUS as it is assumed that these hubs will congregate to become	UK government (2020) The Ten Point Plan for a Green Industrial Revolution

	five possible regions mentioned in the Ten Point Plan for a Green Industrial Revolution.	'SuperPlaces'	
Biomass	Proportionate to the installed capacity from biomass in the region (allocated using postcodes)	Uses renewable energy plans to proxy for the location of growth in the sector	UK government Renewable Energy Planning Database (2020 Q3 quarterly extract)
Fossil fuels (including oil, gas and coal)	In line with UK changes in demand	Assumed in line with demand and investment at UK level	PwC analysis

Source: PwC analysis
Note: Other heat includes gas, district heating, electric heaters and others

Alternative assumptions and sensitivities.

In addition to the main set of assumptions presented in the body of this report, two sets of alternative assumptions were used to test how results would differ under different headline assumptions. These scenarios were:

- **A 'high' scenario** in which the North East attracts more investment in hydrogen and CCUS clusters (and heat pump and H2 uptake is similar to the national take up levels)
- **A low scenario** in which the North East does not attract CCUS or Hydrogen investment, and offshore wind is slightly lower at 10% rather than 13% of headline spend. This scenario also includes lower uptake of EVs.

The alternative assumptions under the high and low scenarios are presented in the tables below.

Table D3: Localisation assumptions under the high alternative scenario
(table D3 presents only assumptions that differ from the core scenario)

Sector	Localisation principle UKTM data	Rationale	Data source
Buildings			
Heat pumps (non-residential)	Proportion of total GVA (all sectors) in the North East relative to the UK	Commercial sector, therefore aligned with regional GVA	ONS (2019) GVA by sector at NUTS1 and NUTS3
Heat pumps (residential)	Proportionate to the number of households in the region	Relevant existing data used as proxy	NOMIS (2019) Annual Population Survey ONS (2019) Households
Hydrogen boiler (non-residential)	Proportion of total GVA (all sectors) in the North East relative to the UK	Commercial sector, therefore aligned with regional GVA	ONS (2019) GVA by sector at NUTS1 and NUTS3
Hydrogen boiler (residential)	Proportionate to the number of households in the region	Relevant existing data used as proxy	NOMIS (2019) Annual Population Survey ONS (2019) Households
CCUS			

CCUS storage	30% of the investment is attributed to the North East	This alternative assumption attributes a greater proportion to the North East	UK government (2020) The Ten Point Plan for a Green Industrial Revolution
CCUS capture	30% of the investment is attributed to the North East	This alternative assumption attributes a greater proportion to the North East	UK government (2020) The Ten Point Plan for a Green Industrial Revolution
Energy			
Hydrogen	30% of the investment is attributed to the North East	The approach for hydrogen follows that of CCUS as it is assumed that these hubs will congregate to become 'Super Places'	UK government (2020) The Ten Point Plan for a Green Industrial Revolution

Source: PwC analysis

Table D4: Localisation assumptions under the low alternative scenario

(table 4C presents only assumptions that differ from the core scenario)

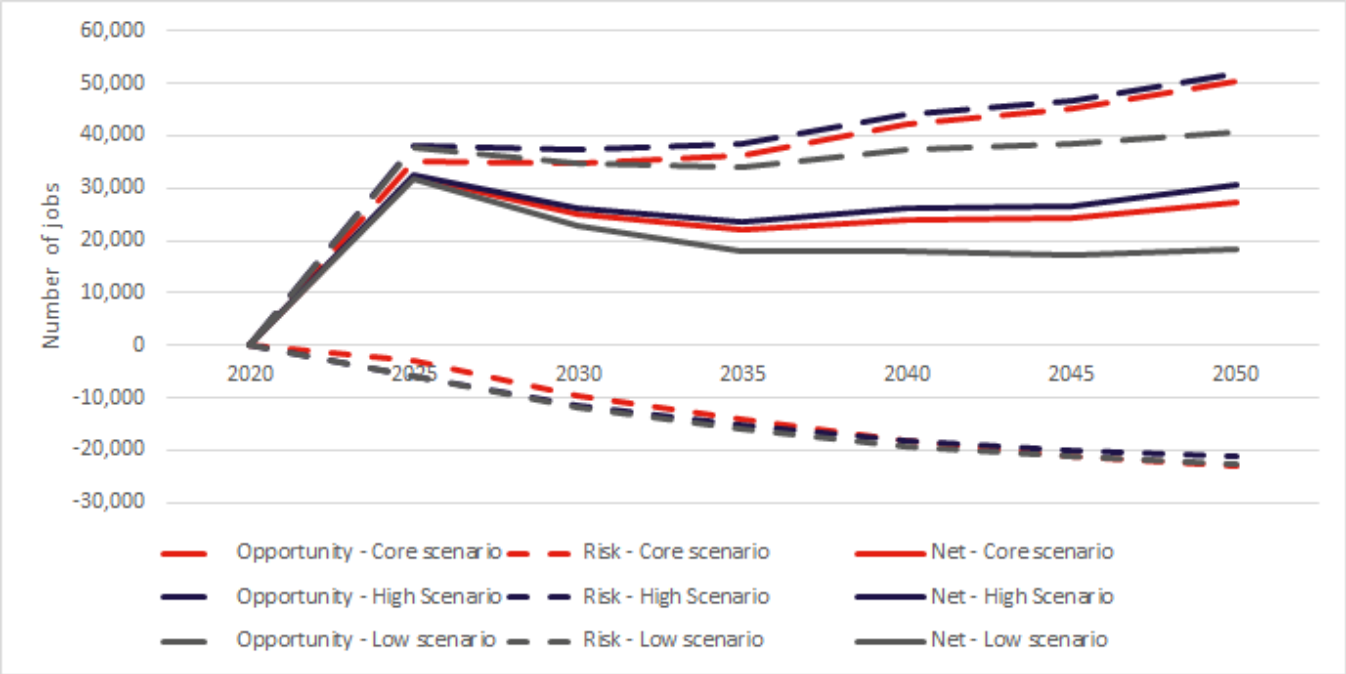
Sector	Localisation principle UKTM data	Rationale	Data source
Transport			
Light road transport electric vehicles	A high-level assumption that the North East will experience a 25% less uptake in electric light road vehicles than the proportion allocated using the region's number of light vehicle registrations	This assumption assumes that the uptake of electric light vehicles is less than the current vehicle registrations, perhaps due to the affordability of electric vehicles	Department for Transport, UK government (2019)
Light road transport fossil fuel vehicles	A high-level assumption that the North East will experience a 25% more uptake in fossil fuel light road vehicles than the proportion allocated using the region's number of light vehicle registrations	This assumption assumes that the uptake of fossil fuel light vehicles is more than the current vehicle registrations, perhaps due to the affordability of electric vehicles alternatives	Department for Transport, UK government (2019)
CCUS			
CCUS storage	No investment in CCUS in the North East	This scenario assumes that there is no CCUS investment in the North East	
CCUS capture	No investment in CCUS in the North East	This scenario assumes that there is no CCUS investment in the North East	
Energy			
Hydrogen	No investment in hydrogen in the North East	This scenario assumes that there is no hydrogen investment in the North East	

Offshore wind	A high-level assumption that the North East accounts for 10% of the UK's offshore wind capacity	This assumption allows for an overestimate in the employment growth of the offshore sector in the North East estimates	

Source: PwC analysis

Figure D5 below presents the difference in estimated net zero exposure under the three sets of localisation assumptions, in relation to jobs. As shown below, the net exposure is relatively similar across the scenarios in the early years of transition. However, by 2050, there are significant differences, with the net impact around ⅓ lower under the low (no cluster) scenario. The relatively late impact of lower cluster investment reflects the 'back-loaded' nature of the capex profile for energy and fuel (relative to the 'front loaded' investment in buildings in particular, which is held constant across the scenarios).

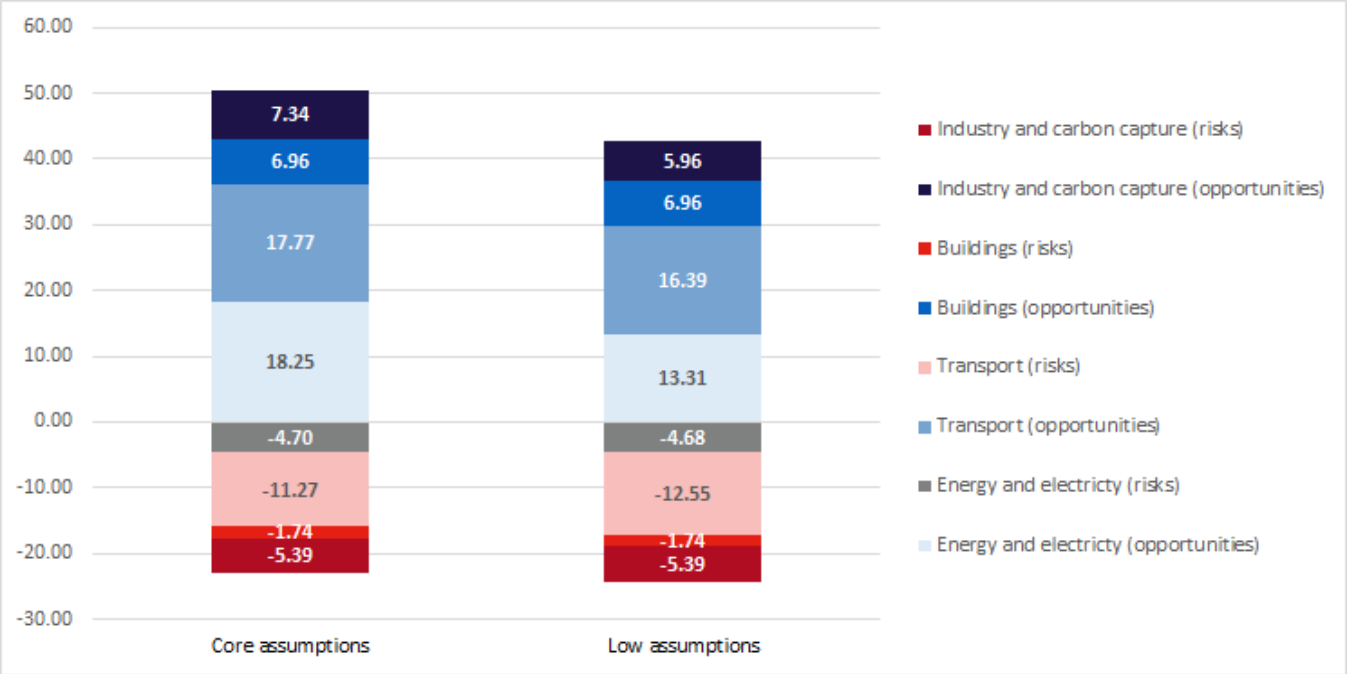
Figure D5: Main, low and high localisation assumptions



Source: PwC analysis

Looking at the area breakdown in 2050 (Figure D6), the net exposure impact can be seen to be driven by a lower net impact from energy in particular (which includes economic activity relating to offshore wind and hydrogen), as expected.

Figure D6: Main and low localisation assumptions and job exposure by sector



Source: PwC analysis

Of note is the relative sensitivity of exposure with respect to the headline spend in Offshore wind. The amount of headline spend associated with offshore wind in the North East varies by three percentage points between scenarios, but this generates a change in employment of 15% between the main and low scenario. In part this is because it is assumed that greater domestic investment helps the region participate in foreign markets. Similarly, lower take up of EVs reduces net road-transport jobs from over 4,000 in the core scenario to around 1,700 in the low take up scenario. This result reflects that much of the value of the net-zero transition in road vehicles is outside of auto manufacturing itself, which is both more concentrated and also less relatively exposed to local market changes.

Reasons for the approach The rationale behind each demand localisation assumption is based on a range of factors. These include the availability of data at the regional and LA level, the ability to be replicated across different regions, demand-side drivers (such as technologies and affordability), and supply-side drivers (such as renewable energy capacity). Where an assumption used is not straight-forward, such as for an emerging sector alternative assumptions have been selected in the other scenarios.

Local supply chain

In addition to local demand assumptions, a set of local supply chain assumptions are applied to account for the presence of local supply chains across the UK. Two sets of local supply chain assumptions are used:

1. Local supply of local demand
2. Local supply of non-local (other national and international demand)

As a starting point, both sets of assumptions on local supply are at present estimated based on the % of jobs in the region for a particular SIC code (estimated based on Nomis Business

Register and Employment Survey (BRES) data for 2019). This could be flexed in future iterations if other assumptions are developed.

In addition, some differences in assumptions between the local and non-local supply chain are embedded in the regional impact tool as set out below.

Similar to other assumptions, the demand impacted pathway (%) requires different assumptions because the impact is expressed as a percentage rather than a cost figure. Localisation assumptions related to demand impacted pathway (%) impacts should be interpreted as whether local supply would be disproportionately affected by [local / non-local] demand shifts (1 representing equally affected, figures over 1 representing an outsized impact on supply of a demand shift).

Local supply of local demand. The following assumptions relate to the local demand supply chain:

- It is assumed that opex expenditure of local demand is captured by local suppliers
- It is assumed that installation expenditure of local demand is captured by local suppliers
- For all other capex it is assumed that supply captured in the local market will be proportionate to current share that the local market has in that SIC (as a % of UK jobs in that SIC).

Local supply of local demand assumptions are applied to local demand estimates (which are the product of UKTM national demand estimates and local demand assumptions).

Local supply of non-local demand. The following assumptions relate to the local demand supply chain:

- It is assumed that no opex expenditure of non-local demand is captured by local suppliers
- It is assumed that no installation expenditure of non-local demand is captured by local suppliers
- For all other capex it is assumed that supply captured in the local market will be proportionate to current share that the local market has in that SIC (as a % of UK jobs in that SIC).

Local supply of non-local demand assumptions are applied to non-local demand estimates. Non-local demand estimates are the sum of UKTM national demand estimates (after adjusting for UK market share) and International demand estimates (after adjusting for UK market share).

Local supply chain assumptions. The approach is subject to the following key assumptions and limitations.

- It is assumed that regional market shares are constant over time.
- Assumptions relating to local capture of installation and operating expenditure are simplifying assumptions. On the whole, this approach broadly aligns with the approach taken in certain EINA estimates, whereby installation and operating expenditure take place mainly in the domestic market rather than being traded. However, extending this assumption to the regional sphere is a strong assumption given the much higher

integration of the domestic market and the small size of local suppliers. Further work could be explored to develop more detailed assumptions in this regard, especially in relation to the larger capital projects where suppliers are more likely to be nationally sourced. This assumption may in some respects overestimate the local impact of local investment, while underestimating the local impact of national or international investment.

Jobs, output and GVA ratios

The steps set out above are designed to estimate economic output that will be supplied from the region based on local, national and international decarbonisation demand. The output figures are then used to estimate GVA and jobs exposure (risk/opportunity).

To estimate GVA and job exposure from output estimates, national ratios of GVA and jobs to output are used. These ratios are estimated using the Annual Business Survey (ABS) data on output, value added, and employment by the appropriate SIC level to which the UKTM cost was mapped (generally, SIC level 4, but sometimes more aggregated SIC levels were used).

The ABS survey data was used as the basis for ratios as it includes data on GVA, output, and employment alongside other variables at a relatively granular SIC level. However, the ratios are at UK national level, and so do not account for differences in productivity across regions.

The tool uses the 2018 (or in some cases, 2017 where 2018 data was not available) ABS data and ratios are held constant over time and across scenarios in the tool. In addition, the ABS data relates to existing sectors in the economy, rather than new sectors which may have different output to GVA or jobs ratios. As a result, estimates are only a proxy for exposure and may over or underestimate the net jobs or GVA impact depending on how productivity evolves.

Other points to note about the use of the ABS data are:

- Data excludes certain sectors (including most notably, financial services).
- For certain sectors at a granular level, data is suppressed to avoid disclosure or is not available. Where this is the case, the SIC level above is used and apportioned using a similar metric (for example output may be apportioned using GVA) if the data is available. If the data is unavailable for a suitable metric, a previous year is used. In each circumstance the approach is referenced in a note.

Skills and job quality.

In addition to the main exposure outputs related to economic output, GVA and jobs, information on job quality and skills challenges is proxied in the tool.

Job quality. As a high level proxy of job quality, the cost per employee for SIC codes is included as a descriptive statistic (data is taken from the ABS and is a UK-level statistic). While this figure is related to employee salaries, however it may not fully capture the quality of jobs as it is both averaged across employees of different types, and may not fully account for non-employed workers (e.g. the self employed). As such these figures are included for broad indication and should be interpreted with caution.

Skills. One of the potential consequences of the net zero transition is that some occupations (and skill sets) will be more in demand than others. This may generate challenges in unemployment or underemployment on the one hand, and skills gaps on the other, if there is a mismatch between the populations' skills and those in demand.

In order to proxy for the potential skills shift required as a result of decarbonisation scenarios, jobs impacts are translated into changes in Standard Occupational Classification (SOC) changes. This is based on ONS Annual Population Survey 2019 data, which is reported at a national level by SIC Division.

Annex E: Pathways, scenarios and counterfactual case

National net zero pathways

There are many different pathways that could be taken to achieve the net zero target. As part of the analysis for the setting of the Sixth Carbon Budget, BEIS modelled four pathways of investment and technological change by which the UK could reach net zero by 2050. The variation in the four pathways is due to technological and behavioural factors, and more detail can be found in Box 1 below, as well as in the published Impact Assessment for the Sixth Carbon Budget.[195] The potential net zero exposure estimates in this report use the core national net zero pathway to assess the impact of net zero on the North East, in line with the Sixth Carbon Budget Impact Assessment.

Box E1: Summary of the Sixth Carbon Budget Impact Assessment scenarios

There are a total of four scenarios in the Sixth Carbon Budget Impact Assessment:

1. **Core pathway** – based on the core "central" assumptions covering carbon targets/values/accounting, pathways, resources, refining and fuel manufacture, CCS, power, transport, residential buildings, commercial/public buildings, industry, agriculture and land use, land-use change, and forestry (LULUCF). Further detail is available in Annex A.2 of the Sixth Carbon Budget Impact Assessment[196];
2. **High CCS pathway** – to reflect upside technology uncertainty this assumes a 4 percentage point increase in carbon capture and storage (CCS) capture rates for nth
of a kind technology (from 95% to 99% in most cases) and higher availability of direct air carbon capture and storage (DACCS) at 25 Mt CO2 by 2050 compared with 13 Mt CO2 in the other pathways;
3. **CCS delay pathway** – to reflect downside technology uncertainty this assumes a delay to CCS availability by 5 years (start date changed from 2025 to 2030) and a 5 percentage point decrease in capture rates. This is also the only scenario in which hydrogen imports are allowed (limited to 70TWh) to offset domestic delay in production at scale; and
4. **High resource pathway** – to reflect an alternative plausible resource scenario this assumes an increase in afforestation planting rates from 30 kilo-hectares per year (kha/yr) to 50 kha/yr from 2030, and a primarily hydrogen-based decarbonisation route for heating in buildings.

[195] Department for Business, Energy and Industrial Strategy (2021) *Impact Assessment for the sixth carbon budget*. Available from https://www.legislation.gov.uk/ukia/2021/18/pdfs/ukia_20210018_en.pdf. Accessed 29 June 2021

[196] Department for Business, Energy and Industrial Strategy (2021) *Impact Assessment for the sixth carbon budget*. Available from https://www.legislation.gov.uk/ukia/2021/18/pdfs/ukia_20210018_en.pdf. Accessed 30 June 2021

Counterfactual case

The counterfactual case shows how UK emissions have the potential to evolve in the absence of new (and as yet unannounced) policy action to reduce emissions. The following box sets out the latest forecasts from BEIS and adjustments made which are of relevance to this study.

Box E2: BEIS's latest forecast scenarios

The reference scenario from BEIS's latest emission projections (EEP 2019) published in December 2020 has been adjusted for:

1. **Updated macroeconomic growth assumptions.** These have been aligned to the OBR long-term forecasts published in March 2020 and the short-term central forecast published in July 2020. The published emissions projections were aligned to March 2019 OBR forecasts.
2. **Emissions accounting changes.** These include AR5 Global Warming Potentials and additional emissions from IAS and wetlands in line with the scope used for the sixth carbon budget in this Impact Assessment.
3. **The emissions projections only extend to 2040.** Beyond this period they are assumed to grow in line with underlying demand drivers.

In terms of policies, the baseline only includes government policies which had been implemented, adopted or planned as of August 2019. These policies are all assumed to be implemented as planned. The baseline does not include more recently announced government policies and ambitions which are yet to be factored into projections, including those policies set out in the PM's 10 Point Plan for a Green Industrial Revolution and the Energy White Paper.

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Disclaimer

This report represents the first substantial attempt by a government department to analyse in detail the potential economic impacts for a particular region from the UK's transition to net zero. The North East of England was chosen to trial this analysis as the region has a number of economic and geographic features of relevance to the transition. The analysis presented in this report is experimental, does not cover all sectors of the economy or all economic impacts, and does not consider the impacts on consumers. The primary focus is on the potential supply side implications for the region from the levels of investment which internal BEIS energy systems modelling results suggest are necessary in key technologies for the UK as a whole to reach net zero by 2050. All modelling assumptions, particularly on the apportionment of national investment totals to the North East region, are illustrative and should not be considered as indicative of government policy. BEIS recognises the inherent complexity of such analysis and is publishing this report in order to demonstrate one approach, and to provide initial evidence of potential gains to a region from the transition. Her Majesty's Government will continue to develop further analysis on the regional impacts of net zero and welcomes discussion among researchers and other interested parties on these topics.

This report is based on research completed in early 2021 and updated in July 2021. Policy announcements after July 2021 may not be fully referenced.

The report presents an illustrative analysis. The authors and researchers do not accept any liability for use of the analysis presented.

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