



Net Zero by 2050:

ONE PLAN. TWO OBJECTIVES.

**HOW GREEN GROWTH CAN BUILD THE
NORTHERN POWERHOUSE**

Analytical Report
July 2024

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/02. Executive Summary

The plan we present helps to illustrate how the nation's agenda for reaching net zero provides significant opportunities to create green jobs and economic growth here in the North of England.

The National Infrastructure Commission, co-located across Leeds and London, will be strengthened as the National Infrastructure and Service Transformation Authority (NISTA), bringing it together with the IPA, has set out clearly that infrastructure is key to the net zero transition (alongside the wider challenge of resilience to climate change). We agree with their analysis in the National Infrastructure Assessment about the critical role of private funding alongside public investment nationally. More of the most significant decarbonisation challenges and new opportunities for generation, from nuclear to tidal, are here in the North of England. Significant projects have been highlighted in this plan which need to be deployed at pace. This means everything from Environment Agency approvals to financing models, all working together in a joined-up way.

That is why it is so critical that our Metro Mayors play a leading role. Each of our recommendations will involve Metro Mayoral Combined Authority and local council action; building on the legacy of cities like Newcastle-upon-Tyne who led the way with their Warmzone over a decade ago to improve energy efficiency, through to the ambition of South Yorkshire Energy launched by Mayor Coppard; a partnership with the private sector and academics that will maximise investment, jobs and supply chain development in the area's leading clean-tech sector.

Across all of the net zero transition, including areas which have higher and lower rates of leverage on public investment, there is a projected average in the North of £2.65 of private investment for every £1 of public money and the creation of an additional 168,000 jobs. In industrial decarbonisation, the Cambridge Econometrics scenario we have commissioned shows that until 2050 around 80 per cent private investment can be achieved versus only 20 per cent from the public finances.

As the new Government has announced its approach through its National Wealth Fund, we here will demonstrate how we can maximise the amount of private investment which can be generated. We are clear that institutions included in that fund, notably the UK Infrastructure Bank, must make proper use of Treasury Guarantees to maximise their role for unlocking institutional investment, alongside other methods of funding.

On grid, we know that there is huge investment to be deployed in enabling generation and storage in the run up to 2030. However, we must also make use of those locations, including here in the North, where there is capacity to connect without any delay.

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This report builds on the 'Net Zero Scenario' set out in Transport for the North's Independent Economic Review.¹ Within this, five main categories were identified whereby decarbonisation could yield significant economic benefits. We have set out our specific recommendations for each of these categories below.

Energy

- a) **Complete procurement by Great British Nuclear from two separate businesses of three small modular reactors (SMRs) each**, unlocking a significant export opportunity and bolstering our energy security. Due to previous delays in making these decisions, the costs for these SMRs will fall in future Comprehensive Spending Review periods and therefore there is no unplanned requirement for budgeting for this expenditure in this current Parliament.

The North is already benefitting from the growth of the nuclear supply chain, including Sheffield Forgemasters and Rolls-Royce SMR headquarters in Manchester. There are many ways to generate net zero electricity, not least through interconnectors supplying nuclear power from overseas markets, but these do not produce high quality jobs in the North as SMRs will do. Carbon has been offshored for the last decade with the consequential loss of manufacturing – we have an opportunity with SMRs to re-build our manufacturing heritage through the building of low carbon infrastructure.

- b) **Develop our wind capabilities from the North East down to the Humber.** Building on the success of the turbine blade factory in Hull we should now look to make even larger components for the offshore sector, while growing Greenport 2 with initial funding in the Hull and East Yorkshire devolution deal. We can re-allocate under-spends from previous competitive funding rounds for offshore wind infrastructure to fill the current funding gap.
- c) **Invest in a turbine supply chain for the tidal barrage on the Mersey**, which should be a development priority both within the city region and across the North.

¹ Transport for the North (2023). The Northern Powerhouse Independent Economic Review <https://transportforthenorth.com/wp-content/uploads/NPIER-2023-Summary-Report-For-Final-Publication.pdf>

Industry

- a) **Continue to make huge strides in carbon capture use and storage (CCUS)** as part of the wider push towards industrial decarbonisation. From the Mersey to Teesside, we have seen the development of successful clusters here in the North of England but are still awaiting the final go ahead for Track 1 deployment. This is whilst the Humber - the UK's largest industrial cluster, with major emitters from Selby through to Immingham - is awaiting key decisions on the deployment of the Track-2 cluster. A decision with accelerated consenting and powers to put pipes in the ground with GB Energy will unlock £15 billion of private investment from Drax, CO2 brought by vessel, Phillips 66 and other businesses working in partnership with Viking alongside a Track 1 extension as an option.

- b) **Expand green hydrogen production, storage and distribution** to ensure the maximum opportunities for industrial decarbonisation are achieved. This should be through specifically targeted support to develop long-term sustainable business models.

Transport

- a) **Turn the North into a centre for the production of Sustainable Aviation Fuel (SAF)**, supporting jobs for those who work in refineries producing jet fuel today, and ensuring that - as production capability develops globally - the UK aviation sector is able to decarbonise at pace. As local authorities review their arrangements for waste disposal, they have the choice to ensure that the North can provide feedstocks for new SAF plants. The Government's commitment to this sector, evidenced by the Sustainable Aviation Fuel Bill announced in the King's Speech, is welcome.

- b) **Deliver a consistent programme of rail electrification.** Extending the TransPennine Route Upgrade to include Hull to Selby is a way to create further scale in the North's electrification portfolio, as well as delivering a key element of the Northern Powerhouse Rail portfolio. Supply chains can then plan for growth and deliver the necessary capacity based on this programme of work.

- c) **We make the UK a leader in building battery and hydrogen trains** through our world-class train factories in Goole and in Newton Aycliffe, alongside their supply chains, making the former a centre for innovation with a facility to bring R&D activity there and the latter delivering the all-electric HS2 fleet.

- d) **Guarantee the supply of hydrogen for commercial vehicles such as buses**, provided by East Bradford Hygen and N-Gen facility.
- e) **Increase procurement of electric and hydrogen buses across areas with franchising**, supporting the ability of Northern suppliers and those across the wider UK to produce buses at scale.

Built Environment

The UK has an ageing building stock which represents a substantial change for energy efficiency. There are several measures proposed by the Net Zero Strategy to decarbonise the building stock and heating systems.

- a) **Deliver retrofit of domestic and commercial buildings at pace, and with the necessary funding and skills support**, including a 75% reduction in public buildings emissions by 2037, whilst securing a UK and Northern supply chain for heat pumps, insulation and other technologies. If this is delivered in conjunction with energy companies, households can pay via their bills (rather than through a traditional loan set up) which increases eligibility and affordability.

Land Use

Land use will need to shift to favour low-carbon agriculture which will require investment in agriculture and forestry sectors. We need to deliver substantial decarbonisation of agriculture, with a tripling of tree planting rates to 30,000 ha per year by 2035 and the restoration of at least 25,000 ha of peatlands by 2035.

- a) **Back propositions including the Northern Forest**, which seeks to deliver 50 million extra trees, leveraging private investment through public backing.

/03. Introduction

Net zero is a global challenge, but also a huge economic opportunity for the North of England.

Ten years ago, in 2014, the then Chancellor George Osborne set an ambitious agenda to address the huge economic gap in productivity terms between the North and London & the South East. The Northern Powerhouse Partnership was set up in 2016 to convene business in support of that goal, and here we lay out what business and private investors can do if we have the full support of the UK Government, the UK Investment Bank, Metro Mayors and local government collectively.

Our proposition is simple: **we must maximise efforts to cut carbon emissions, and adapt to climate change, in such a way that addresses economic disparities at the same time.** We need a strategy to achieve our decarbonisation targets which is not focused on offshoring our emissions by exporting jobs in steel-making and other industries (adding to, not removing, global emissions), but by exploring green growth opportunities here.

Two hundred years after the North of England fuelled Britain's first Industrial Revolution with our coal powered factories which made us a global trade power, we are now competing globally to develop innovations and export opportunities in emerging green sectors. The North has a comparative advantage; thanks to our manufacturing excellence, our carbon intensive industrial clusters are working to decarbonise through our growing expertise in nuclear and other renewable energies. We will build on our existing capabilities whilst also developing new industries in emerging technologies.

In 2019, the then Energy Minister, Chris Skidmore, set legally binding targets to achieve net zero by 2050. There is cross-party consensus on the issue, as demonstrated by the Conservative-Liberal Democrat coalition (which helped secure the Siemens wind turbine blade factory in Hull) and the Labour government before it. The net zero agenda is now bringing together policymakers, businesses, regulators and civil society to create long-term change. It is also underpinning economic transformation for Northern cities like Hull, as the nuclear sector has for decades in towns like Warrington and Whitehaven.

The North has an opportunity to lead the transition by capturing more of the supply chains than we managed in the early stages of the net zero economic race. This will secure higher productivity, create good jobs, and re-industrialise the North. We have commissioned independent analysis which shows that **every £1 of public money can leverage another £2.65 of private investment**, close to the Government's stated target for returns from the National Wealth Fund. We can expect even more in some sectors, with industrial

decarbonisation until 2050 at around 80 per cent private investment versus only 20 per cent public.

It is time for the net zero debate to be properly aligned with the economic ambition to transform the North. This is about jobs for working people in so-called 'left behind' towns such as Grimsby and Blyth, as well as huge growth sectors in our great cities for those in knowledge-intensive jobs, including in our world-class universities.

Public support for this huge transition is dependent upon securing a just transition, in which those who work in those areas most at risk of economic dislocation, such as a blast furnace in Scunthorpe or an oil refinery in Cheshire, are front of the queue for the new jobs we can and must create.

The evidence used by Cambridge Econometrics was based on the situation as it existed under the last government. As the intentions of the new government become clearer, the assumptions of what may be possible, and so the maximum leverage of private investment based on public spending, could indeed change. This plan has been prepared in a period of flux but does include the role of the National Wealth Fund including the UKIB and GB Energy, which we feel are particularly important and are critical institutions for the North.

This is our business-led plan for green jobs and growth, building the Northern Powerhouse in the same year as our nation achieves net zero.

/04. Background

The original Northern Powerhouse Independent Economic Review (NPIER), published in 2016, laid out a transformational scenario that set out the scale of the prize to be won if the North successfully capitalised on its strengths and overcame barriers to growth. This prize was a boost to the economy of 850,000 additional jobs and £100bn in additional GVA by 2050 compared with a ‘business as usual’ scenario.²

More specifically, it identified four prime capabilities and three enabling capabilities. Notably and of relevance to this paper, energy was one of the prime capabilities noted for its expertise around generation, storage, and low carbon technologies and processes, especially in nuclear and offshore wind. In 2016, the NPIER noted how well placed the North is to seize the opportunity of net zero, which crosses over with the North’s further manufacturing prime capability. However, the review also established the significant barriers to the North reaching its potential and capitalising off its capabilities.

Barriers to the North and its Productivity

The UK’s productivity problem is so acute because regions, including across the North, do not have as productive cities as in comparable advanced economies, including across continental Europe.

The NPIER’s 2023 refresh highlighted that since the original NPIER in 2016, the productivity gap has widened slightly from 16.8% to an estimated 17.9% in 2021 (represented by GVA per job). The rest of England, excluding London, currently has a productivity rate of £51,900 per job, which is projected to increase to £66,800 per job by 2050. Meanwhile, in the North, productivity currently stands at £47,500 per job, which is projected to increase to £62,300 per job by 2050. Essentially, by 2050, the productivity of the North will be higher than the rest of the UK’s current productivity but will fall significantly short of where it stands in 2050.³ The NPIER (2023) in both editions recognises the following as the key drivers of this productivity gap:

- A considerable investment gap (spending measured as fixed capital expenditure per capita), with investment in the North being considerably lower, particularly in science, technology, and infrastructure.

² Transport for the North (2016), The Northern Powerhouse Independent Economic Review

³ Transport for the North (2023), The Northern Powerhouse Independent Economic Review

- An enterprise gap (measured as business starts per capita) which was negatively affecting innovation.
- A skills gap with the North having a smaller proportion of the workforce with higher level skills and a larger proportion with low level skills.
- A lack of agglomeration whereby the North wasn't capitalising on its potential due to economic activity across towns and cities being too spread out and disconnected from each other.
- A lack of connectivity in particular physical connectivity through transport, was a primary cause of the lack of agglomeration effects.⁴

The refresh published in 2023 set out four individual change scenarios which model the impact of what different approaches to advancing the North may look like. They consist of Technology and Innovation, Inclusive Productivity, Development Supply and Net Zero. The NPIER finishes with the New Transformational Scenario which would be the result of all four scenarios being realised by 2050.

Importantly, without any of these change scenarios the North's current trajectory is strong jobs growth, with unemployment and economic inactivity projected to continue to decline. However, productivity growth is low and has worsened since the business-as-usual scenario set out in the original NPIER. The baseline benchmark is the foundation of the NPIER's modelling and illustrates the outcomes if a 'policy off' or business as usual is employed between now and 2050.

Net Zero Scenario

The net zero scenario considers the effects of the implementation of a 2050 plan such as the one advanced later in this work in relation to the decarbonisation of the built environment, transport system, energy generation, industry, waste and agriculture by 2050. Though we should be mindful of the uncertainties in econometric modelling, we have commissioned additional work to inform this report. This explores in more detail some of the assumptions in the original Northern Powerhouse Independent Economic Review on the proportion of private investment which could be attracted, the headlines of which are highlighted below.

The following table illustrates the broad areas based on the national Net Zero Strategy whereby decarbonisation can achieve economic benefits as listed in the NPIER.⁵

⁴ Transport for the North (2016), The Northern Powerhouse Independent Economic Review

⁵ Transport for the North (2023), The Northern Powerhouse Independent Economic Review

Table 1: Summary of the decarbonisation categories which will yield economic benefits

Decarbonisation Area	Summary
Industry	<p>Net zero requires a major shift in how industry makes goods and consumes energy. Therefore, its technology strategy to 2050 focuses on three primary areas:</p> <ul style="list-style-type: none"> - Development and adoption of industrial digital technologies - Better energy management - Reuse of materials <p>The scale of opportunity for the North in this regard is significant given that over 50% of the UK’s industrial carbon emissions are within six spatially concentrated clusters of activity, of which three are in the North (Teesside, the Humber Estuary and Cheshire/Merseyside/Deeside). These three locations have been identified as areas of focus for investment in hydrogen, carbon capture and storage along with other technologies over the long term.</p> <p>Of the £4 billion per annum of the investments in the industry sector allocated to the North of England, we now assume 20% (£0.8 billion) is public investment (primarily to funding publicly owned CCUS and hydrogen infrastructure and grants/tax incentives to accelerate fuel switching) and 80% (£3.2 billion per annum) from the private sector.</p>
Energy	<p>For the UK to reach its 2050 decarbonisation goals, renewable energy sources will need to constitute a much larger share of the energy mix than now. The North will require significant investment across a range of sectors to achieve this.</p> <p>Of the £10 billion per annum of investments in the energy sector allocated to the North of England, we assume £3 billion is public investment (primarily in direct funding of national energy generation and supporting low-income households in the energy transition) and £7 billion is private investment.</p>
Transport System	<p>A decarbonisation strategy set out by Transport for the North focuses on surface transport and sets out a trajectory whereby a 56% reduction in emissions should be achieved between 2018-2030 and a 96% reduction between 2018-2040. The following key themes support this target:</p>

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	<ul style="list-style-type: none"> - Uptake of zero emission vehicles - Uptake of hydrogen vehicles - Demand management and digital substitution - Decarbonisation of freight transport and logistics industry - Rail decarbonisation - Modal shift to active travel, public transport and micro mobility. <p>We assume that £4 billion per annum investments in the transport sector are allocated to the North of England, of which £1.2 billion is public investments (primarily in upgrading public and active transport infrastructure at the required scale and pace) and £2.8 billion is private investment.</p>
<p>Built Environment</p>	<p>The UK has an ageing building stock which represents a substantial challenge for energy efficiency. There are several measures proposed by the Net Zero Strategy to decarbonise the building stock and heating systems.</p> <ul style="list-style-type: none"> - Phasing out the installation of new gas boilers by 2035 - Incentivising heat pump installations - Reducing direct emissions from public sector buildings by 75% by 2037. <p>£3 billion per annum in investment in the built environment sector is allocated to the North of England. Of this, we expect £0.8 billion to be covered by public investments (primarily in decarbonising public buildings and supporting low-income households in the transition to green buildings) and the remaining £2 billion is expected from private investment.</p>
<p>Land Use</p>	<p>Farming practices will need to shift to favouring low carbon agriculture and the country will need to increase rates of woodland and peatland restoration/creation alongside maintaining food production and security. This will require investment in agriculture and forestry sectors. The Net Zero Strategy commits to substantial decarbonisation of agriculture, with a tripling of tree planting rates to 30,000 ha per year by 2035 and the restoration of at least 25,000 ha of peatlands by 2035.</p> <p>We assume £1 billion per annum of investments for decarbonising the land use sector are allocated to the North of England, of which 50% (£0.5 billion) is public investment (primarily in directly funding environmental restoration and grants to encourage sustainable land use practices) and the remaining 50% (£0.5 billion, primarily in sustainable agriculture and offsetting) would be private investment.</p>

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The Importance of Clear and Certain Policy

Overall, these areas represent a significant opportunity to leverage both public and private investment into net zero. It is perhaps more important that government commitments to achieve net zero remain firm to instil confidence in business, than being prescriptive about the amount of public investment to be made each year. If the private sector is confident that the policy environment will remain stable, and that returns are possible, they will commit investment. Having said that, we remain confident that public investment will leverage in a higher ratio of private investment than originally envisaged in the NPIER.

As highlighted by our Powerhouse 2050 report published in 2017, the North of England has generated over forty percent of the UK's electricity for many years. The M62 belt of coal-fired power stations is now almost all closed, with the exception of a repurposed Drax and offshore wind taking their place.⁶ Three of the six largest industrial clusters by emissions are situated within the North with the Humber being the largest, which contributes to us generating a quarter of the UK's total CO2 emissions per annum (90m tonnes). This presents a significant challenge in transitioning these clusters to a net zero position while maintaining competitiveness within the sector. But tackled ambitiously, it also presents a huge opportunity to transition the region to be at the heart of clean power generation.

With employees in net zero related fields generating 1.7 times more GVA than the UK average⁷, government investment into the net zero economy is vital to drive productivity in the North. It is emphatically clear that the North has an asset base compatible with leading the net zero transition. From offshore wind, to nuclear, to carbon capture, use and storage, the opportunities are abundant. Moreover, failure to grasp the opportunities to decarbonise and enable clean growth of existing high carbon industrial activity within the North risks being a huge own goal environmentally and economically. The alternative to decarbonisation would be cessation of activity at home and exporting emissions to parts of the world which have fewer controls on emissions or investing now to sustain the current jobs and add to them.

The NPIER demonstrates the headline impacts of the Net Zero Scenario by 2050 compared to the outcomes of the Baseline Benchmark. It details the potential of net zero to provide

⁶ Northern Powerhouse Partnership (2017), Powerhouse 2050: The North's route map for productivity

⁷ Energy & Climate Intelligence Unit in partnership with CBI Economics and The Data City (2023), Mapping the Net Zero Economy

£23 billion of additional GVA growth to 2050, 168,000 more jobs and an additional £1,500 of additional productivity per worker over the forecast baseline.⁸

Table 2: NPIER Net Zero Scenario Modelled Outputs to 2050 (over the baseline)

Measure	Value
Additional annual GVA	£23bn
Additional Jobs	168,100
Additional Productivity per worker	£1,500
Additional Population	285,000

Source: Cambridge Econometrics/SQW

Given these outcomes, this report will analyse the current state of the Net Zero Economy in the North, highlighting major successes, areas of opportunity, and the scale of the intensive carbon producing sectors of the economy. The next section is a brief literature review on the research done to date surrounding net zero in the North of England.

External Research

This report will build on previous research undertaken to lay out the opportunities, challenges, and ambition to achieve net zero in the North of England. Reports such as NPP's Powerhouse 2050 report highlight how the North has historically been the powerhouse for the rest of the country. The North is home to three of the UK's six largest Industrial Clusters by Emissions they are situated in Merseyside, Teesside and The Humber. The Humber emits more carbon dioxide than any other region by a substantial 50% more than the second largest.⁹ Moreover, the North's economy is more carbon intensive than the English average which can be partly attributed to the presence of industries such as iron, steel, agri-food, and chemicals.¹⁰ Therefore, these statistics not only represent the challenge for net zero in the North but also the capacity. It requires a major shift, but the North is more than capable of achieving it and has already made headway in doing so. According to NPP analysis of data produced by the Department for Energy Security & Net Zero, in 2022 the North generated 50% of electricity generated by renewable sources in England.¹¹ The region boasts a rich

⁸ Transport for the North (2023), The Northern Powerhouse Independent Economic Review

⁹ Repowering the Black Country and UKRI, UK Industrial Clusters Decarbonisation

¹⁰ Institute for Public Policy Research (2017). Net Zero North Delivering the Decarbonisation Mission in the North of England.

¹¹ Department for Energy Security & Net Zero (DESNZ). Renewable Electricity – generation by region 2003-2022.

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asset base, such as carbon capture in The Humber, offshore wind in the North East, and low-carbon technology and manufacturing in the North West. The importance of capitalising on the region's strengths is a common thread throughout existing research.

The Northern Powerhouse 11 (2019) identified the following projects as key to the North's transition: the continued deployment of offshore wind, development of CCUS, new nuclear, and low-carbon transport.¹² Our previous research with N8 on the Net Zero North report placed emphasis on the importance of the North's strong array of research and innovation assets which are anchored by universities, institutes such as the Advanced Manufacturing Research Centre and large companies such as Sellafield, Siemens, and Unilever.¹³ At a pan-northern level, there are distinct challenges and opportunities for the North, not least the higher levels of carbon-intensive businesses, a poor skills system, and insufficient levels of connectivity between firms across the North. However, there is a significant prize for the North if it achieves net zero. The Local Government Association (2020) predicted that regions outside of London would be home to 1.04 million or 88% of total direct green jobs projected to reside in England by 2050.¹⁴ The Energy & Climate Intelligence Unit found that employees in this industry generate 1.7 times more GVA than the UK average.¹⁵ Clearly, government investment into the net zero economy is vital to drive up productivity in the North.

Research produced by each region offers an insight into the unique strengths of each place and the potential prize to be won if the North pursues net zero backed by both public and private investment. Starting with the Humber 2030 vision, over £15 billion of private investment will be unleashed in the Humber. The Humber can meet 50% of the UK's renewable power needs and has the hydrogen storage capacity to power two million UK homes for one year.¹⁶ It is also home to a multitude of companies and projects pioneering in net zero such as BECCS at Drax, the UK's flagship green hydrogen project Gigastack, and ABP and Air Products Immingham Green Energy Terminal.¹⁷ Given the Humber's capabilities in carbon capture and hydrogen and its position as one of the most carbon-intensive industrial clusters, the net zero transition, on the one hand, represents a risk to jobs, the local economy, and industry. On the other hand, decarbonising the Humber will continue the viability of industry sectors while creating new green jobs in innovative technologies. The potential for leveraging private sector investment is immense in this region.

¹² Northern Powerhouse 11 (2019). Northern Powerhouse: Energy and Clean Growth

¹³ N8 Research Partnership and The Northern Powerhouse Partnership (2021). Net Zero North

¹⁴ Local Government Association, Local Green Jobs Data of LG Inform

¹⁵ Energy & Climate Intelligence Unit et al (2023). Mapping the Net Zero Economy

¹⁶ CBI, Humber Energy Board, Humber Industrial Cluster Plan and Marketing Humber(2023), Humber 2030 Vision

¹⁷ CBI, Humber Energy Board, Humber Industrial Cluster Plan and Marketing Humber(2023), Humber 2030 Vision

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The North West of England produces around thirty-eight mega-tonnes of carbon dioxide, the same as the Republic of Ireland.¹⁸ Furthermore, the Net Zero North West manifesto produced by the industry-led cluster sets out £30 billion of near-term investable projects, generating a £207 billion overall investment, targeted at decarbonising industrial sectors across the North West.¹⁹ Some of these include power sector decarbonisation, wide-scale hydrogen production and use, and industrial energy efficiency measures. In terms of jobs, the projects can safeguard and create 34,500 green jobs in the near term and 660,000 green jobs in the future.²⁰ Moreover, the North West hosts the ground-breaking decarbonisation cluster Hynet, which is vital to replacing methane with hydrogen in the region's gas grids. It will maintain and create 6,000 permanent jobs in the region.²¹ More specifically, Liverpool is currently working on harnessing the power of one of its greatest natural assets, tidal. The Mersey Tidal Power project could generate enough power for one million homes, create green jobs and grow the local economy.²² Furthermore, the opportunity for new nuclear power is distinct in the North West, as it represents over 35% of the nuclear workforce nationally, with more than 27,000 people employed in the area contributing more than £3.9 billion GVA to the UK economy.²³ As is the case with a large proportion of the research produced surrounding the barriers to net zero, the UK's planning system, which has various barriers along with constant policy churn, has made investors hesitant to commit.

The North East of England has led the way in offshore wind with developments such as the Dogger Bank Wind Farm, which is set to be the world's largest offshore wind farm once constructed, and the Sofia Offshore Wind Farm. These developments have bolstered supply chains and encouraged innovation such as JDR Cables' subsea cable manufacturing facility.²⁴ The Offshore Renewable Energy (ORE) catapult is the UK's leading research centre for renewable energy with assets such as a 100m blade test facility.²⁵ Aside from this, the North East is also home to Nissan which is the region's largest employer and has a huge role to play in EV vehicle development and deployment²⁶.

¹⁸ Net Zero North West and Siemens (2021), Economic Investment Prospectus

¹⁹ Net Zero North West (2024), Net Zero North West Manifesto – Pioneering a Net Zero Future

²⁰ Net Zero North West (2024), Net Zero North West Manifesto – Pioneering a Net Zero Future

²¹ Hynet (2020), Unlocking Net Zero for the UK – Hynet North West

²² Liverpool City Region Combined Authority – Mersey Tidal Power Brochure

²³ Net Zero North West (2024), Net Zero North West Manifesto – Pioneering a Net Zero Future

²⁴ Northern Powerhouse Partnership (2022), The Internationalisation of the Northern Powerhouse

²⁵ NOF (2023). North East England is energising the offshore wind industry with its regional strengths and global appeal

²⁶ Northern Powerhouse 11 (2019). Northern Powerhouse: Energy and Clean Growth

Classification - Public

Overall, there is consensus amongst the literature that the North is in a strong position to lead in the net zero transition, but it must ensure that carbon intensive industries are a key part of that transition.

/05. The Net Zero Economy

In our own previous research, we considered Foreign Direct Investment in the North of England, and this highlighted significant strengths in investment related to net zero. Foreign investment into renewable energy in the North of England has increased from \$6.95 billion between 2012-16 to \$20.25 billion 2017-21 – a 193% rise. However, it is worth noting that the 2012-16 figure was boosted by a project worth \$1.2 billion. Conversely, coal, oil and gas appear to have suffered from the shift to green alternatives, dropping from \$1,299 million between 2012-16 to \$471 million between 2017-21.

In this work, we have looked at projects and opportunities in light of the levels of leverage which have been identified as obtainable by the additional econometric based analysis undertaken on the net zero scenario in the NPIER. For example, RedCAT in Lancashire, a support programme for low carbon commercialisation, is led by the East Lancashire Chamber of Commerce and has achieved £11.5 million of investment and sales for £2.2 million of public investment.

In terms of industrial decarbonisation, the figures on the total quantum of private investment are within Track 1 £5 billion from Hynet on the Mersey and adding in Track 2 £15 billion unlocked through access to Carbon Capture and Storage across the Humber, of which £2 billion is at Drax power station.

As we assess the opportunities for net zero to grow in the North, and to raise productivity here, this paper of technical analysis accompanies this plan. We have highlighted areas with overall net zero strengths already present, and so where there may be the strongest basis for smart specialisation. The rest of this chapter will look at the size and scale of the net zero economy in the UK and then focus on the North. We will explain what we mean by “the net zero economy”, how our approach may differ from previous research in this area, and how we have used different data methods throughout this report. You can find more details on the methodology in Appendix A.

Our main data source for this research is the Data City, who use information from Companies House to identify active companies registered in the UK. They use web scraping to match these entries to company websites, where they collect information such as keywords, locations and more to build a profile of the company. This allows Data City to group companies into industries that are more relevant and dynamic than the Standard Industrial Classification (SIC) codes. We use the net zero Real Time Industrial Classification (RTIC) for our analysis, but as Annex A shows, we have made some changes to this classification. For instance, previous work on the net zero economy using this classification included major oil companies such as BP, Exxon Mobil and Shell in the analysis. We decided

to exclude such companies from our analysis for two reasons. Firstly, much of their business still involves extracting and refining fossil fuels, which belongs to our carbon-intensive sector that we will cover in the next chapter. Secondly, these companies have very large turnovers, and we cannot determine what proportion of the business relates to net zero or carbon intensive activities. Including them in our net zero definition would distort our results and interpretations. Our list of companies therefore consists of those we are more confident that their activities are solely or mainly related to developing and/or implementing the technologies to decarbonise the UK economy.

Finally, we can choose to look at only a company's registered address or also its trading addresses. We will make it clear which definition we use in our analysis, as we have used both. We adopted this approach as we do not know exactly how activity and employment are distributed across each site for companies with multiple locations. For example, a company's registered address may not have any actual activity or employees and could be an address for correspondence and/or the company's legal advisors. So, in our analysis that looks at all of a business's locations, we have split figures such as GVA, revenue, employment and others equally across each site. We know that this will not be exact for every company, but this is an accepted method that has been used in previous reports such as the Department for Science, Innovation and Technology's analytical report about UK Innovation Clusters.

The Net Zero Economy across the UK

Considering the points set out above and detailed in the methodology section, we estimate that the UK net zero economy comprises approximately 22,500 registered limited companies, contributing £55.7bn of GVA to the UK economy, creating more than 685,000 jobs. That is a contribution of more than 9% of total UK GVA and suggests that around 2% of total UK jobs are within the sector, though these are likely to be underestimates given some gaps in data. This high contribution of GVA with a comparatively lower share of total jobs is why productivity measured as GVA per job is estimated to be approximately £88,000, more than 50% higher than the UK average of approximately £58,000.

Whilst the sector's contribution to the UK economy is significant, we are particularly interested in seeing where these companies are located, given the north's comparative advantage in energy and potentially net zero as outlined in the NPIER.

Our initial stage of research involved analysing these companies based solely on their registered location. It quickly became apparent that this analysis was skewed by the "head office" effect with many companies using London addresses for their accountants, legal

advisors etc. We have therefore chosen not to solely present this data as it may present a misleading picture of the net zero economy.

Fortunately, our data set provides us with both registered addresses and other locations operated by these companies with 22,501 companies operating across a total of 51,332 locations. Of these, 244 could not be assigned to a region leaving us with 51,088 sites to analyse.

Table 4: Net Zero Companies by ‘megaregion’

Region	No. of sites	GVA (£bn)	Turnover (£bn)	Employees	Innovate UK Funding (£m)	Private Investment Raised (£m)
Northern Powerhouse	9,817	11.5	77.4	138,821	256	2,215
London and South East	16,379	19.2	174.8	250,985	278	12,599
Midlands	6,482	5.5	29.4	65,077	290	660
East of England	4,796	4.6	17.9	41,950	134	809
South West	5,294	7.7	68.5	76,595	110	3,634
Northern Ireland	1,261	1.3	6.4	12,596	13	762
Scotland	5,072	4.4	53.7	78,718	251	1,638
Wales	1,987	1.4	7.6	20,327	88	145
Total	51,088	55.6	435.6	685,069	1,420	22,460

Source: NPP analysis of The Data City Data

Table 5: Net Zero Companies by ‘megaregion’ as percentage of total

Region	No. of sites (%)	GVA (%)	Turnover (%)	Employees (%)	Innovate UK Funding (%)	Private Investment Raised (%)
Northern Powerhouse	19.2	20.7	17.8	20.3	18	9.9
London and South East	32.1	34.5	40.1	36.6	19.6	56.1
Midlands	12.7	9.9	6.7	9.5	20.4	2.9
East of England	9.4	8.3	4.1	6.1	9.4	3.6
South West	10.4	13.9	15.7	11.2	7.7	16.2
Northern Ireland	2.5	2.3	1.5	1.8	0.9	3.4

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Scotland	9.9	7.9	12.3	11.5	17.7	7.3
Wales	3.9	2.6	1.7	3	6.2	0.6
Total	100	100	100	100	100	100

Source: NPP analysis of The Data City Data

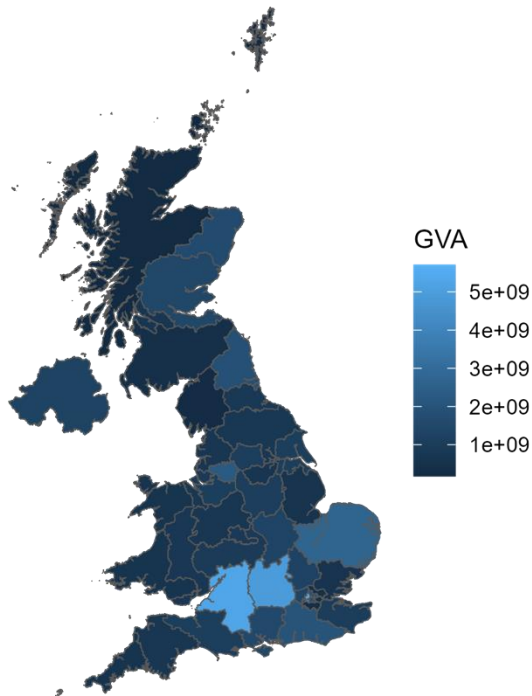
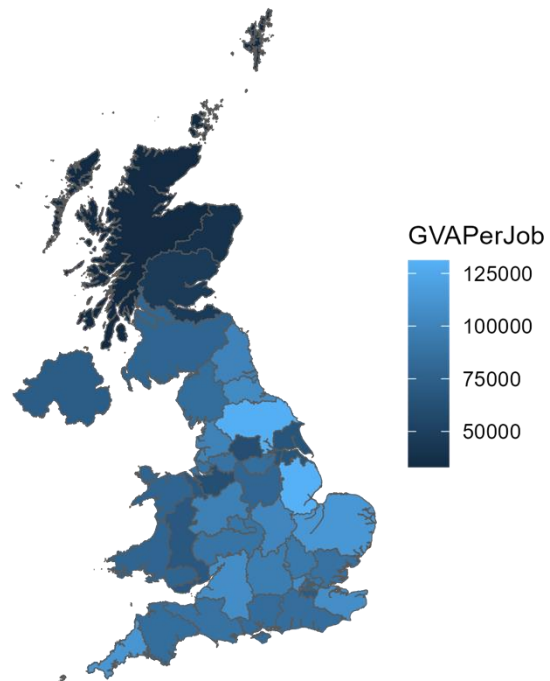
Moving on to consider GVA per job, we have 27,700 sites with data for both GVA and the number of employees, almost 55% of those sites used in the tables above. Though containing the greatest number of net zero sites, London and the South East had only the 4th highest level of GVA per job from the 8 regions listed. The Northern Powerhouse region was just behind the capital but the East of England and South West recorded levels of over £100,000 of GVA per job. Perhaps surprisingly, Scotland had a level of less than half this of just £48,000.

Table 6: GVA Per Job of Net Zero Companies

Megaregion	No. of sites	GVA Per Job (£)
Northern Powerhouse	5,645	84,054
London and South East	8,607	87,628
Midlands	3,657	95,129
East of England	2,720	100,376
South West	2,848	100,901
Northern Ireland	670	72,632
Scotland	2,505	47,987
Wales	1,048	73,396

Source: NPP analysis of The Data City Data

Originally, we had planned to break these figures down further to the Local Authority level. However, we encountered problems with either missing data or low numbers of businesses in an area, which made meaningful comparison difficult. Instead, we have used the ONS's ITL2 regions, which sit between local authority and region geographic sizes and broadly represent counties.

GVA by all sites
of Net Zero companiesGVA per job of all sites
of Net Zero companies**Table 7: Top 10 ITL2 regions by number of net zero sites**

ITL2 Region	No. of sites
Inner London - West	5,274
East Anglia	2,625
Berkshire, Buckinghamshire and Oxfordshire	2,505
Gloucestershire, Wiltshire and Bath/Bristol area	2,440
Inner London - East	2,178
Surrey, East and West Sussex	1,992
Eastern Scotland	1,939
Leicestershire, Rutland and Northamptonshire	1,710
Greater Manchester	1,603
West Central Scotland	1,358

Source: NPP analysis of The Data City Data

Table 8: Top 10 ITL2 regions by GVA from net zero sector

ITL2 Region	GVA (£m)
Inner London - West	5,706
Gloucestershire, Wiltshire and Bath/Bristol area	5,288
Berkshire, Buckinghamshire and Oxfordshire	4,913
East Anglia	2,710

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Greater Manchester	2,262
Surrey, East and West Sussex	2,015
Inner London - East	1,880
Northumberland, and Tyne and Wear	1,861
North Eastern Scotland	1,644
Hampshire and Isle of Wight	1,520

Source: NPP analysis of The Data City Data

Table 9: Top 10 ITL2 regions by number of employees in the net zero sector

ITL2 Region	Employees
Inner London - West	90,052
Gloucestershire, Wiltshire and Bath/Bristol area	52,749
Berkshire, Buckinghamshire and Oxfordshire	45,126
North Eastern Scotland	44,451
Inner London - East	37,747
Surrey, East and West Sussex	29,325
Cheshire	25,654
East Anglia	21,750
Greater Manchester	20,470
West Yorkshire	19,192

Source: NPP analysis of The Data City Data

Table 10: Top 10 ITL2 regions by GVA per job in the net zero sector

ITL2 Region	No. of sites	GVA per job (£)
Lincolnshire	246	131,144
North Yorkshire	409	130,143
East Anglia	1,376	113,553
Cornwall and Isles of Scilly	403	113,061
Kent	647	107,570
Gloucestershire, Wiltshire and Bath/Bristol area	1,221	106,693
Outer London - West and North West	526	106,417
Tees Valley and Durham	428	105,104
Leicestershire, Rutland and Northamptonshire	818	102,203
Northumberland, and Tyne and Wear	734	99,996

Source: NPP analysis of The Data City Data

While these insights provide us with an understanding of the locations of firms and the amounts of GVA and employment relative to each other and the national total, it does not provide us with an indicator of how important these companies and their locations are relative to each other and the national average/total, nor does it provide us with information about how important the net zero economy is to each local area. For example,

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while London takes the largest share of net zero GVA, it only makes up a small proportion of London's total GVA. Similarly, a place may not rank in the top 10 in terms of overall employment numbers, but that employment could be significant in the local area.

The tables below therefore provide another insight into the net zero economy of the UK by looking at net zero GVA as a proportion of total GVA and net zero employment as a proportion of total employment.

Table 11: Top 10 ITL2 regions for GVA from the net zero economy as a proportion of total GVA

ITL2 Region	Net Zero GVA as % of total
North Eastern Scotland	9.2%
Gloucestershire, Wiltshire and Bath/Bristol area	5.8%
Northumberland, and Tyne and Wear	5.1%
Cornwall and Isles of Scilly	4.5%
Berkshire, Buckinghamshire and Oxfordshire	4.2%
East Yorkshire and Northern Lincolnshire	4.1%
East Anglia	3.7%
Lincolnshire	3.3%
Tees Valley and Durham	3.2%
Dorset and Somerset	3.1%

Source: NPP analysis of The Data City Data

Reflecting on the overall proportion of the economy, the North East of Scotland has the highest proportion of net zero jobs as a proportion of its total employment base.

In terms of the North of England, we can see Northumberland and Tyne and Wear (a major centre for the offshore wind catapult in Blyth for example), followed by the Humber (East Yorkshire and Northern Lincolnshire; home to the Hull blade factory and Grimsby as a major support base for offshore wind) then Tees Valley and Durham.

Table 12: Top 10 ITL2 regions for employment from the net zero economy as a proportion of total employment

ITL2 Region	Net zero jobs as % of total
North Eastern Scotland	16.5%
Cheshire	4.8%
Inner London – West	4.1%
Gloucestershire, Wiltshire and Bath/Bristol area	3.9%
East Yorkshire and Northern Lincolnshire	3.6%

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Berkshire, Buckinghamshire and Oxfordshire	3.2%
Inner London - East	2.6%
Northumberland, and Tyne and Wear	2.6%
Surrey, East and West Sussex	2.1%
Cornwall and Isles of Scilly	2.0%

Source: NPP analysis of The Data City Data

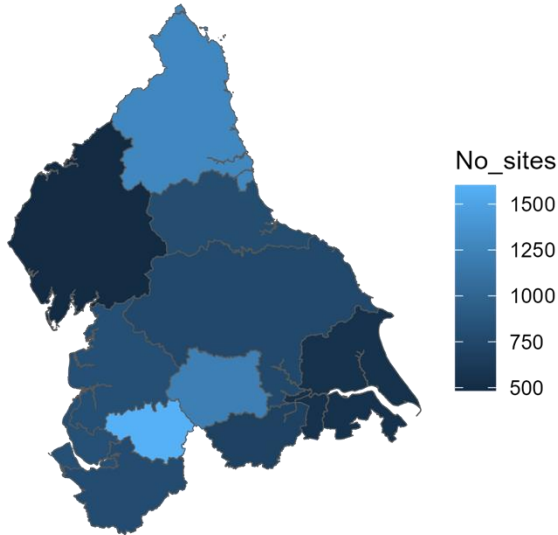
The significant importance of North East Scotland, with an institution that links it to Northumberland with the Offshore Wind Catapult, is a significant outlier position of strength. In the case of the North, Cheshire comes out next followed by the Humber then Northumberland and Tyne & Wear.

The reflection we can draw from these results is geographic concentration which makes the self-evident point that the net zero NPIER scenario will produce uneven results; some places will gain more, others may capitalise less. Next, we have looked at a more granular level within travel to work areas.

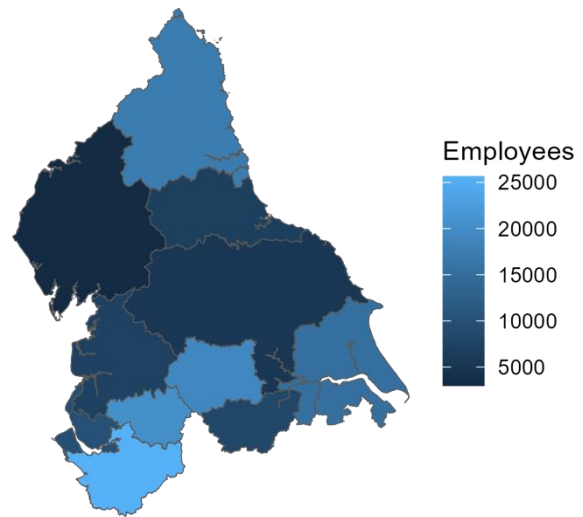
Net Zero in the North

Moving on to consider just net zero company sites based in the north of England, we now have 9,817 locations to analyse. Productivity within the North ranges from £130,000 in North Yorkshire to just £61,000 in West Yorkshire, a substantial variance within one industry and relatively localised geography.

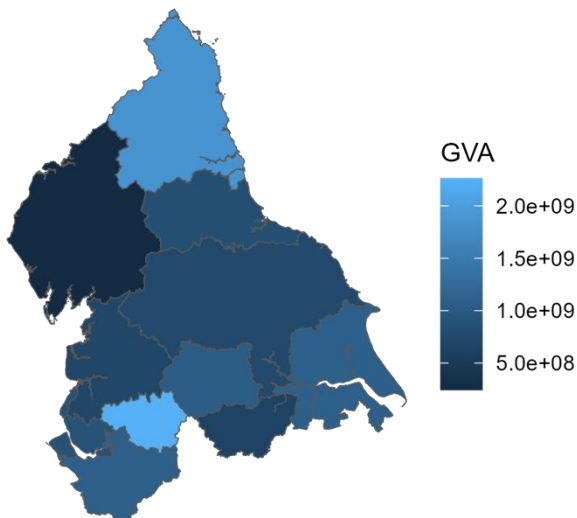
All sites of Net Zero companies



Number of employees by all sites of Net Zero companies



GVA of all sites of Net Zero companies



GVA per job of all sites of Net Zero companies

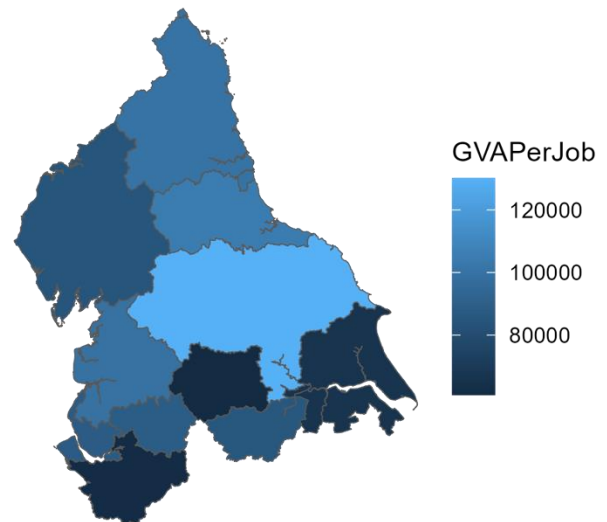


Table 13: Northern regions by GVA per job

ITL2 Region	GVA per job (£)	No. of sites	GVA (£m)	Employees	Innovate UK Funding (£m)	Dealroom Funding (£m)
North Yorkshire	130,143	756	759	5,514	46	32
Tees Valley and Durham	105,104	791	845	6,944	6	61
Northumberland, and Tyne and Wear	99,996	1,284	1,862	17,421	115	452
Lancashire	99,599	815	714	7,277	10	41
Greater Manchester	88,466	1,603	2,262	20,470	7	320
Merseyside	88,294	825	904	9,850	5	12
South Yorkshire	85,804	696	652	8,220	14	674
Cumbria	84,580	484	243	2,983	1	1
East Yorkshire and Northern Lincolnshire	66,218	548	1,093	15,298	41	62
Cheshire	61,577	790	1,097	25,654	7	45
West Yorkshire	60,907	1,225	1,051	19,192	4	514

Source: NPP analysis of The Data City Data

As with our national analysis, this again does not necessarily tell us the importance of the sector to these areas, so the table below looks again at GVA from net zero as a proportion of the total and net zero employment as a proportion of the total. The table is sorted by GVA as a proportion of the total.

On these measures we can see that GVA is more significant in Northumberland and Tyne and Wear and East Yorkshire and Northern Lincolnshire, both in the top 10 regions nationally. On employment, we see that Cheshire relies most heavily on the net zero sector, followed again by East Yorkshire and Northern Lincolnshire.

Table 14: Northern ITL2 regions GVA and jobs as a % of the regional economy

ITL2 Region	Net Zero GVA as % of total	Net zero jobs as % of total
Northumberland, and Tyne and Wear	5.1%	2.6%
East Yorkshire and Northern Lincolnshire	4.1%	3.6%
Tees Valley and Durham	3.2%	1.4%

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North Yorkshire	2.9%	1.3%
Cheshire	2.9%	4.8%
Greater Manchester	2.5%	1.4%
Merseyside	2.3%	1.4%
South Yorkshire	2.0%	1.4%
Cumbria	1.8%	1.2%
Lancashire	1.8%	1.1%
West Yorkshire	1.6%	1.7%

Source: NPP analysis of The Data City data

/06. Clusters in the Net Zero Economy

This section of the report will build on the economic landscape of the net zero economy previously set out and detail net zero hotspots along with clusters within several subsectors. Identifying differences between regions in terms of the presence of net zero clusters and the subsectors to which they belong can inform policy to ensure each place is engaging in smart specialisation within travel-to-work areas, developing specific expertise and excellence within broader capabilities which overall may represent pan Northern or pan UK capabilities. We will present the results from a hotspot analysis of the entire net zero economy, a clustering technique performed on specific subsectors and, interwoven throughout this, will be findings from a keyword analysis extracted from The Data City platform to reveal overrepresented technologies or processes occurring in specific areas. Firstly, the approach to clustering will be set out. You can find more details on this in Appendix A.

Three forms of analysis constitute our approach to gaining more granular insight into the net zero economy. Firstly, we conduct a hotspot analysis of the overall net zero economy using our custom net zero list. This method is most appropriate for the data due to it consisting of over 22,500 companies across 50,000 locations which renders methods such as HDBSCAN at risk of being inaccurate as it would struggle to distinguish between areas of different densities to break the clusters down. Therefore, this approach can provide a general understanding of which areas have a higher concentration of net zero companies. A hotspot analysis which follows the Getis-Ord-Gi approach checks the number of companies in a hexagon cell together with the number of companies in the neighbouring hexagon cells. Following this it compares the number of companies within these cells with a hypothetical random distribution which is essentially the number of companies we would expect to find in the cells if the location of companies was completely random¹. Therefore, if the number of companies in the cell is much greater than expected we would classify this as a hotspot. Conversely, if the number of companies in a cell is much lower than expected this would classify as a coldspot. Moreover, the hotspot classification is broken down by confidence levels with which we can make assertions regarding its statistical significance.

The second approach used to discern spatial clusters is Hierarchical Density-Based Spatial Clustering of Applications with Noise (HDBSCAN). It is a clustering algorithm which in this case identifies companies which are spatially close and have a high density whilst determining those that are isolated and therefore don't belong to a cluster. A key parameter of HDBSCAN is called `min_Pts`, it determines how densely points must be packed together to be considered part of the same cluster. The `min_Pts` chosen for each subsector will be denoted in the relevant section. More details on this method can be found in

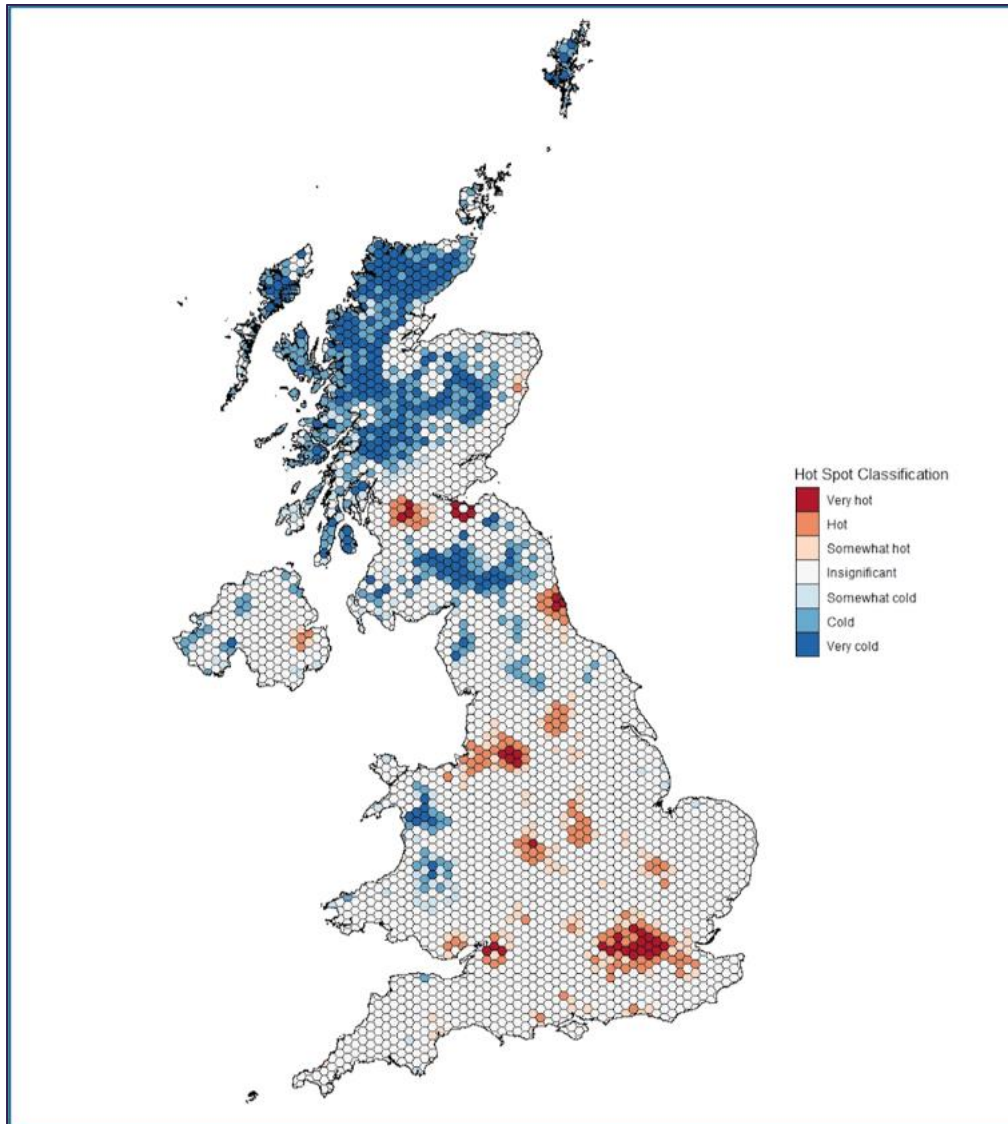
Classification - Public

Appendix A. We analysed several subsectors from the net zero economy: carbon capture, renewables, and building technologies. It must be noted that one limitation of HDBSCAN as pointed out in the Department for Science Technology and Innovation report²⁷ is that geographically separated areas may be identified as one cluster. This commonly happens with Northern Ireland. Moreover, a similar outcome may occur as it did in DSIT's paper that a large Northwest England cluster which spans cities such as Manchester and Liverpool are found. This however is an accurate reflection of the geospatial grouping of firms in that subsector. HDBSCAN is a powerful tool and context has been intertwined into the analysis to better contextualise its results.

Finally, on The Data City platform there is a tool to conduct a keyword analysis on specific locations and subsectors. This is useful to better explore what keywords are over-represented in a particular location or sector. This textual data can therefore indicate any dominant practices, technologies and or narratives across the companies in the specific list⁴. A keyword analysis of the northern regions has been conducted which will be presented separately and we have analysed specific clusters detected by the HDBSCAN the results of which will be intertwined into the latter's findings.

Overall, the aim of the methods is to identify groupings of companies operating in the net zero economy through statistical analysis. This means that large scale companies operating at a large scale in a location with an extensive supply chain may be overlooked in the analysis. To counteract this the report is substantiated by case studies and wider knowledge surrounding the net zero economy.

²⁷ Department for Science, Innovation and Technology (2024), Analytical Report Identifying and describing UK Innovation clusters

Figure 1: Hotspot Analysis of the Net Zero Economy

Source: Map produced by The Data City of all Net Zero Companies

Note: A 'Very hot' confidence level is 95%, 'Hot' is 90%, 'Somewhat hot' is 85% and vice versa for the coldspots. Each hexagon cell is 10km.

The map above represents the hotspots identified out of the entirety of the UK's net zero economy. If the number of companies in the cell is much greater than expected we would classify this as a hotspot. Conversely, if the number of companies in a cell is much lower than expected this is classified as a coldspot. There are 7 areas which have at least one 'very hot' hotspot. As one might expect, London has multiple hotspots and we can say with a 99% level of confidence that this is a statistically significant number of hotspots. However, this must be caveated with the fact that we believe some companies use a London address for their registered address, possibly their accountant or solicitor's address, without having a presence in the city themselves and this may have some effect on the confidence level and

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number of hotspots. Places including Manchester, Birmingham, Newcastle upon Tyne, Edinburgh and Glasgow all have an area which we are 99% confident has a statistically significant number of net zero companies. There are also several locations in the North with which we can be 95% confident that there is a statistically significant number of net zero companies such as Liverpool, Warrington, Leeds, and Sunderland. Interestingly, the geospatial distribution of firms between Liverpool and Manchester has been identified in the hotspot analysis. It should be noted that this analysis highlights where the SMEs and concentration of businesses are rather than specific clusters or places where the primes set out in the NPIER are located. The Humber hasn't been identified as a hotspot when looking at all net zero companies. However, it proves to have a cluster when looking at renewable energy. Given the Humber's renewable offshore wind capabilities which are predominantly forged by Siemens Energy and Ørsted it is unsurprising that it is home to a renewable energy cluster.

Keyword analysis findings

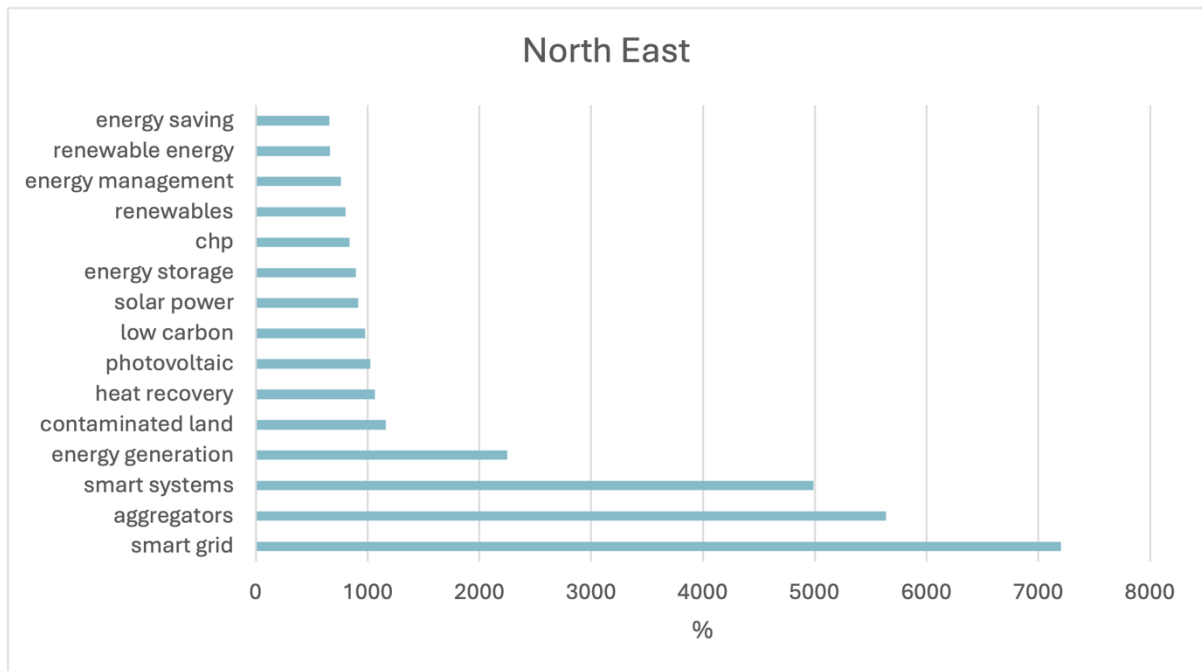
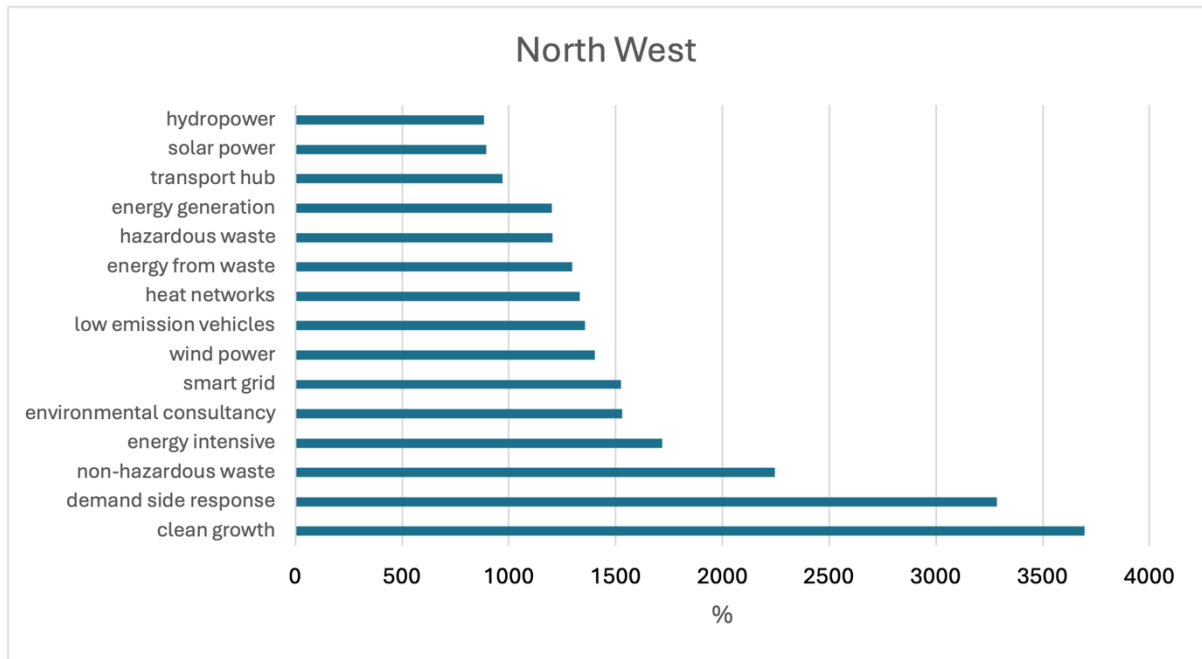
Companies in the North West are significantly more likely to use the phrase 'clean growth' and 'demand size response' compared to the average UK company, being 3697 and 3286 times more likely, respectively. Notably, the North West stands out as the sole region among the three to have 'environmental consultancy' as an overrepresented phrase, ranking fifth on the list with companies being 1532 times more likely to use it.

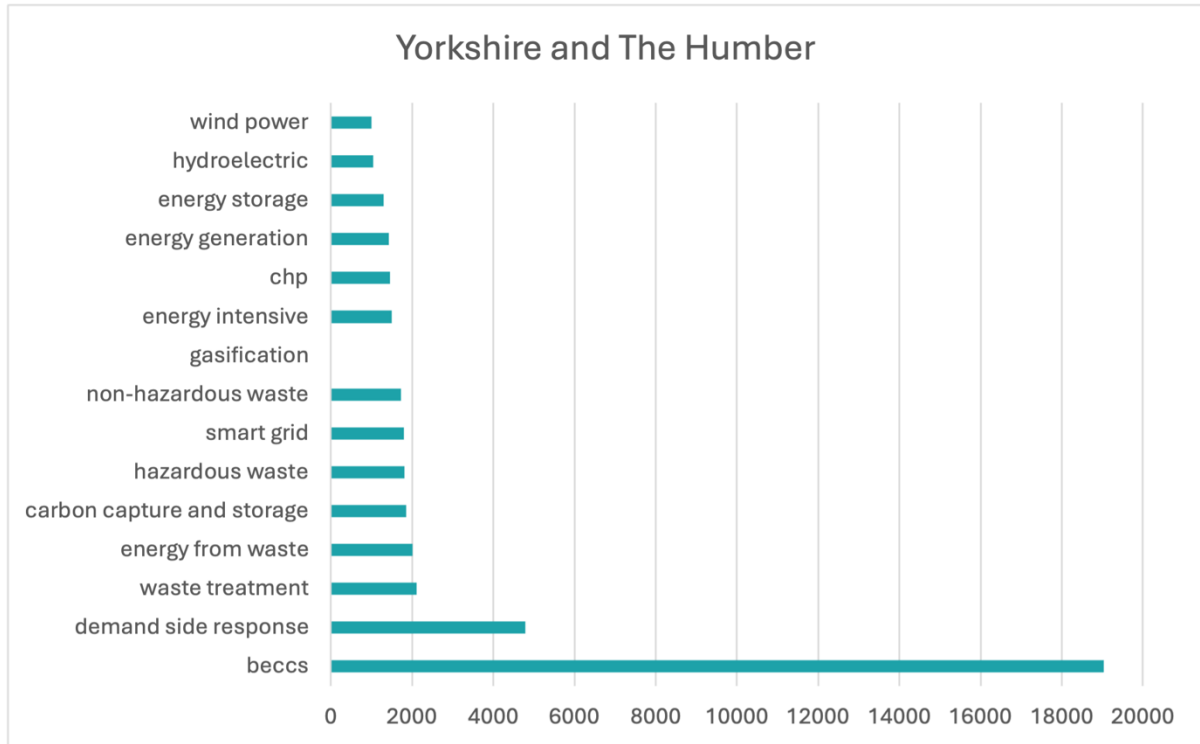
In the North East, the phrase 'smart grid' is notably overrepresented, with companies here being 7201 times more likely to use it than the average UK company. This corresponds with previous research highlighting the potential for smart grid technology as a growth opportunity in the North East.²⁸ Additionally, terms such as aggregators, smart systems, and energy generation are also significantly overrepresented, aligning with existing evidence on the region's industry specialization in Electrical Equipment manufacturing.

In Yorkshire and The Humber, 'bioenergy with carbon capture and storage' (BECCS) is substantially more prevalent, being 19035 times more likely to be used than the average UK company. This aligns with the presence of companies like Drax, engaged in creating large-scale carbon removal projects, and the associated supply chain activities in the region.

²⁸ North East Evidence Hub – Emerging Markets Evidence Base <https://evidencehub.northeast-ca.gov.uk/spotlight-analysis/emergent-markets/emergent-markets-smart-grids>

Figure 2: Keyword Analysis of the net zero companies in the North





Clustering Results for Net Zero Subsectors

Results from the HDBSCAN clustering algorithm are presented in this section. The sectors explored were Building Technologies, Carbon Capture, and renewables. We will briefly define what these sectors entail using the taxonomy created by The Data City and CBI Economics earlier this year.²⁹ Firstly, Building Technologies is defined as companies providing technology and services for increased energy efficiency in buildings. Carbon Capture includes companies dedicated to carbon capture, storage, and utilisation. Finally, renewables relate to companies providing energy from renewable sources. Details on the parameters of the HDBSCANs can be found in the appendix at the end of the report.

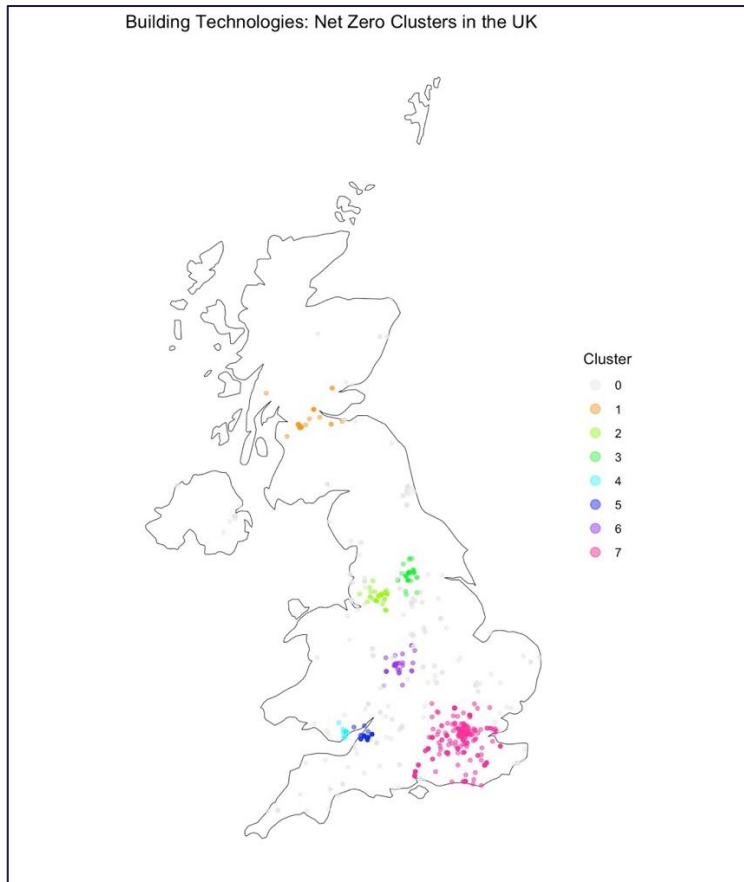
For ease of understanding the presentation of the maps will be briefly explained:

- Each dot represents the location of a registered or operating address of a company. The transparency of the dots is impacted by the density of companies in the same location.
- Each colour represents a unique cluster a company location it has been assigned to. The varying cluster numbers merely acts as labels; they don't have a quantitative value.

²⁹ Energy & Climate Intelligence Unit (2023), The UK's net zero economy

- The grey dots represent companies in cluster 0 which are companies considered as noise or those that don't belong to a cluster.

Figure 3 Building Technologies Clusters



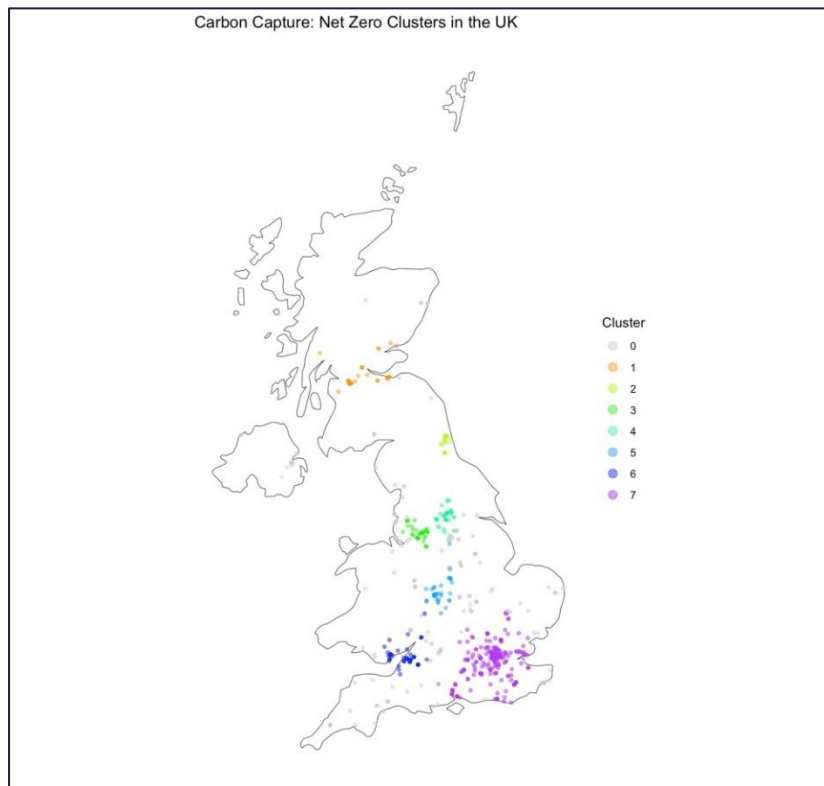
Source: NPP analysis of The Data City Data

In total, there are 486 companies in the Building Technologies subsector of net zero with 1076 sites across the UK. Given the relatively low number of companies within this sector the number of companies required in a spatial location to be classified as a cluster is 30. Under these parameters, there are seven clusters across the UK two of which are in the UK. There is a clear distinction between a cluster in Leeds and Manchester. Building Technology companies in Manchester are 358 times more likely to use the keyword solar than the average UK company, whilst those in Leeds are 1523 times more likely to use the key phrase low carbon. It is apparent that the North West England effect is slightly at play in Cluster 4. Moreover, when one considers the London cluster this is likely influenced by the head office effect and the algorithm hasn't been able to distinguish between areas such as Oxford, Reading, and London. The results of the keyword analysis for building technology companies in London demonstrated that they are 12,934 times more likely to use the phrase green bonds. Furthermore, given London's economic constitution, it is often inaccurate to use it

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as a benchmark for other English regions. Accounting for this, the fact that the North West and Yorkshire both have a building technology is impressive, given that the other UK/English regions tend to have either one or no clusters. At a broader level, when assessing key phrases for this sector these companies are 13,815 times more likely to use the phrase hydroelectricity and 12,459 times more likely to use the phrase heat networks which alludes to some of the dominant practices occurring in this subsector.

Figure 4 Carbon Capture Spatial Clusters



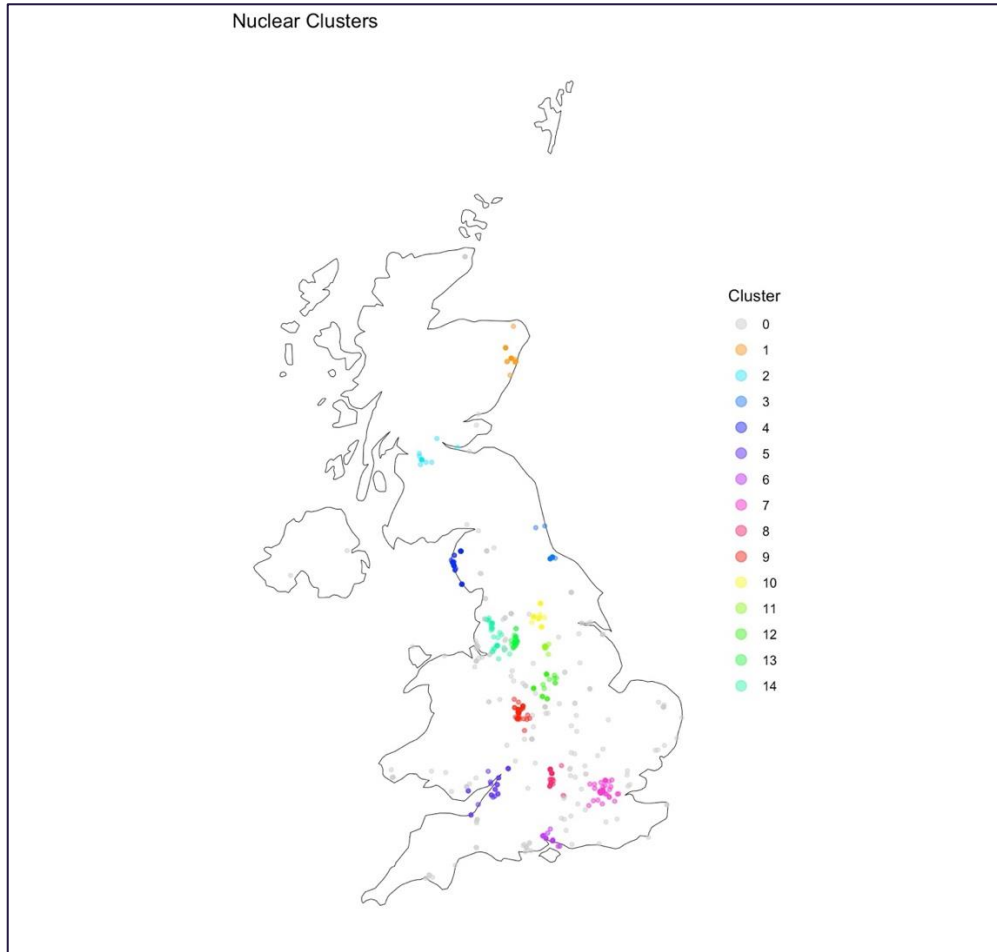
Source: NPP analysis of The Data City Data

The Carbon Capture subsector of the net zero economy consists of 192 companies, which span 278 sites in the UK. For a group of companies to qualify as a cluster the parameter has been set to 7. In total, 7 clusters were identified by the algorithm three of which are based in the North in the Manchester area, Leeds area and Newcastle upon Tyne. Despite these clusters spanning a larger geographical area, it has successfully picked up on clusters we'd expect to see. For example, the broad Leeds area cluster covers Selby which is home to Drax Power Station whereby Carbon Capture is a core part of their technologies. Moreover, the London cluster is a significant cluster however this is likely due to the head office effect and should be assessed cautiously. The cluster in London and Scotland is emblematic of the limitation of HDBSCAN in that geographically separate places may be placed in a cluster

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along with that of the one around Gloucester and Bath. However, this indicates that the clusters in the North of England are particularly distinct.

Figure 5 Nuclear Clusters



Source: NPP analysis of The Data City Data

The Nuclear subsector of the net zero economy includes both nuclear energy generation and nuclear fusion. It consists of 316 companies spread across 673 sites. For this analysis, the cluster requirement was set to 14. This produced 14 clusters, it identified 6 of these clusters in the North. The clusters are located in Manchester, Leeds, Warrington/North West area, Sheffield, Middlesbrough and Cumbria. A cluster of particular interest is Cumbria, which is home to the likes of Sellafield, the National Nuclear Laboratory, and Calder Hall Power Station. This cluster is more dispersed but given the rural geography of Cumbria it clearly illustrates a strong nuclear capability. The sector keyword enrichment found that net zero nuclear companies are 2949 times more likely to use the word nuclear

than the average UK company. The North West, which is home to over 35% of the nuclear workforce nationally and employs 27,000 people,³⁰ has 2 clusters.

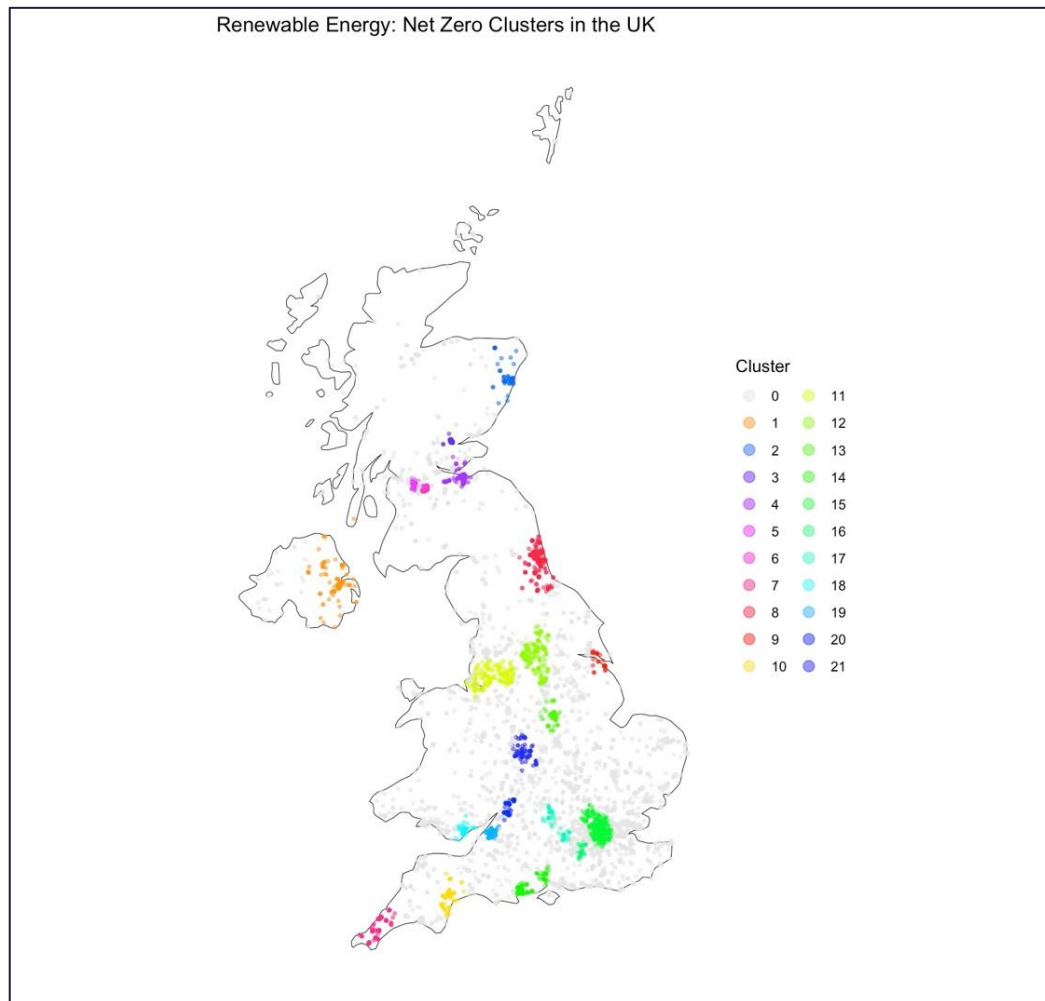
Small Modular Reactors (SMRs)

Within the Net Zero economy there are specialist supply chains, particularly in manufacturing, which do require specialist capabilities.

Rolls Royce SMR have invested in innovation capability including at the AMRC in Sheffield to do the work now to support them to get to point of starting to build their reactors in a factory environment before deploying them on site.

There are also existing supply chain assets for similar capabilities, including Sheffield Forgemasters, in the city. This gives South Yorkshire a significant head start in attracting the future supply chains in SMR and demonstrates that many capabilities in Net Zero related opportunities are existing parts of the advanced manufacturing prime capability.

³⁰ Net Zero North West https://api.netzeronw.co.uk/uploads/manifesto_e4d6d5143e.pdf

Figure 6 Renewables Spatial Clusters

Source: NPP analysis of The Data City Data

Renewable energy is one of the biggest subsectors of the net zero economy. In total, there are 5,905 companies across 10,291 sites. The prevalence of the renewable energy sector is illustrated by the plethora of grey dots on the map. Given the scale of this subsector, to determine a cluster there must be 80 or more companies which are spatially co-located. Under this parameter, 21 clusters were identified using HDBSCAN. Evidently, this sector is distributed more sporadically than others with both the North East and The Humber hosting their own cluster. In total, the North has 4 distinct clusters with the cluster surrounding Leeds likely including companies in Sheffield. In the North East, Sunderland and Newcastle upon Tyne constitute a cluster. A keyword analysis revealed that renewable companies in Sunderland are 5,922 and 4,616 times more likely to use the phrase energy generation and solar power than the average company. For Newcastle upon Tyne, the most overrepresented phrase is energy storage, which is 5,502 times more likely. In Yorkshire, the overrepresented phrases in the Leeds/Sheffield cluster were bioenergy with carbon capture

Classification - Public

and storage at 79,837 times more likely, and more specifically, for Sheffield combined heat power, it was 8,356 times more likely to be used than the average UK company. Moving over to the North West cluster, which has previously been identified in the analysis, it is one of the more substantially sized clusters of the UK. It is useful to pinpoint locations within this cluster and undertake a keyword analysis to understand what it consists of. For Manchester City, companies are over 24,000 and 8,000 times more likely to use the phrase clean growth and transport hub, a similar case in Trafford. For Liverpool, the Wirral and St. Helens companies here were 2,184 times more likely to use the phrase photovoltaic. There are considerable number of renewables clusters in the South of England spanning the likes of London, Oxford, Bristol, Bournemouth, and Cornwall. In terms of keywords analysed a lot of these places were overrepresented in clean energy and energy generation. Companies in Southampton however were 83,000 and 10,700 times more likely to use the phrase bio energy and pollution control. More widely, for the renewables subsector the graph below depicts the overrepresented words and phrases.

/07. The Carbon-Intensive Sector

This section will explore the size and scale of carbon-intensive industries across the UK, with a detailed focus on the North. Capitalising on the transition to net zero offers an abundance of economic and employment opportunities. However, economic activity and employment is potentially at risk should the transition to net zero result in a displacement from those areas currently reliant on carbon-intensive industries. Our main data source for this section is again The Data City. However, there is not an applicable RTIC which covers all types of carbon-intensive industries. Therefore, we used the AI-powered 'list' tool provided by The Data City, to produce a custom list of carbon-intensive companies (more details on the process and content of the list are in Annex A). The industries included in this list are mainly fossil-fuel generated energy companies and manufacturing companies. Most of the companies which were manually removed from the net zero RTIC, are included in this list. In order to generate this list, firstly, we provided approximately 10 companies which we were certain should be included. The industries of which these companies came from were varied which was important as once this list was inputted, AI was used to expand the list further, adding companies similar to the original list. Due to the nature of this process, some irrelevant companies were included to begin with, however, after removing those and regenerating the list multiple times, a final list was established. As explained in the previous chapter, we can choose to look at only a company's registered address or also its trading addresses. Due to the same data issues as the net zero section, we have again only presented data based on known addresses for each company.

The final list of carbon-intensive companies came to an estimated total of approximately 2,000 registered limited companies, contributing more than £15.7 billion of GVA to the UK economy and supporting over 350,000 jobs. This results in an average of just over £44,000 GVA per job in the carbon-intensive economy (based on the companies for which provided both GVA and employee data).

Table 15: Carbon Intensive Sector Headline Figures

Metric	Value
Total Turnover (£m)	863,079
Total Employees	350,826
Total Companies	1,996
Total GVA (£m)	15,705
Innovate UK funding (£m)	52
Dealroom funding (£)	4,033

Source: NPP analysis of The Data City Data

Classification - Public

For this section of the analysis, the figures for each company were divided equally between the number of sites under their operation. Although we cannot be certain that the outputs of companies are shared equally across every operational site, this is the most precise method that we can use without access to individual site data.

Consequently, we can now assess 7,161 sites from 1,996 companies, 7,103 of which can be allocated to a UK region. London & South East have the largest share of the total carbon-intensive company sites with 39.2% and 35.8% of the workforce, however, there is a more even balance across the rest of the country's regions. The North holds the next largest share of sites with a 17.8% of the total and 12.1% of the workforce.

When looking at the two funding sources that we have assessed, London & South East receive the highest share of Innovate UK funding at 38.8% of the total. However, this region has a much lower proportion of Private Investment raised (8.3%) whereas the Rest of England boast an 86.1% share of the total.

Table 16: Headline figures of the Carbon Intensive Sector

Region	No. Sites	GVA (£m)	Turnover (£m)	Employees	Innovate UK Funding (£m)	Private Investment raised (£m)
London & South East (England)	2,782	5,736	438,956	125,558	20.1	315.8
Midlands (England)	920	1,458	61,316	44,425	5.4	2.9
North (England)	1,262	3,247	85,552	42,305	12.5	209.8
Northern Ireland	58	372	12,559	10,151	1.2	0
Rest of England	839	2,762	74,295	58,587	6.4	3,283
Scotland	973	1,111	96,882	22,454	2.2	220.1
Wales	269	969	30,793	46,818	4.0	0.8
Total	7,103	15,654	800,353	350,297	51.8	4,033

Source: NPP analysis of The Data City Data

Table 17: ITL1 Regions % share of key metrics

Region	No. Sites (%)	GVA (%)	Turnover (%)	Employees (%)	Innovate UK Funding (%)	Private Investment raised (%)
London & South East (England)	39.2	36.6	54.8	35.8	38.8	7.8
Midlands (England)	13.0	9.3	7.7	12.7	10.4	0.1

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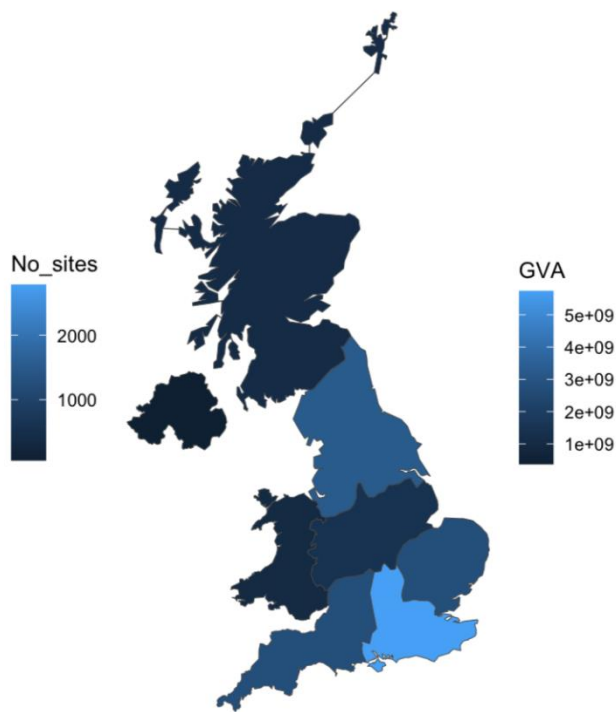
North (England)	17.8	20.7	10.7	12.1	24.2	5.2
Northern Ireland	0.8	2.4	1.6	2.9	2.2	0.0
Rest of England	11.8	17.6	9.3	16.7	12.3	81.4
Scotland	13.7	7.1	12.1	6.4	4.3	5.5
Wales	3.8	6.2	3.8	13.4	7.7	0.0
Total	100	100	100	100	100	100

Source: NPP analysis of The Data City Data

All sites of Carbon-Intensive companies



GVA by all sites of Carbon-Intensive companies



Number of employees by all sites of Carbon-Intensive companies



Moving on to productivity, 51% (3616) of all sites used in the tables above had available GVA and employee data and could be assigned to a UK region, therefore could be assessed on productivity within their region. Wales tops the list as most productive in the carbon-intensive industries with £79,000 GVA per job despite having a lower proportion of the total carbon-intensive GVA (6.2%). The next most productive is the North, although fairly lower, with just under £70,000 GVA per job. This figure is significantly higher than the average Northern productivity rate (£47,000) set out in the NPIER and higher than the productivity rate of the rest of England (excluding London) (£51,900), also. Surprisingly, London and the South East are on the lower end of the spectrum with just under £50,000 GVA per job in carbon-intensive industries despite holding a 36.6% share of the total GVA.

Table 18: Number of sites and GVA per job (£) by ITL1 region

Region	No. sites	GVA per Job (£)
London & South East	1,058	49,874
Midlands	626	68,989
Northern Powerhouse	700	69,662
Northern Ireland	41	32,833
Rest of England	599	48,641

Classification - Public

Scotland	367	53,739
Wales	225	79,007
Total	3,616	

Source: NPP analysis of The Data City Data

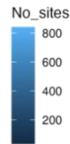
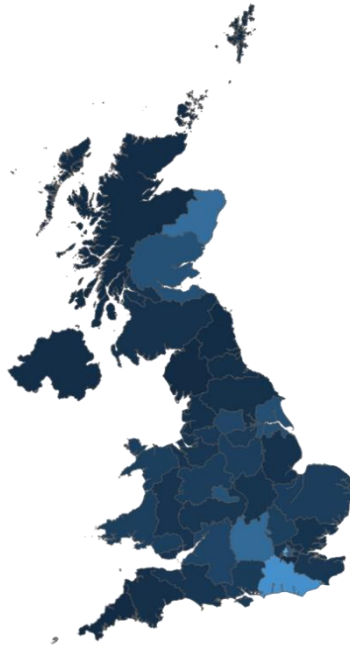
The same analysis can be conducted at ITL2 geography; however, this is more easily visualised in the maps below. When looking at the number of sites operated by a carbon-intensive company, the previously found trends are followed mostly with ITL2 areas in London & South East, highlighting for having high numbers. However, areas of Scotland such as North Eastern Scotland are also highlighted, which illustrates a high prevalence of these companies here despite that not being immediately apparent from national figures. The GVA by carbon-intensive companies in certain areas follows this trend fairly closely with areas of London & South East being highlighted once again. More specifically, Inner London – West and Bedfordshire and Hertfordshire appear to generate the most GVA. However, Greater Manchester, East Wales, and South Yorkshire are also spotlighted in this variable.

Despite Inner London continuing to lead across most variables, employee data also turns our attention to West Wales and The Valleys, and East Wales. Both have some of the highest employee numbers of carbon-intensive sites which is interesting because Wales also has the highest productivity rates in the UK, as noted previously. Therefore, this suggests a highly productive carbon-intensive industry here which could transform the national net zero economy if a transition were to take place.

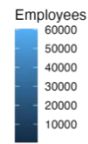
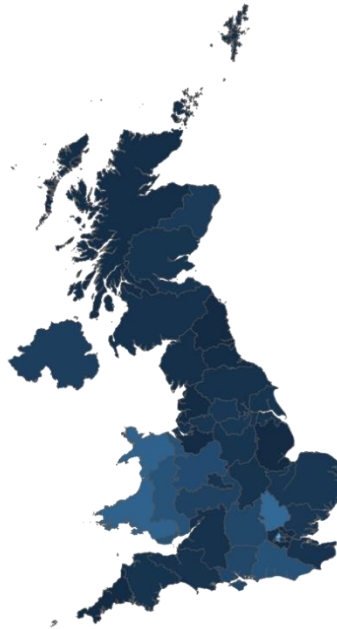
As suggested by the mega-region analysis, ITL2 regions in London & South East are not as highly regarded in terms of GVA per job. There is, in fact, a much more even spread across the country in this variable with Lincolnshire, Cheshire, and Northumberland and Tyne & Wear having the highest productivity rates.

Overall, Inner London ITL2 regions are the highest performing in most single variables and, therefore, should be a target area for facilitating a net zero transition. This is more significant because of the head office effect which is likely at play here. The industrial practices which are carbon-intensive more likely be taking place outside of the city centre, the head offices will be based in Inner London. Therefore, the decisions made in the Inner London sites will have an impact on sites across the whole country.

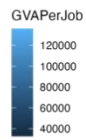
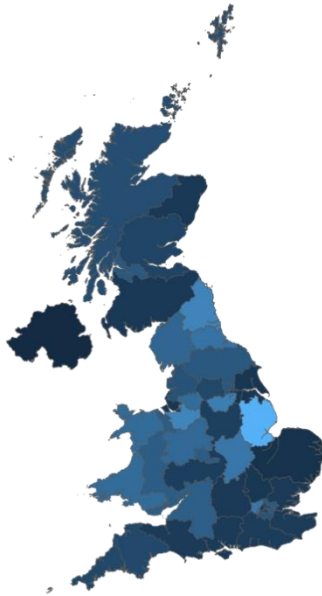
All sites of Carbon-Intensive companies



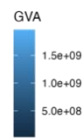
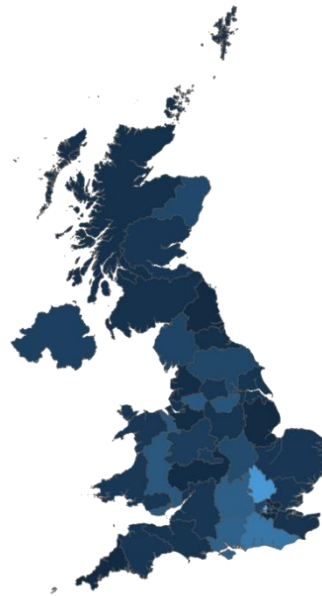
Number of employees by all sites of Carbon-Intensive companies



GVA per job of all sites of Carbon-Intensive companies



GVA by all sites of Carbon Intensive companies



Classification - Public

Table 19: Top 10 ITL2 regions by GVA per Job

ITL2 Regions	No. Sites	GVA per Job (£)
Lincolnshire	45	135,897
Cheshire	46	104,258
Northumberland, and Tyne and Wear	41	104,002
South Yorkshire	101	99,247
Outer London - West and North West	80	94,969
Leicestershire, Rutland and Northamptonshire	78	94,370
Tees Valley and Durham	49	91,392
Greater Manchester	97	86,081
West Wales and The Valleys	153	85,679
Shropshire and Staffordshire	106	83,803

Source: NPP analysis of The Data City Data

Table 20: Top 10 ITL2 regions by number of sites

ITL2 Regions	No. Sites
Inner London - West	841
Surrey, East and West Sussex	658
North Eastern Scotland	460
Berkshire, Buckinghamshire and Oxfordshire	444
Inner London - East	330
West Midlands	299
Eastern Scotland	281
East Yorkshire and Northern Lincolnshire	270
West Yorkshire	215
Gloucestershire, Wiltshire and Bath/Bristol area	201

Source: NPP analysis of The Data City Data

Table 21: Top 10 ITL2 regions by GVA

ITL2 Regions	GVA (£m)
Inner London - West	1,962
Bedfordshire and Hertfordshire	1,613
Surrey, East and West Sussex	1,157

Classification - Public

Hampshire and Isle of Wight	868
Berkshire, Buckinghamshire and Oxfordshire	827
Greater Manchester	732
East Wales	729
South Yorkshire	693
Leicestershire, Rutland and Northamptonshire	529
North Eastern Scotland	484

Source: NPP analysis of The Data City Data

Table 22: Top 10 ITL2 regions by number of employees

ITL2 Regions	Employees
Inner London - West	60,320
Bedfordshire and Hertfordshire	30,039
West Wales and The Valleys	27,027
East Wales	19,791
Surrey, East and West Sussex	19,517
Shropshire and Staffordshire	16,355
Hampshire and Isle of Wight	14,421
Berkshire, Buckinghamshire and Oxfordshire	14,408
Herefordshire, Worcestershire and Warwickshire	12,088
Northern Ireland	10,151

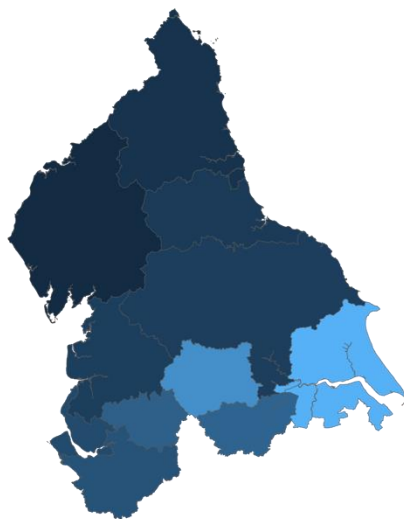
Source: NPP analysis of The Data City Data

Focusing specifically on the North of England, data is available for 1,262 operational sites. For local authorities in the North, on average, there are approximately 20 carbon-intensive sites, with the highest number in the East Riding of Yorkshire (199). Across the North, each ITL2 region has a high proportion of either productivity, number of sites, or employee counts. For instance, whilst Cheshire does not outperform its counterparts across the aforementioned factors, it is the most highly productive ITL2 region in the North. Additionally, whilst East Yorkshire has the highest number of sites, it does not have comparatively high employee, GVA and productivity levels. Therefore, there is not a uniform trend in the North of high GVA or high employee counts across companies. A notable trend across companies was the spatial distribution of companies. Most companies in the carbon intensive industries are located in industrial areas. To analyse productivity, we analysed GVA and employee data which was available for 700 sites (55% of all sites). Across the region's carbon intensive industry, there are generally high productivity rates with the highest at £104,000 GVA per job in Cheshire and lowest at just under £43,000 GVA per job in East Yorkshire. Overall, the average productivity rate is £108,000 GVA per job across the North.

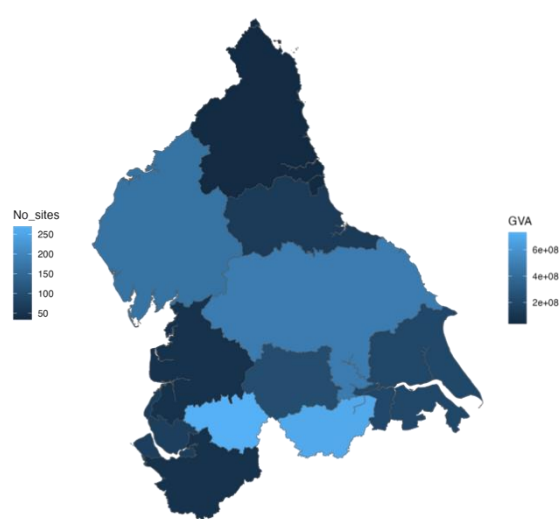
Classification - Public

Therefore, the carbon intensive industry in the North represents a positive challenge and opportunity for the North's transition. Moreover, most carbon intensive companies being located in the industrial heartlands of the North speaks to the importance of ensuring places with a sizeable carbon intensive industry aren't left behind in the transition to net zero. Its scale is substantial, and the importance of including and adapting this sector shouldn't be understated.

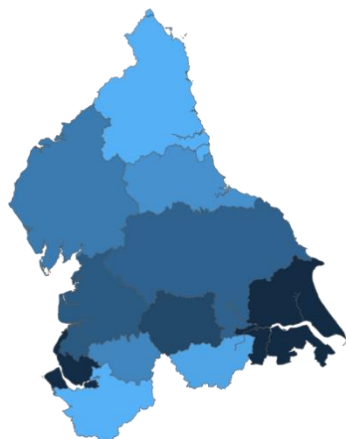
All sites of
Carbon-Intensive companies



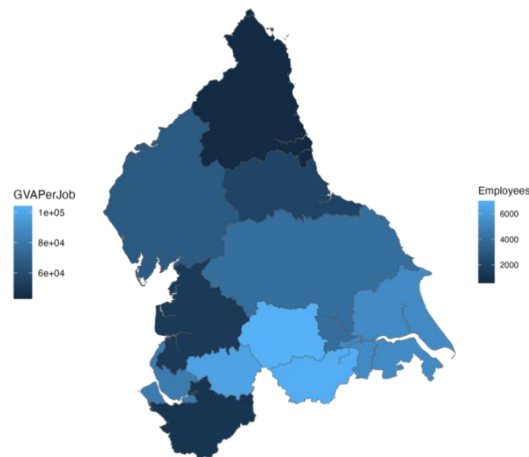
GVA of all sites
of Carbon-Intensive companies



GVA per job of all sites
of Carbon-Intensive companies



Number of employees by all
sites of Carbon-Intensive companies



Classification - Public

/08. Net Zero in the North; Recommendations

Support the transition of workers in carbon intensive sectors related to our prime economic capabilities, largely in energy, to new green jobs. Whether it be oil refineries such as the Phillips 66 Humber facility or Stanlow in Ellesmere Port, or the former coal-fired power station at Drax in Selby, we need to secure jobs for workers at these facilities. The workforce at these sites faces real risks if we do not have a credible plan for their future.

Put an end to deindustrialisation and the offshoring of emissions to reach net zero targets artificially. The UK must cut our emissions without exporting manufacturing and carbon intensive jobs. Decarbonising the end product would allow us to keep jobs in the steel industry and other sectors.

Commit to large-scale expansion of our nuclear capabilities. The North has a strong nuclear heritage in West Cumbria and in Warrington at Birchwood. Sellafield in Cumbria, previously home to Calder Hall and the Windscale plants before their closure, is of the generation of energy without carbon emissions.

Unleash private sector investment by maximising the potential of catalytic public funding. Our asks of government, of our Metro Mayors and of industry are designed to unlock private investment, including from the insurance sector underpinned by Treasury guarantees issued by the UK Infrastructure Bank. This would generate tax revenues which could be re-invested, securing additional growth - and even higher Treasury revenue – in the long-term. We would call upon the Office for Budget Responsibility (OBR), with the support of the National Infrastructure Commission, to calculate the benefits of these decisions for the nation's finances over future decades.

Energy Propositions

The NPIER highlights that for the UK to reach its 2050 decarbonisation goals, renewable energy sources will need to constitute a much larger share of the energy mix than now. The North will require significant investment across a range of sectors to achieve this. It is expected that around 50% of the £500 million investment required in new offshore wind and nuclear capacity will be located in the North. However, the location of the facilities themselves is less important than that of the associated manufacturing supply chains.

Our recommendations:

- a) **Complete procurement by Great British Nuclear from two separate businesses of three small modular reactors (SMRs) each**, unlocking a significant export opportunity and bolstering our energy security. Due to previous delays in making these decisions, the costs for these SMRs will fall in future Comprehensive Spending Review periods and so there is no unplanned requirement for budgeting for this expenditure in this current Parliament.

The North is already benefitting from the growth of the nuclear supply chain, including Sheffield Forgemasters and Rolls-Royce SMR headquarters in Manchester. There are many ways to generate net zero electricity, not least through interconnectors supplying nuclear power from overseas markets, but these do not produce high quality jobs in the North as SMRs will do. Carbon has been offshored for the last decade with the consequential loss of manufacturing – we have an opportunity with SMRs to re-build our manufacturing heritage through the building of low carbon infrastructure.

- b) **Develop our wind capabilities from the North East down to the Humber.** Building on the success of the turbine blade factory in Hull we should now look to make even larger components for the offshore sector, while growing Greenport 2 with initial funding in the Hull and East Yorkshire devolution deal. We can re-allocate under-spends from previous competitive funding rounds for offshore wind infrastructure to fill the current funding gap.
- c) **Invest in a turbine supply chain for the tidal barrage on the Mersey**, which should be a development priority both within the city region and across the North.

Industry

- a) **Continue to make huge strides in carbon capture use and storage (CCUS)** as part of the wider push towards industrial decarbonisation. From the Mersey to Teesside, we have seen the development of successful clusters here in the North of England but are still awaiting the final go ahead for Track 1 deployment. This is whilst the Humber - the UK's largest industrial cluster, with major emitters from Selby through to Immingham - is awaiting key decisions on the deployment of the Track-2 cluster. A decision with accelerated consenting and powers to put pipes in the ground with GB Energy will unlock £15 billion of private investment from Drax, CO2 brought by vessel, Phillips 66 and other businesses working in partnership with Viking alongside a Track 1 extension as an option.
- b) **Expand green hydrogen production, storage and distribution** to ensure the maximum opportunities for industrial decarbonisation are achieved. This should be

through specifically targeted support to develop long-term sustainable business models.

Transport

- a) **Turn the North into a centre for the production of Sustainable Aviation Fuel (SAF)**, supporting jobs for those who work in refineries producing jet fuel today, and ensuring that - as production capability develops globally - the UK aviation sector is able to decarbonise at pace. As local authorities review their arrangements for waste disposal, they have the choice to ensure that the North can provide feedstocks for new SAF plants. The Government's commitment to this sector, evidenced by the Sustainable Aviation Fuel Bill announced in the King's Speech, is welcome.
- b) **Deliver a consistent programme of rail electrification.** Extending the TransPennine Route Upgrade to include Hull to Selby is a way to create further scale in the North's electrification portfolio, as well as delivering a key element of the Northern Powerhouse Rail portfolio. Supply chains can then plan for growth and deliver the necessary capacity based on this programme of work.
- c) **We make the UK a leader in building battery and hydrogen trains** through our world-class train factories in Goole and in Newton Aycliffe, alongside their supply chains, making the former a centre for innovation with a facility to bring R&D activity there and the latter delivering the all-electric HS2 fleet.
- d) **Guarantee the supply of hydrogen for commercial vehicles such as buses**, provided by East Bradford Hygen and N-Gen facility
- e) **Increase procurement of electric and hydrogen buses across areas with franchising**, supporting the ability of Northern suppliers and those across the wider UK to produce buses at scale.

Built Environment

The UK has an ageing building stock which represents a substantial change for energy efficiency. There are several measures proposed by the Net Zero Strategy to decarbonise the building stock and heating systems.

- a) **Deliver retrofit of domestic and commercial buildings at pace, and with the necessary funding and skills support**, including a 75% reduction in public buildings emissions by 2037, whilst securing a UK and Northern supply chain for heat pumps, insulation and other technologies. If this is delivered in conjunction with energy

companies, households can pay via their bills (rather than through a traditional loan set up) which increases eligibility and affordability.

Land Use

Land use will need to shift to favour low-carbon agriculture which will require investment in agriculture and forestry sectors. We need to deliver substantial decarbonisation of agriculture, with a tripling of tree planting rates to 30,000 hectares per year by 2035 and the restoration of at least 25,000 hectares of peatlands by 2035.

- a) **Back propositions including the Northern Forest**, which seeks to deliver 50 million extra trees, leveraging private investment through public backing.

/A. Appendix

Net zero list of companies

This list was created using The Data City's Machine Learning list function. Directly from Data City website: "They are built by first defining a training set of companies that are examples of the industry vertical you wish to investigate. Companies are ranked by how representative they are of the companies selected in the training set."

We inputted a lot of the net zero RTIC companies into this list and removed ones we felt didn't wholly represent net zero such as ESSO, BP and ExxonMobil along with their subsidiaries. Many of these companies were then placed into a Carbon Intensive list. Given the number of companies in the net zero Economy it wasn't viable to go through each one individually to ensure we felt they belonged in the net zero category. Instead, we ordered the list in descending order by turnover to ensure big companies, which would likely skew the data, were net zero companies and if they weren't we removed them from the list.

Hotspot Analysis

We conducted a hotspot analysis of the overall net zero Economy using our custom net zero list. This method is most appropriate for the data due to it consisting of over 22,500 companies across 50,000 locations which renders methods such as HDBSCAN at risk of being inaccurate as it would struggle to distinguish between areas of different densities to break the clusters down. Therefore, this approach can provide a general understanding of which areas have a higher concentration of net zero companies. A hotspot analysis which follows the Getis-Ord-Gi approach³¹ checks the number of companies in a hexagon cell together with the number of companies in the neighbouring hexagon cells. Following this it compares the number of companies within these cells with a hypothetical random distribution which is essentially the number of companies we would expect to find in the cells if the location of companies was completely random. Therefore, if the number of companies in the cell is much greater than expected we would classify this as a hotspot. Conversely, if the number of companies in a cell is much lower than expected this would classify as a coldspot. Moreover, the hotspot classification is broken down by confidence levels with which we can make assertions regarding its statistical significance.

Hierarchical Density-Based Spatial Clustering - HDBSCAN

³¹ Esri, How hotspot analysis (Getis-ord Gi*) works <https://pro.arcgis.com/en/pro-app/3.1/tool-reference/spatial-statistics/h-how-hot-spot-analysis-getis-ord-gi-spatial-stati.htm>

To discern spatial clusters, we utilised Hierarchical Density-Based Spatial Clustering of Applications with Noise (HDBSCAN). It is a clustering algorithm which in this case identifies companies which are spatially close and have a high density whilst determining those that are isolated and therefore don't belong to a cluster. A key parameter of HDBSCAN is called `min_Pts`, it determines how densely points must be packed together to be considered part of the same cluster. The `min_Pts` chosen for each subsector will be denoted in the relevant section. We analysed several subsectors from the net zero economy: carbon capture, renewables, building technologies and nuclear clusters. It must be noted that one limitation of HDBSCAN as pointed out in the DSIT report³² is that geographically separated areas may be identified as one cluster. This commonly happens with Northern Ireland. Moreover, a similar outcome may occur as it did in DSIT's paper that a large Northwest England cluster which spans cities such as Manchester and Liverpool are found. This however is an accurate reflection of the geospatial grouping of firms in that subsector.

Cluster	No of Company Sites	Min_Pts	Number of clusters
Building Technologies	1076	30	7
Carbon Capture	278	7	7
Renewable Energy	10291	80	21
Nuclear	673	14	14

The parameters of the HDBSCAN are based on the number of organisations in each subsector. Therefore, due to a varying number of organisations in each subsector the results aren't directly comparable as they have differing parameters. For example, the Renewable Energy subsector includes 10291 companies therefore a high `min_Pts` value is needed to differentiate clusters. As explained in the DSIT paper selecting a low HDBSCAN

³² Department for Science, Innovation and Technology (2024), Analytical Report Identifying and describing UK Innovation cluster

parameter value means fewer number of firms are required for the collective to be classified as a cluster.

Creation of the carbon-intensive list

To create the list, we used The Data City's Machine Learning list function. According to Data City "They are built by first defining a training set of companies that are examples of the industry vertical you wish to investigate. Companies are ranked by how representative they are of the companies selected in the training set."

We created an initial training set list which included the types of companies we knew were carbon intensive. This was mainly oil companies as well as some manufacturing, materials and mining companies. Initial list:

- Encirc limited.
- Exxonmobil + subsidiaries
- BP + subsidiaries
- Anglo American + subsidiaries
- Esso Petroleum + subsidiaries
- TATA steel + subsidiaries

The first run of the list included many companies that were irrelevant to what we needed, so we filtered out those companies. At this point, we added every company manually removed from the net zero CIC. This process of filtering was repeated approximately five times.

Finally, a keyword analysis was conducted. We created a list of keywords which we wanted to be represented in the list of companies. For those keywords which were not present, we found companies which were relevant to add to the list. The keywords were as follows:

- Coal
- Oil
- Gas
- Mining
- Fossil Fuels
- Quarrying
- Oil refining
- Petrochemical
- Construction emissions
- Landfill
- Combustion

Classification - Public

- Methane
- Fracking
- Energy
- Materials
- Manufacturing
- Aviation

Limitations

Naturally, there are limitations in this process. It is impossible to be certain that every carbon-intensive company in the UK has been included in the list without excessive manual combing through the 5 million companies available on The Data City website. Therefore, we must trust that the list we are working with is accurate enough to create an overview of the current carbon-intensive economy of the UK while recognising it is not perfect. There is also a small risk that some companies which are not carbon-intensive have been included in the list due to errors in the machine learning process. However, the 120 companies with the highest turnover were manually checked to ensure they were correctly identified as a carbon-intensive company. Therefore, we can safely work under the assumption that even if there is the inclusion of a small number of companies which are not carbon-intensive, their operations are relatively small and will not greatly affect the overall results.