OXFORD ECONOMICS

UK GREEN GROWTH INDEX

CHALLENGES AND OPPORTUNITIES FROM THE NET ZERO TRANSITION ACROSS THE NATIONS AND REGIONS OF THE UK

SEPTEMBER 2021

Commissioned by

LLOYDS BANKING GROUP

ABOUT OXFORD ECONOMICS

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September 2021

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FOREWORD

Lloyds Banking Group commissioned Oxford Economics to help share the story of the opportunities and challenges that the green economy presents for the UK.

Ultimately, we want to highlight the opportunities for the UK, showing how green investments can grow our economy across all nations and regions of the country and help it to recover, while also helping to improve our environment and reduce harmful carbon emissions.

Following a foundational paper released in July 2021, this second paper examines the opportunities for green growth across the different nations and regions of the UK.

During this critical year, we need to ensure that actions coming out of the United Nations Climate Change Conference (COP26) in November, as well as other government climate policies, are relevant to the UK's nations and regions. To help inform this discussion, we have asked Oxford Economics to take stock of how different parts of the UK could be impacted by the challenges and opportunities that will emerge from the net zero transition.

This research shows clear signs that the UK's green economy is starting to take shape. Every nation and region has its own story, but each has an important role to play in transitioning to a greener economy. In line with this research, Lloyds Banking Group is committed to supporting regional regeneration to ensure no part of the UK is left behind by the transition. We will mobilise support across our business help to make sure every nation and region can seize the huge opportunities that the green economy represents.

Lloyds Banking Group
September 2021

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EXECUTIVE SUMMARY

In 2019 the UK parliament passed legislation to commit the country to reducing net emissions of greenhouse gases by 100% by 2050. Reaching this goal will require substantial investment: the Climate Change Committee estimates that the UK will need to invest some £1.4 trillion between 2020 and 2050 to reach net zero. This includes an average of £50 billion per year between 2025 and 2050—an amount broadly comparable to the government's annual spending on schools. The need to invest is particularly great in areas such as low-carbon power, the electrification of transport, and the upgrading of homes to improve insulation and fit low-carbon sources of heat and hot water.

This need to invest means there is a unique opportunity for British businesses to innovate, produce, and supply the goods and services needed to enable the transition, not only in the UK but across the globe.

At the same time, for many parts of the economy the transition will create challenges due to the need to adapt products, processes, and skills. For example, agriculture is anticipated to undergo significant changes in response to reduced consumption of meat and dairy products, and an increased need to use land for tree planting and the growth of biofuel crops. In some industries, particularly those linked to fossil fuels, activity will need to be scaled back.

The nature and scale of these opportunities and challenges will inevitably vary across the UK. Disruption may be greater in areas where there are concentrations of high emitting industries, while areas which already have an emerging base of green economy activity may be able to more quickly capitalise on the new opportunities. Broader competitiveness factors, particularly those related to skills and innovation, will also create differences in the experience of the transition across the nations and regions of the UK.

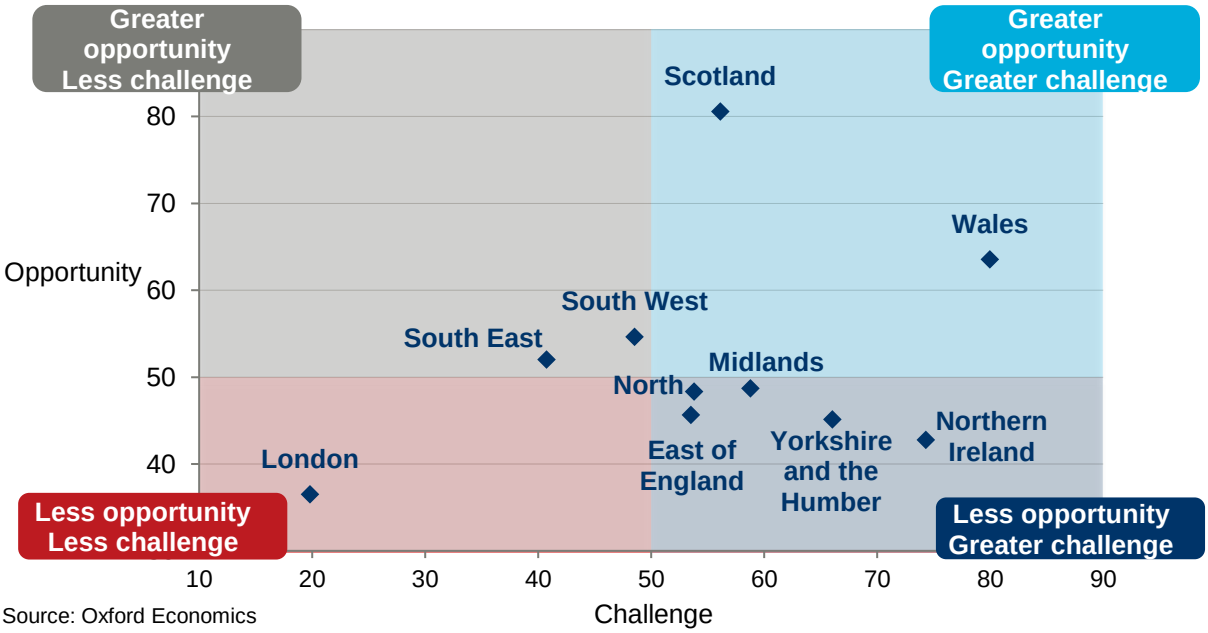
While there remains considerable uncertainty in exactly how the transition could evolve across different parts of the UK, it is informative to start taking stock of which areas may be most affected, both positively and negatively.

To do this we have reviewed a range of data to develop a broad sense of where challenges and opportunities may be greatest. We have amalgamated these data into a "UK Green Growth Index" to assess the degree to which each UK nation and region may be impacted by the challenges of transition, and how well placed they may be to capitalise on green growth opportunities.

Our research suggests that green growth opportunities are especially strong in Scotland, given its existing base of green economy activity (particularly in the energy sector) and its access to a workforce with relevant skills. Similarly, Wales appears well placed to capitalise on green growth opportunities, although it may face greater disruption in the nearer term due to its reliance on high emitting industries. Northern Ireland is also relatively exposed to disruption and may need to accelerate efforts to put in place the factors needed to fully exploit green economy opportunities.

Amongst English regions, the South East and South West appear to be best placed to capitalise on the green economy and are less exposed to disruption from the transition than many other parts of the UK. In contrast, Yorkshire and the Humber may face greater disruption and, like Northern Ireland, has further to go to develop some of the factors needed to capitalise on green growth. London is somewhat of an outlier: its status as a city-region with a service-orientated economy means it is much less exposed to the challenges than areas which rely more on industrial activity, but it also has less scope to capitalise on green economy opportunities in fields such as manufacturing and energy (although it is well positioned to develop as a centre for green finance and other professional services).

Fig. 1. Green growth challenges and opportunities across the UK



Source: Oxford Economics

In exploring these themes, it is important to emphasise that across all parts of the UK considerable thought and effort is being dedicated to determining how to make economies more sustainable and how to capitalise on green growth. Every part of the UK has centres and clusters of expertise in particular aspects of the green economy. Through this research we hope to inform discussion around how each part of the UK may make the most of its own attributes and characteristics to thrive in a net zero future.

1. INTRODUCTION

1.1 THE GREAT GREEN OPPORTUNITY

The Climate Change Committee (CCC) estimates that the UK will need to invest £1.4 trillion between 2020 and 2050 to reach net zero.[1] This includes an average of £50 billion per year between 2025 and 2050—an amount broadly comparable to the government's annual spending on schools.[2]

The CCC suggests that some 40% of the investment between 2020 and 2050 will need to be directed to the power sector, and a further 24% will be needed in land transport to electrify the UK's vehicle fleet. Another substantial area of investment will be homes, where there is a need to invest some £253 billion to improve home insulation and fit low-carbon sources of heat and hot water. The estimated investment need is smaller for agriculture, although the sector is nonetheless anticipated to undergo significant changes in response to reduced consumption of meat and dairy products, and an increased need to use land for tree planting and the growth of biofuel crops.

Governments around the world are seeking solutions to similar challenges and considering how their own transitions can be financed. But this need to invest means that there is also a unique opportunity for British businesses to innovate, produce, and supply the goods and services needed to enable the transition, not only in the UK but across the globe.

Official estimates suggest that the UK's green economy already supports 200,000[3] to 400,000[4] jobs. And while there is considerable uncertainty surrounding future growth, two recent studies have suggested that by 2050 the number of jobs in the green economy could grow to between 1.4 million[5] and 2.5 million[6].

While there is undoubtedly significant growth potential for the UK's green economy, the impact of this growth on the overall size of the economy is so far unclear. Many of the new green jobs will emerge as a result of the transformation of existing roles, for example as heating engineers switch to fitting heat pumps instead of gas boilers, or car manufacturers switch production from petrol-powered to electric vehicles. What is more, certain carbon-intensive activities, such as those linked to fossil fuels, will need to scale back over the next 10 years or so.

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[1] Climate Change Committee, *The Sixth Carbon Budget: The UK's Path to Net Zero*, 2020.

[2] HM Treasury, *Policy paper: Budget 2020*, accessed April 2021.
Table 1.9 shows that the Departmental Resource Budget for Schools was £47.6 billion in 2020-21.

[3] ONS, *Low carbon and renewable energy economy estimates*, accessed April 2021.

[4] ONS, *Environmental goods and services sector (EGSS) estimates*, accessed April 2021.

[5] Ecuity, *Local green jobs – accelerating a sustainable economic recovery*, 2020.

[6] McCullough et al., *UK business opportunities of moving to a low-carbon economy*, 2017.

1.2 AIMS OF THIS STUDY

This study builds on our earlier research for Lloyds Banking Group which reviewed existing evidence on the economic implications for the UK of the transition to a net zero future.[7] From that review it was clear that different industries would face very different challenges and opportunities. It was also clear that other enabling factors will be central to the UK's ability to capitalise on green growth opportunities, most notably ensuring the workforce has the right skills to adapt to and embrace new approaches and activities, and that the UK can build on its strengths in research and engineering to help deliver the innovation upon which the net zero economy will rely.

It follows from these conclusions that different parts of the UK will similarly face different challenges and opportunities from the net zero transition, reflecting differences in their industrial structures, skills endowments, and innovative capacities.

Our previous research also highlighted that growth prospects for the UK's green economy are extremely uncertain, as reflected in the wide range of green growth forecasts produced by different researchers. This uncertainty is likely to be even greater for any single part of the UK. The location of green economy activity may be strongly influenced by the decisions of policymakers and investors, and such decisions are difficult to predict, particularly over a period of decades.

Nonetheless, it appears reasonable to believe that parts of the UK with greater existing bases of green industry and other "green economy success factors" should be better placed to capitalise on green growth opportunities.

Similarly, parts of the UK which rely more on those industries and activities that will experience more disruption from the transition may face greater challenges as the country moves towards net zero.

In this study we build on these observations to develop a "UK Green Growth Index". In doing so our aim is to give a sense of which UK nations and regions may be most exposed to the challenges posed by the net zero transition, and where there may be greatest scope to capitalise on the growth of the green economy.

We start in Chapter 2 by outlining our approach, and in Chapter 3 we provide an overview of our findings. Subsequent chapters present detailed results for each UK nation and region. The appendices set out further details of our methodology and data sources.

[7] Oxford Economics, *Green Growth: opportunities for the UK*, 2021

2. DEVELOPING A UK GREEN GROWTH INDEX

The UK's path to net zero is not yet fully mapped out. In certain crucial areas the route to decarbonisation relies on new technologies which are still in development, while the extent to which UK businesses may capture the global market for green goods and services is similarly unclear. It is arguably even more challenging to identify how specific parts of the UK may be affected by these uncertain trends.

Nonetheless, by looking across a range of indicators we can start to build up a picture of where challenges and opportunities may be greatest across the nations and regions of the UK. To do this we have brought together a range of sub-national data sets into a "UK Green Growth Index" to summarise the degree of challenge and opportunity that each part of the UK could face.

In this chapter we outline the main principles and elements of our index. Further details of the methodology and data sources are presented in the appendices.

2.1 CONCEPTUAL FRAMEWORK

Our starting point is that the net zero transition is likely to create challenges and opportunities for the economies of the nations and regions which make up the UK. Our index is therefore constructed across two "domains" to reflect this:

- **Green growth challenge:** the degree to which the net zero transition could create economic challenges.
- **Green growth opportunity:** the degree to which the conditions are in place to capitalise on the growth of the green economy.

Within each domain we have identified a set of themes which may be expected to influence an area's prospects. These themes were informed by the literature review and consultations undertaken for our first phase of research.[8]

To consider the degree of challenge that different parts of the UK could face we identified the following three themes:

- **Dependence on carbon-intensive industry.** Parts of the UK that are more reliant on carbon-intensive industry may be more exposed to labour market and other economic disruption from scaling back or re-orientating such activity during the transition.
- **Emissions**. Parts of the UK with greater current emissions will need to make greater efforts and investments to adapt.
- **Fossil fuel power infrastructure.** Reaching net zero will drive greater demand for electricity and this will need to be generated from clean

[8] Oxford Economics, *Green Growth: opportunities for the UK*, 2021

sources. Areas where there is still a large reliance on fossil fuels are likely to face a greater need for investment and adaptation.

For the green growth opportunity domain we identified four themes:

- **Base of green industry.** Parts of the UK with a current or expected future base of green activity may be better placed to capitalise on green growth opportunities.
- **Skills and training.** Areas with highly skilled workers in relevant fields may be better placed to adapt to and enable the innovation needed to drive the transition.
- **Innovation.** A stronger base of innovative activity may mean that a nation or region is better placed to develop the technologies and techniques needed to decarbonise its economy and capitalise on green growth opportunities.
- **Renewable energy.** Areas with a larger existing renewable energy sector may be more likely to have the skills, expertise and infrastructure to build on this in future.

It is important to acknowledge that there is a degree of overlap between the themes. For example, emissions are likely to be greater in parts of the country more reliant on carbon-intensive industry. Areas with more research, development, and innovation may also have a greater concentration of highly-skilled workers. And so on. Nonetheless, our intention is to take a broad perspective and capture as many considerations as possible. The statistical techniques applied within the scoring process take into account the scope for overlap and help us to avoid “double counting”.

2.2 INDICATORS

Guided by the themes outlined above, we searched existing literature and data sources to identify data sets to help us understand the prospects for each nation and region of the UK. We filtered the long lists of variables identified into a final list of indicators from which to calculate index values for each of the two domains. This shortlisting sought to avoid including too many variables which would essentially do the same job within the index, and to ensure that the factors driving the results could be clearly identified and explained. The shortlisting was informed by a combination of statistical analysis and expert judgement.

The final lists of indicators are presented below. There are further details of the indicators and data sources in the appendices.

Fig. 2. Indicators included in the degree of challenge domain

Theme	Indicators and rationale
Dependence on carbon-intensive industry	**Jobs in high emitting industries** *The share of jobs within the 10 highest-emitting industries. Examples of these industries include fossil fuel extraction and processing, utilities, transport, and agriculture. A greater reliance on such activities may indicate a greater risk of labour market disruption, as well as a greater need for investment and adaptation.*
	Jobs requiring upskilling *The share of jobs that will require skills to be significantly adapted to meet the needs of the net zero economy (based on the Place-based Climate Action Network's Just Transition Jobs Tracker).*[9]
	Reliance on livestock farming *The share of regional gross value added (GVA) which relies on livestock farming—the element of agriculture which may be most exposed to disruption from the transition.*
Emissions	**Commercial emissions** *The overall level of emissions from industrial and commercial sources, relative to the size of the area's workforce.*
	Commercial emissions -v- expected *The extent to which emissions are higher or lower than would be expected given the area's industrial structure. If emissions are lower than expected, this may indicate that the area is more advanced with the decarbonisation process or that the area's specialisms within industries are more orientated towards lower emitting activity.*
	Household emissions *The level of emissions from domestic sources, relative to the area's population. A higher value may indicate a greater need to invest in lower emissions technologies for homes.*
	Transport emissions *Emissions from transport, relative to the area's population. A higher value may indicate a greater need for investment or behaviour change to reduce transport emissions.*
Fossil fuel power infrastructure	**Fossil fuelled generating capacity** *The overall scale of electricity generating capacity that relies on fossil fuels. A greater value implies a greater need to invest in cleaner replacement technologies. Considered in absolute terms since the power generated is assumed to be distributed nationally.*

[9] Place-based Climate Action Network (PCAN), *Just Transition Jobs Tracker*, 2019.

Fig. 3. Indicators included in the green growth opportunity domain

Theme	Indicators and rationale
Base of green industry	**Green economy jobs** *Current jobs in the low carbon and renewable energy economy relative to the overall size of the workforce. A strong existing base of green industry may provide a good foundation for future growth. Values for English regions have been imputed based on each region's sector mix.*
	Energy jobs needed by 2050 *National Grid forecasts of the jobs needed in the energy sector and its supply chains to meet net zero.[10] Estimated as a share of current jobs.*
	Vehicle manufacturing *Share of regional GVA which comes from motor vehicle manufacturing. Future growth in electric vehicle manufacturing might be expected to occur in areas where there is already a strong base of vehicle manufacturing.*
Innovation	**Research and development** *The value of research and development expenditure, relative to the nation or region's population. Indicates the overall intensity of innovation activity.*
	Firms innovating to reduce their environmental impact *Based on the BEIS UK Innovation Survey. Indicates the share of firms for which sustainability is already an important factor in the decision to innovate.[11]*
Skills and training	**Science, technology, engineering, mathematics (STEM) workers** *The share of workers employed in STEM occupations. Indicates the degree to which an area already has a stock of workers in the types of occupations which may be most important to driving innovation and adaptation efforts.*
	Higher education students in green-related subjects *The number of higher education students enrolled in green-related subjects, relative to the area's population. Indicates the potential future supply of highly-skilled workers in relevant fields.*
Renewable energy	**Domestic renewable energy installations** *The share of households with renewable energy installations. Indicates the area's propensity to be an early adopter of domestic renewable energy.*
	Commercial renewable energy capacity *Renewable energy capacity installed by businesses, relative to the size of the area's workforce. Indicates the propensity of businesses to be an early adopter of renewable technologies.*
	Grid renewable energy capacity *Total grid renewable energy capacity relative to population. Indicative of the existing base of green energy expertise and support infrastructure.*
	Electric vehicle charging points *Number of charging points relative to population size. Indicates the uptake of electric vehicles and influences their desirability for potential new users.*

[10] National Grid, *Building the Net Zero Energy Workforce*, 2020.

[11] Department for Business, Energy & Industrial Strategy, *UK innovation survey 2019*, 2020.

2.3 CALCULATING THE INDICES

The final step in our analysis was to normalise, aggregate, and weight the indicators to obtain an overall index value for each nation and region in each of the two domains.

The indices are presented such that a value of 50 is equivalent to the UK average. The index values also provide insights into the degree to which performance differs from the UK average: for example, a value of 25 or 75 is one standard deviation less or greater than the UK average. Index values were capped such that they could not fall below zero or exceed 100.

Our results are presented in the next chapter. Full details of the methodology can be found in Appendix 1.

3. RESULTS ACROSS NATIONS AND REGIONS

In this section we provide a comparative overview of the challenge and opportunity indices across the different parts of the UK.

It is important to emphasise at the outset that even in parts of the UK receiving lower index values, considerable efforts are underway to work towards a more sustainable economy. Every part of the UK has important green economy assets, such as innovation centres, universities, and clusters or corridors of enterprises in particular fields (some examples are provided in the chapters focusing on each region). We hope that the index will stimulate debate and discussion around how each area may best manage the challenges of transition and capitalise on its own unique set of attributes and assets to realise green growth.

3.1 GREEN GROWTH CHALLENGE INDEX

The values from the Green Growth Challenge Index are presented in the chart below. The bar for each area is shaded to show how each of the three themes contributes to a nation or region's index value, taking into account the weightings applied.

Our analysis suggests the net zero transition could present the greatest challenges for Wales and Northern Ireland. These nations have the greatest share of employment in high-emitting sectors and the some of the highest rates of emissions across all of the nations and regions. This implies that there could be the greatest potential for economic disruption in these parts of the UK, and relatively high levels of investment will be needed to re-orientate infrastructure and economic activity towards cleaner activities and technologies.

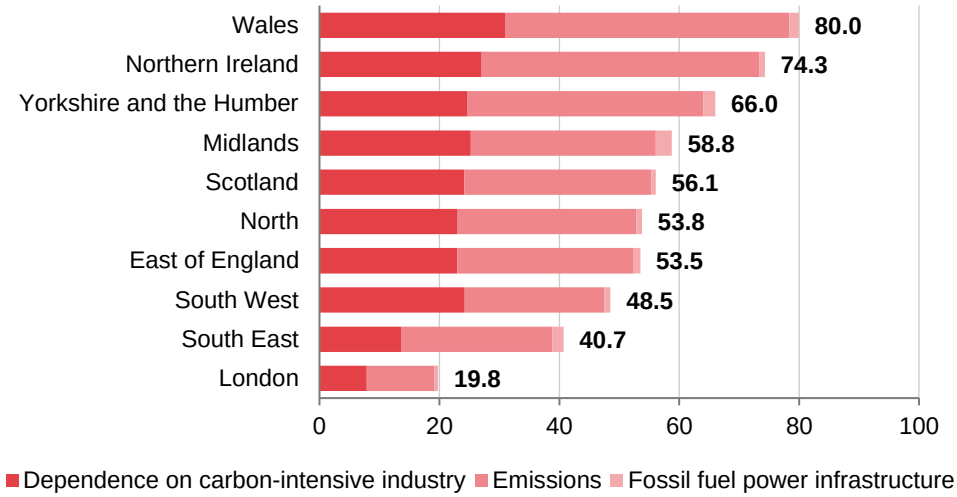
At the other end of the scale, London receives the lowest value on the challenge index, indicating that it may be less affected by many of the challenges the net zero transition will present. This finding is perhaps unsurprising given the unique nature of London as the UK's only city-region, with an economy that is much more orientated towards services and much less reliant on industry. Emissions from households and transport are also lower on average, reflecting a housing mix with a greater share of smaller properties[12] and the greater availability and use of public transport.

Other regions in the south and east of England also appear relatively well placed to face the challenges of the net zero transition. In the South East there is a relatively low dependence on carbon-intensive industries such as oil extraction and heavy manufacturing. Across the South East, South West, and East, rates of emissions are generally below the UK average (although an

[12] Ministry of Housing, Communities & Local Government, *English Housing Survey 2018-19*, accessed July 2021

important exception is transport emissions, which are relatively high in the East and South East).

Fig. 4. Green Growth Challenge Index
A higher value denotes that a nation or region is more exposed to disruption from the net zero transition



Source: Oxford Economics

Our index suggests that Yorkshire and the Humber could face the greatest degree of challenge amongst English regions. While it has a similar degree of dependence on carbon-intensive industry to most other English regions, emissions rates are relatively high, and the region is home to a large amount of fossil fuelled power generating capacity. In fact, only the Midlands has more fossil-fuelled generating capacity. We also find that the Midlands has the third greatest dependence on carbon-intensive industry. In part this reflects that a relatively high share of jobs (more than 11%) is estimated to require upskilling to meet the needs of the net zero economy.[13]

3.2 GREEN GROWTH OPPORTUNITY INDEX

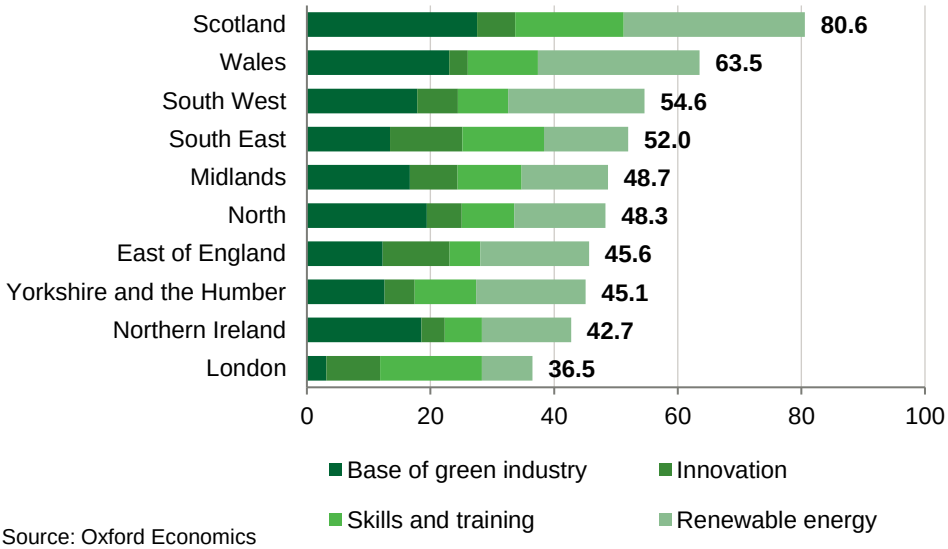
Across all parts of the UK there is scope to capitalise on the opportunities presented by the green economy. Our analysis suggests that these opportunities could be particularly strong in Scotland, where there are already some 21,000 green economy jobs. This means that Scotland is home to 11% of the UK's green jobs, compared to the nation's 8% share of jobs across all industries. Scotland also appears well placed for further green growth, due to a strong concentration of higher education students in green-related subjects and a well-developed base of renewable energy infrastructure (although take up of domestic renewables is lower than in other parts of the UK).

Green growth opportunities also appear strong for Wales. Similar to Scotland, the current share of green economy jobs in the Welsh workforce is above the UK average, with the energy sector expected to drive further demand over the

[13] Place-based Climate Action Network (PCAN), *Just Transition Jobs Tracker*, 2019.

coming decades. Wales also has a relatively high take up of renewable energy infrastructure across households, businesses and the grid. Wales does, however, have scope to build its innovation ecosystem: an average of £251 per resident is spent on research and development, which is less than half the UK average.

Fig. 5. Green Growth Opportunity Index
A higher value denotes where green economy opportunities could be strongest



Source: Oxford Economics

In sharp contrast to the challenge index, our analysis suggests that green growth opportunities may be limited in London. While London has the greatest density of electric vehicle charge points out of all nations and regions (almost 70 per 100,000 residents), it has relatively little renewable energy capacity. Once again, this may reflect a lack of space suited to wind energy, and less private roof space for domestic solar installations. More broadly, opportunities are limited for London to capitalise on green growth in the energy and manufacturing industries. Nonetheless, London has a large base of workers in science, technology, engineering, and mathematics roles and relatively high rates of spending on research and development. It could therefore offer good potential to act as an enabler of the transition through its role as a centre of financial and other advanced services, even if this potential is not well reflected within the variables used in our model.

Northern Ireland sits just above London in the index. Although its industry composition is favourable to green economy opportunities, its overall index value is held back by lower rankings for innovation and skills.

Amongst English regions, opportunities appear slightly stronger in the South West and South East. The former is mid-ranked in terms of its base of green industry and innovation, but benefits from a strong showing in the renewable energy intensity theme (the South West is the highest ranked area for renewable energy installations amongst households and businesses). The South East appears well placed to capitalise on its strong base of research and development activity and skilled workforce.

Relatively little separates the Midlands and the North in our index. The Midlands is mid-ranked across most of the themes, although has a lower concentration of renewable energy than many other parts of the UK. The North benefits from strong opportunities in green industry, particularly the energy sector and vehicle manufacturing.

The degree of opportunity is also very similar for the East of England and Yorkshire and the Humber. The East scores highly for innovation, but this is offset by a lower ranking on skills and training due to a relatively low concentration of higher education students in green-related subjects. The key strengths for Yorkshire and the Humber are its base of green industry and renewable energy capacity, although the region is expected to have less growth potential in the energy sector than some other parts of the UK.

3.3 CHALLENGES AND OPPORTUNITIES

We can plot the challenge and opportunity index values for each nation and region to identify groups that may be affected in similar ways by the net zero transition.

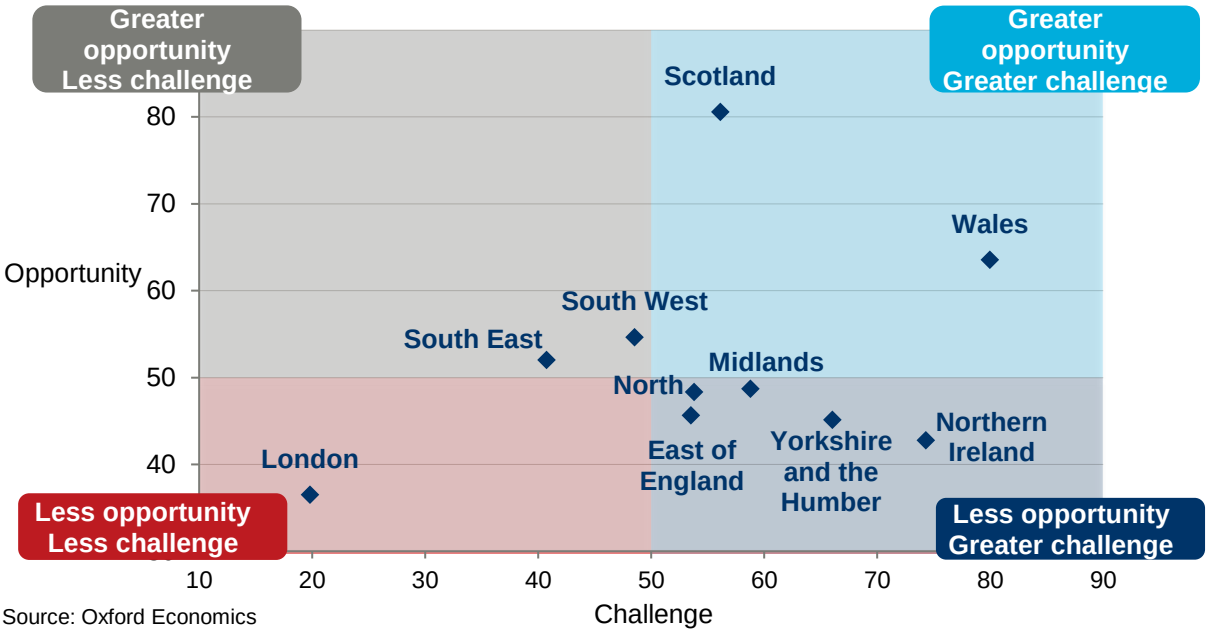
In bringing together the two indices we find a central cluster of English regions which may face similar degrees of challenge and opportunity. But around this cluster are a number of outliers which warrant particular consideration.

Wales and Northern Ireland appear on the right-hand side of the diagram, reflecting that they may experience some of the greatest disruption from the transition. However, Wales has a high score on the opportunity index, indicating there is already a firm foundation of green economy activity upon which to build, particularly within the energy sector. In contrast, for Northern Ireland there is a greater need to develop some of the factors needed to drive its green economy towards a smooth transition.

Scotland is another outlier. While our analysis suggests the transition could present a similar degree of challenge to many English regions, Scotland already has a strong base of green economy activity and assets from which to build and is well positioned to become one of the UK's green growth leaders.

The other clear outlier is London, where the service-based economy is likely to be much less impacted by the transition, but where it will also be more difficult to develop aspects of the green economy based on manufacturing or natural resources (although there is clearly potential for London to capitalise on its position to become a centre of green finance and other services).

Fig. 6. Green growth challenges and opportunities



Source: Oxford Economics

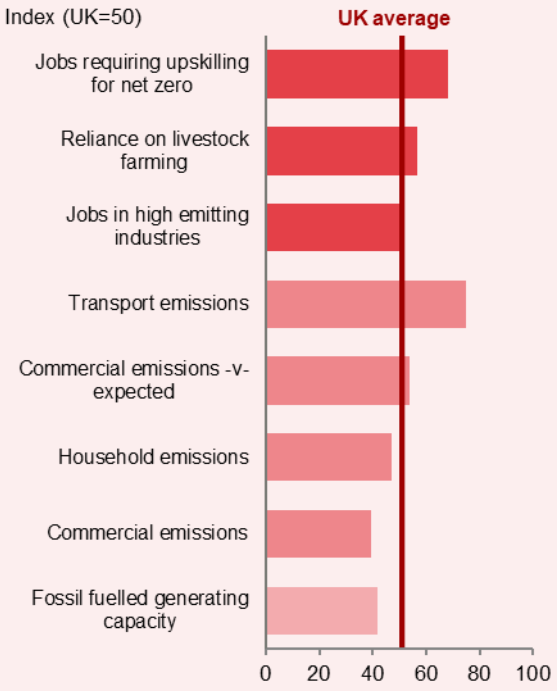
Turning to the cluster of English regions in the centre of the diagram, we observe that for the most part those in the south are slightly better placed in terms of both challenges and opportunities. This may imply a need for more investment in northern regions of England, in line with the government's "levelling up" agenda.

In the next chapters of our report we take a more detailed look at individual nations and regions to identify the key strengths, opportunities, and assets in each case.

4. EAST OF ENGLAND

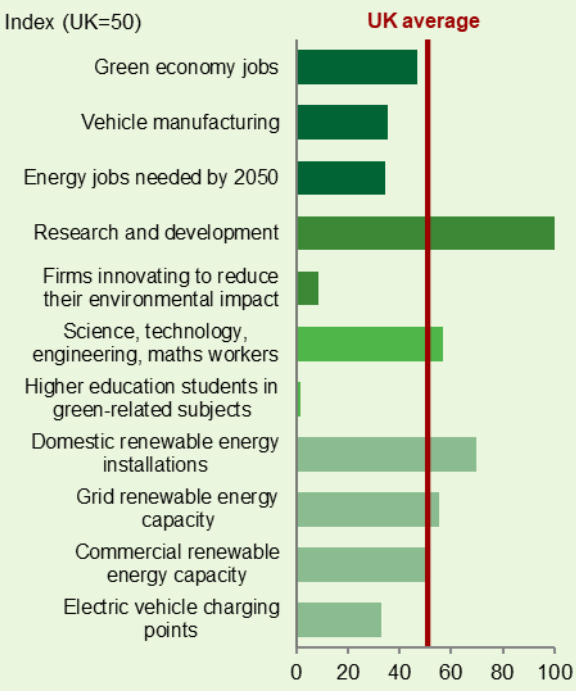
CHALLENGE INDEX 7th out of 10

The transition to net zero poses less of a challenge to the economy of the East of England than for many other parts of the UK. Only London and the South East are estimated to have a lower dependence on carbon-intensive industry, while rates of emissions from businesses and households are below average.



OPPORTUNITY INDEX 7th out of 10

The East of England is a knowledge leader for the UK, with a very strong base of innovative activity and a high share of workers with skills in science, technology, engineering, and mathematics (STEM) occupations. However, there is scope to further capitalise on these attributes to increase the role of green industry.



STRENGTHS

- The East benefits from a substantial base of innovation infrastructure, centred on universities and research centres. The East has the highest rate of investment in research and development amongst all UK nations and regions, with more than £1,000 per resident spent in 2018. The East's position as a knowledge leader is reinforced by its workforce: some 37% of workers are in science, technology, engineering, and mathematics occupations, the third highest share in the UK.
- There is a lower dependence on carbon-intensive industry than in many other parts of the UK, and rates of household and commercial emissions are below average.
- There is established base of renewable energy: nearly 4% of households have renewable installations—the third highest share amongst UK nations and regions, while renewable generating capacity from the region's power stations is also slightly above average.

INVESTMENT NEEDS AND OPPORTUNITIES

- While there are clusters of green economy activity, there is further scope to leverage the region's innovation investment and infrastructure to grow the size of energy and other green economy sectors.
- Investment is needed to reduce emissions from transport: the East has the highest rates of transport emissions in the UK relative to its population. There are just 21 electric vehicle charging points per 100,000 residents, compared to an average of 31 across the UK.
- There may be scope to leverage the region's educational infrastructure to develop the skills needed for net zero. Some 10.9% of jobs are estimated to need upskilling to meet the needs of the net zero economy (the second highest share in the UK). Despite the presence of Cambridge University, the overall number of higher education students in green-related subjects is relatively low, potentially limiting the supply of future green economy workers. Nonetheless, the region has a dedicated Skills for Energy programme which seeks to ensure an ongoing pipeline of qualified individuals to support current and future needs across the energy sector.
- There is further potential to increase the focus on sustainability as a driver for innovation amongst businesses: only 5.5% of firms cited reducing environmental impact as an important driver of innovation—the lowest share in our comparison.

KEY GREEN ECONOMY ASSETS

- The Cambridge-Norwich tech corridor incorporates a number of science and business clusters at the heart of the region. Areas of specialism include some that will be key to delivering net zero, such as agricultural technology and renewable energy.
- The Cambridge Cleantech cluster connects companies, academics, investors, and innovators to facilitate innovation in clean technologies.
- The East of England benefits from a concentration of clean energy expertise, including a strong focus on offshore wind. This is supported by the Offshore Renewable Energy Catapult, which works with innovators, companies, and academics to facilitate research, development and innovation, and to accelerate the development of new technologies.

ECONOMIC INDICATORS[14]

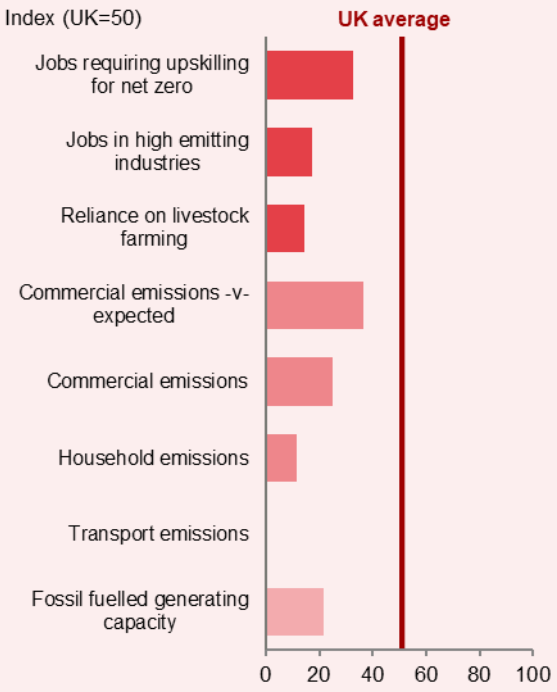
GVA	Jobs	Population	Emissions
£165 billion	3.2 million	6.2 million	32.4Mt CO_2
9% of the UK total	9% of the UK total	9% of the UK total	9% of the UK total

[14] See Appendix 4: Sources for regional economic indicators for details of the data sources used in this section.

5. LONDON

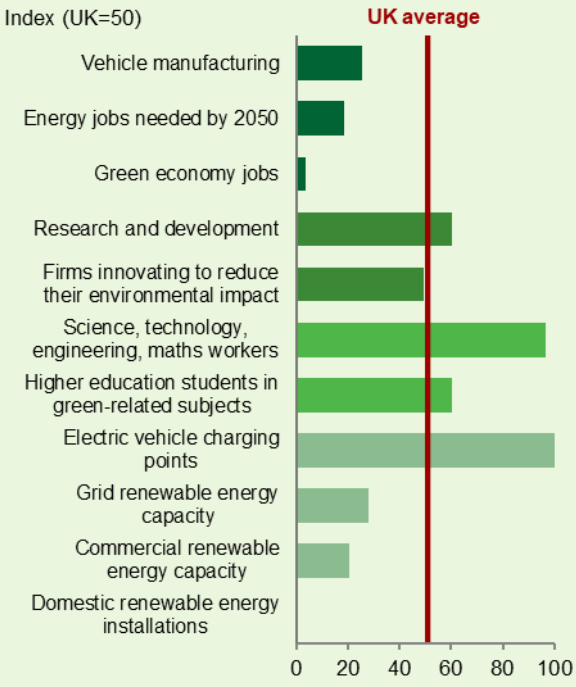
CHALLENGE INDEX **10th** out of 10

The net zero transition poses less of a challenge for London compared to all other parts of the UK across the three themes in our Green Growth Challenge Index. London has a low dependence on carbon intensive industry and rates of emissions from businesses, households, and transport are below average. These factors reflect London's status as a city region with a service-orientated economy and high population density.



OPPORTUNITY INDEX **10th** out of 10

London has the potential to act as an enabler of the net zero transition through its role as a centre of financial and other advanced services. The region has the innovation and skills base needed to adapt and capitalise on green growth opportunities. However, spatial constraints and a service-driven economy mean that there are fewer opportunities for industrial- and energy-related green growth.



STRENGTHS

- London benefits from a highly-skilled workforce: 42% of workers are in science, technology, engineering, and mathematics occupations, the highest share in the UK, while there is an above-average concentration of higher education students in green-related subjects. London's skills based is complemented by above-average levels of investment in research and development.
- While London contributes 24% of UK GVA, 17% of jobs, and is home to 13% of the population, it accounts for just 8% of the UK's emissions. In part this reflects a very service-orientated economy which results in much lower levels of emissions than in areas

with a greater dependence on industry. Even after accounting for London's industry profile commercial emissions are below-average, suggesting a degree of comparative efficiency.

- Household emissions are lower than the UK average, reflecting the benefits of greater housing density to reducing emissions. Transport emissions are significantly lower than in all other regions, reflecting the widespread availability of public transport and the density of the urban economy, which means that many journeys are relatively short.

INVESTMENT NEEDS AND OPPORTUNITIES

- The region has strong potential to act as an enabler of the transition through its role as a centre of financial and other advanced services, even if this potential is not well reflected within the variables used in our model. It is estimated that London supports 12% of jobs in the UK green economy, but these represent a relatively small proportion of London's 5.9 million jobs.
- There is potential to increase the focus on renewable energy: London has the lowest penetration of domestic and commercial renewable energy installations across all UK nations and regions.

KEY GREEN ECONOMY ASSETS

- London is one of the main locations for the Connected Places Catapult which connects industry, academics, investors, and the public sector with the aim of accelerating innovation for cities, transport, and places.
- The Government's 10 Point Plan for a Green Industrial Revolution identifies a clear role for London in the Green transition, envisaging the City as a world leader in carbon markets.
- The London Cleantech Cluster is a platform founded by organisations undertaking clean technology initiatives. It supports, coordinates, and promotes these activities to boost the deployment and growth of clean technologies.

ECONOMIC INDICATORS[15]

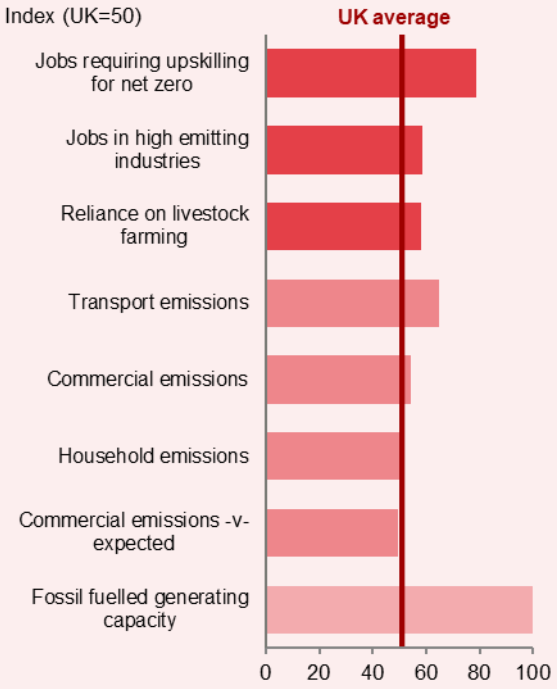
GVA	Jobs	Population	Emissions
£447 billion	5.9 million	8.9 million	28.9Mt CO_2
24% of the UK total	17% of the UK total	13% of the UK total	8% of the UK total

[15] See Appendix 4: Sources for regional economic indicators for details of the data sources used in this section.

6. MIDLANDS

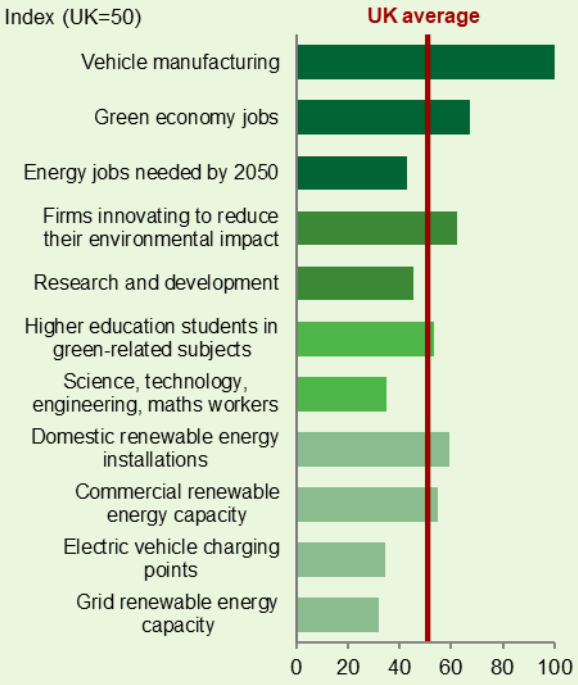
CHALLENGE INDEX 4th out of 10

The Midlands sits close to the UK average across most of the indicators in our Green Growth Challenge Index. However, a relatively high share of workers is estimated to need re-training to meet the needs of the net zero economy. The region is also home to a high concentration of coal-fired power stations, which the UK government has announced will be closed by 2024.



OPPORTUNITY INDEX 5th out of 10

The Midlands is the UK's main centre for motor vehicle manufacturing. As such, it is well-placed to capitalise on the growing market for electric vehicles. The specialism is one element of the Midlands' strong overall base of green economy activity, which should provide a solid foundation for growth in the years ahead.



STRENGTHS

- Some 61,000 workers were employed in the automotive manufacturing industry in the Midlands in 2019 and, as such, the region should be well placed to capitalise on the growing market for electric vehicles. More broadly, the Midlands is estimated to already have a relatively high concentration of green economy jobs upon which to build.
- A relatively high share of firms in the region are already innovating to reduce their environmental impact. An estimated 8.5% of firms reported that sustainability was an important driver of their innovation—the second highest share in our comparison.
- The take up of renewable energy equipment amongst households and businesses is slightly ahead of the UK average.

INVESTMENT NEEDS AND OPPORTUNITIES

- The Midlands is an important generator of energy for the UK. However, it is home to much of the UK's gas-fired power generating capacity and the majority of the country's coal-fired power generation capacity is located in the region (the government has announced the latter will close by 2024). This implies a need for investment to shift generation towards renewables, as well as the development of carbon capture, usage, and storage to enable gas power stations to operate more cleanly.
- Just over 11% of jobs are estimated to need reskilling to meet the needs of the net zero economy—the highest share across all nations and regions. There is therefore a need to leverage the region's skills and training infrastructure to ensure the workforce is equipped for the future and to enable the Midlands to realise its full green growth potential.

KEY GREEN ECONOMY ASSETS

- The Energy Systems Catapult, has its headquarters in Birmingham and a second site in Derby. The Catapult centre, overseen by Innovate UK, was set up to accelerate the decarbonisation of the UK's energy system. It does this by bringing together innovative businesses and researchers to foster collaboration and accelerate the development of new goods and services.
- The Black Country is one of seven UK strategic industrial clusters to receive support from BEIS and Innovate UK to develop the world's first net zero industrial cluster by 2040. The Black Country has a base of more than 3,000 energy-intensive businesses, many of them working in metal processing. The programme will seek to provide cost-efficient energy infrastructure; help manufacturers to use resources more efficiently; and help businesses to benefit from new opportunities in the circular economy.

ECONOMIC INDICATORS[16]

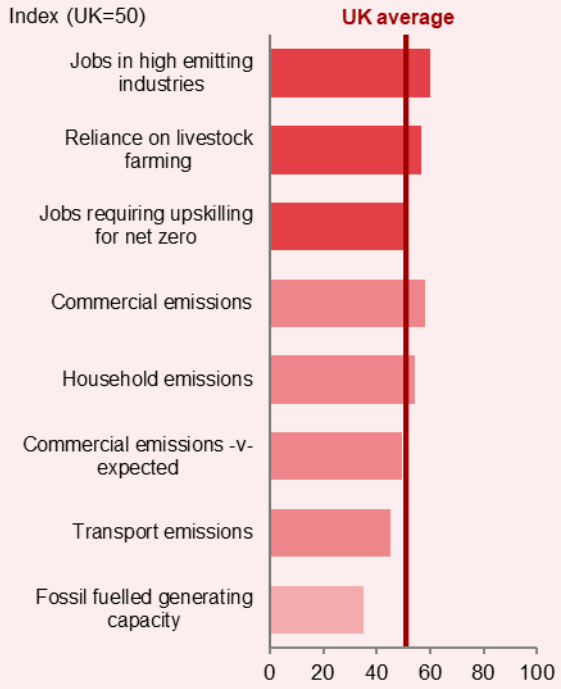
GVA	Jobs	Population	Emissions
£251 billion	5.3 million	10.7 million	60.1Mt CO_2
13% of the UK total	15% of the UK total	16% of the UK total	17% of the UK total

[16] See Appendix 4: Sources for regional economic indicators for details of the data sources used in this section.

7. NORTH

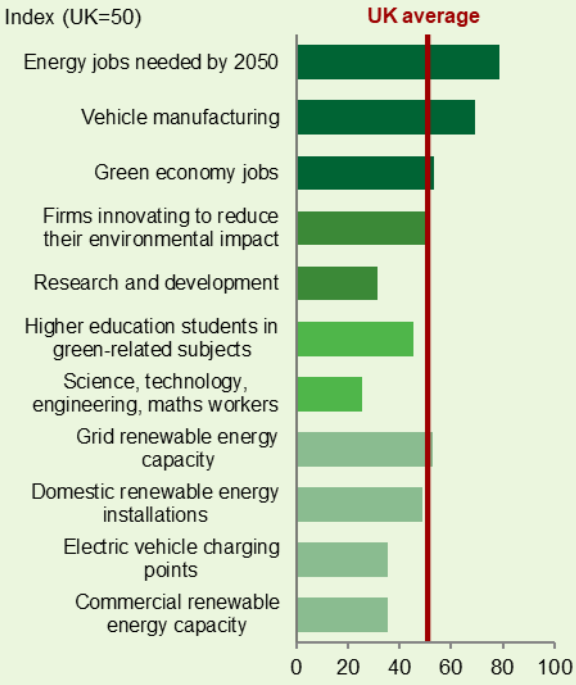
CHALLENGE INDEX 6th out of 10

Our Green Growth Challenge Index indicates that the North is placed mid-table amongst the nations and regions of the UK. It scores at around the UK average across most of the indicators reviewed. It does, however, have a slightly above-average dependence on jobs in carbon-intensive industry, and rates of emissions from businesses and households are also slightly above average.



OPPORTUNITY INDEX 6th out of 10

The net zero transition presents an opportunity for the North to build on its base of green economy jobs. The region has particular strengths in energy and electric vehicle manufacturing. However, to realise its full potential the region will need to increase investment in innovation, and to boost the supply of workers in science, technology, engineering, and mathematics occupations.



STRENGTHS

- The North benefits from an established green economy, which already supports an estimated 14% of UK jobs in the sector. Almost 8% of firms in the region cite reducing environmental impact as an important driver of innovation.
- The energy sector is a significant employer, and renewables already play an important role in the North's grid generating capacity. Renewable energy activity includes offshore wind on the North East coast, and an important support base at the Port of Blyth. The energy sector's transition to net zero will present a major opportunity for the North, with an estimated 80,000 job opportunities by 2050 including in offshore wind, carbon capture, storage, and usage, and support to the decarbonisation of other industries through the development of advanced fuels.

- There is a significant motor vehicle manufacturing industry in the North—the second largest amongst UK nations and regions behind the Midlands. Nissan plans to build a £1 billion electric vehicle hub in the region, creating 1,650 new jobs with a further 4,550 expected to be created in the supply chain. The development, supported by around £100 million of government funding, will include an electric battery plant, a battery recycling facility, and production of a new all-electric car.

INVESTMENT NEEDS AND OPPORTUNITIES

- There is a need to reduce industrial emissions through the increased use of sustainable fuels and process innovation. A number of initiatives are underway in this area (see below).
- To maximise the region's green growth potential it will be necessary to increase investment in innovation and skills. Investment in research and development of £375 per inhabitant is significantly below the UK average of £558, while the share of workers employed in science, technology, engineering, and mathematics occupations is also below average.
- Transport emissions are below the UK average and there is an opportunity to reduce these further by increasing the availability of electric vehicle charging points: there are currently just 22 per 100,000 residents (compared to a UK average of 31) and electric vehicle ownership rates in the North of England are significantly lower than in the south.
- There is scope for greater investment in renewables amongst businesses: installed capacity relative to the size of the workforce is currently only around half the UK average.

KEY GREEN ECONOMY ASSETS

- The government has identified clusters for decarbonisation, including areas in Merseyside and Teesside as part of its Industrial Decarbonisation Strategy. Decarbonisation efforts should create growth opportunities, and government investment is already supporting a number of projects in the region, including the Net Zero Teesside carbon capture, usage, and storage project, while Net Zero North West has recently launched its Economic Investment Prospectus stating the investment case for decarbonising and clean growth.
- The region benefits from a cluster of clean energy, including a strong focus on offshore wind. This is supported by the Offshore Renewable Energy Catapult, which works with innovators, companies, and academics to facilitate research, development, and innovation, and to accelerate the development of new technologies.
- The Net Zero NW Cluster Plan will set out the transition to net zero for industry in the North West of England and North East Wales, describing the investments, technologies, infrastructure, and sequencing required to fulfil the UK's Industrial Clusters Mission. Through the new green economy opportunities created, the plan hopes to create 33,000 jobs and secure £4 billion of investment.

ECONOMIC INDICATORS[17]

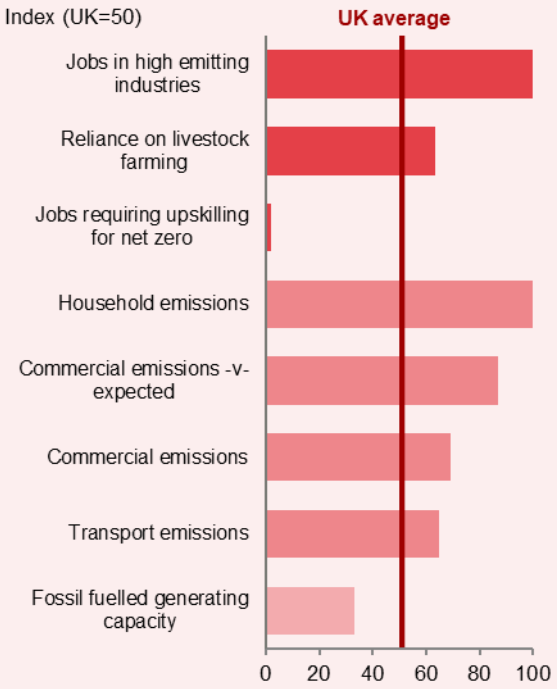
GVA	Jobs	Population	Emissions
£237 billion	4.9 million	10 million	53.4Mt CO_2
13% of the UK total	14% of the UK total	15% of the UK total	15% of the UK total

[17] See Appendix 4: Sources for regional economic indicators for details of the data sources used in this section.

8. NORTHERN IRELAND

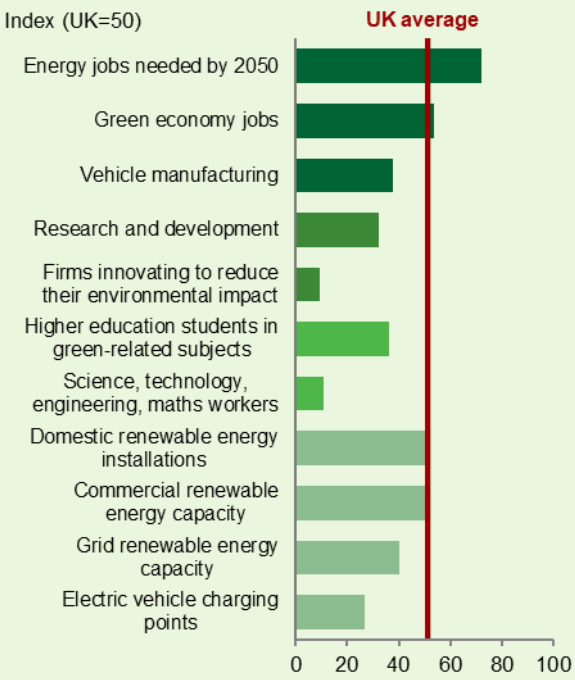
CHALLENGE INDEX 2nd out of 10

Northern Ireland faces challenges in the transition to net zero given its heavy dependence on jobs in carbon intensive sectors. There is also a strong need to reduce emissions from businesses, households, and transport.



OPPORTUNITY INDEX 9th out of 10

Northern Ireland already has a solid base of green economy activity upon which to build and the energy sector could provide an important source of new jobs in the coming decades. However, to realise its green economy potential Northern Ireland will need to further develop its skills base and increase investment in innovation.



STRENGTHS

- The green economy accounts for 5,000 jobs in Northern Ireland. This means that the current share of jobs in the green economy is broadly in line with the UK average and should provide a solid base for further growth. Within the green economy, particular specialisms include low emissions vehicles and low carbon heat, within which Northern Ireland contributes 8% and 4% of the UK total, respectively.
- There is further potential for employment growth in the energy sector to support the net zero transition. Despite a high dependence on jobs in high emitting sectors, the proportion of Northern Ireland's jobs requiring upskilling for the net zero economy is relatively low.
- Northern Ireland generates almost 50% of its electricity from renewable sources, mainly from onshore wind for which it is second only to Scotland in terms of installed capacity. The net zero transition will require an estimated 13,000 energy-related jobs in Northern Ireland.

INVESTMENT NEEDS AND OPPORTUNITIES

- Emissions rates are considerably higher than the UK average, particularly household emissions, which are the highest across all UK nations and regions. The CCC has identified that considerable savings could be made in Northern Ireland by switching conventional oil boilers to heat pumps. This implies an important investment need which could potentially support green economy jobs in the household renewables sector.
- Commercial emissions are also much higher than the UK average, partly reflecting Northern Ireland's relatively high degree of dependence on manufacturing. Northern Ireland does not have large industrial clusters so the ability for individual companies to decarbonise their operations is critical. One such example is Encirc, which has shown how sustainable glass bottles can be created without fossil fuels.
- Agriculture is an important sector and accounts for more than a quarter of Northern Ireland's emissions, compared to an average of 10% for the UK as a whole. The Northern Ireland government's consultation on its proposed Energy Strategy identified opportunities for agriculture to support the growth of biogas to help decarbonise the gas network.
- The CCC recommends a more rapid deployment of electric vehicles in Northern Ireland to reduce transport emissions. There is scope to invest in electric vehicle charging points: at present there are 17 per 100,000 inhabitants, compared to the UK average of 31.

KEY GREEN ECONOMY ASSETS

- Two battery storage sites in Northern Ireland, with a total operational capacity of 100MW, have been developed by Low Carbon and Gore Street Energy Storage Fund. The sites near Drumkee, County Tyrone, and Mullavilly, County Armagh, will be critical in supporting Northern Ireland's transition to a low-carbon electricity system, helping to smooth peaks and troughs in the supply and demand for renewable energy.
- The Collaborative Circular Economy Network (CCEN) network brings together five councils, four manufacturing businesses, and a social enterprise. It covers more than 1,000 people employed in recycling glass, plastic, paper, and food waste. The network enables collaboration to promote recycling and the circular economy, and provides a platform for manufacturers to export recyclable products.
- There are proposals for new waste management infrastructure in Mallusk that will operate alongside other recycling programmes to help divert residual municipal waste from landfill through the extraction of materials for recycling and the generation of sustainable energy. It can also contribute to other low carbon technologies such as hydrogen production, district and industrial heating, and energy storage.

ECONOMIC INDICATORS[18]

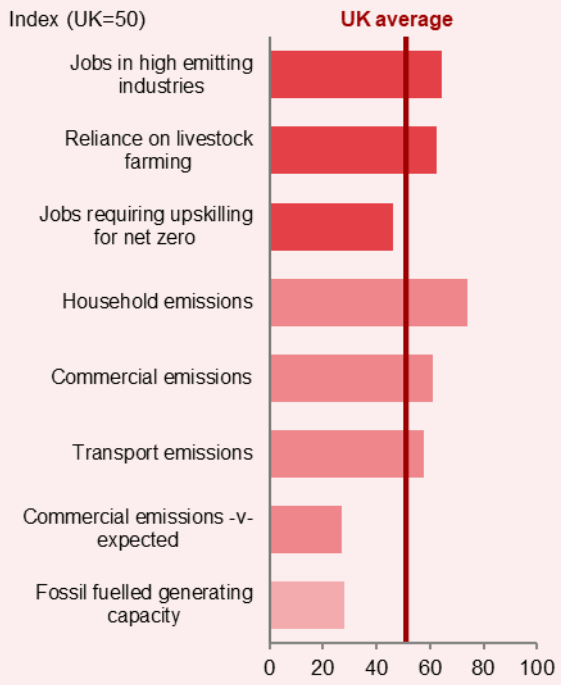
GVA	Jobs	Population	Emissions
£42 billion	887,000	1.9 million	12.7Mt CO_2
2% of the UK total	3% of the UK total	3% of the UK total	4% of the UK total

[18] See Appendix 4: Sources for regional economic indicators for details of the data sources used in this section.

9. SCOTLAND

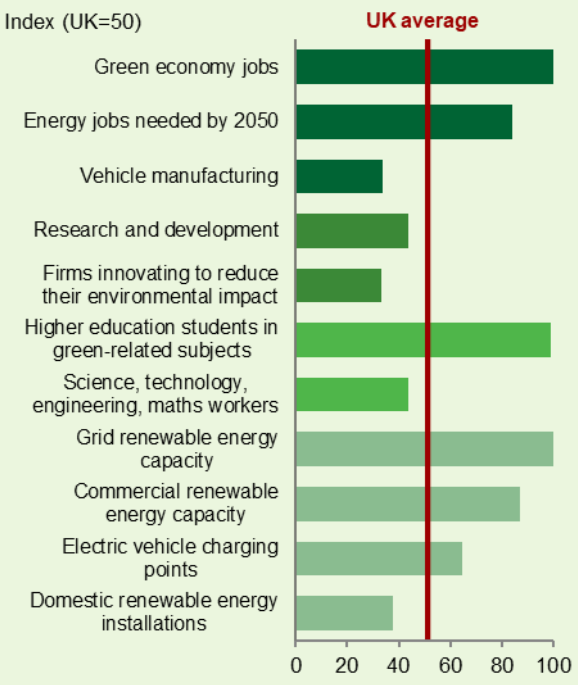
CHALLENGE INDEX 5th out of 10

Our Green Growth Challenge Index suggests that Scotland is mid-ranking in terms of the degree of challenge it could face during the transition to net zero. There is a need to reduce emissions rates, which are above the UK average, particularly for households. In common with other parts of the UK there is also a need to reduce economic reliance on carbon-intensive industry.



OPPORTUNITY INDEX 1st out of 10

Scotland is particularly well-placed to take advantage of the opportunities that the green economy presents and has set a target for net-zero emissions of all greenhouse gases by 2045. The nation already has around 21,000 green economy jobs—more than 10% of the UK total. Low-carbon energy is a particular specialism, with a large volume of capacity already in place. Scotland also benefits from a strong supply of skilled workers to support and enable the transition.



STRENGTHS

- Scotland produces by far the most low-carbon energy of any other part of the UK, with more on-shore wind capacity than the rest of the UK combined. Scotland is also one of the UK's main locations for hydroelectric power. The National Grid's forecasts indicate strong further potential for energy sector growth to 2050.
- Partly driven by the well-developed renewable energy sector, Scotland's green economy is the largest in the UK, relative to the size of the overall workforce.
- Green prospects are further enhanced by Scotland's universities, which accommodate a relatively large number of students in green-related subjects.

INVESTMENT NEEDS AND OPPORTUNITIES

- Household emissions rates are above the UK average, while only 2.4% of households have renewable energy installations—compared to an average of 3.0% across Great Britain. This may, in part, reflect colder outside temperatures and a greater reliance on heating oil in some areas. Nonetheless, there is scope for investment to improve insulation and install low-carbon heating and hot water systems. One example of this is underway in Fife, where 300 homes are testing boilers powered by zero carbon hydrogen.
- Scotland is a key centre for the UK's fossil fuel industries. Carbon capture, usage, and storage, as well as hydrogen power, could provide opportunities for oil and gas workers to transition to the green economy. This objective which is supported by the UK government's North Sea Transition Deal, which should secure investment in Scotland and support jobs.
- Scotland's economy is relatively more reliant on livestock farming than many other parts of the UK. There is an opportunity to explore alternative uses of the land currently used for this purpose, for example through "re-wilding" and tree planting.

KEY GREEN ECONOMY ASSETS

- Scotland is home to the Offshore Renewable Energy Catapult, based in Glasgow, with another site at Fife. The Catapult provides facilities and expertise for businesses to develop, test, and demonstrate new innovations in offshore renewable energy. For example, EchoBolt developed a wind turbine bolt inspection technology that uses ultrasonics and promises to reduce bolt maintenance costs by 90%.
- Scotland's "Hydrogen Coast" is a cluster of hydrogen projects along the east coast that aim to reduce the nation's carbon footprint, including the Fife domestic heating project described above. Other examples include Acorn Hydrogen, a production plant powered by fossil fuels, with the carbon captured and sent for storage in the North Sea; HyStorPor, which is investigating the storage of hydrogen in geological formations, and Aberdeen Vision, which is exploring the potential to incorporate hydrogen into the gas distribution network.

ECONOMIC INDICATORS[19]

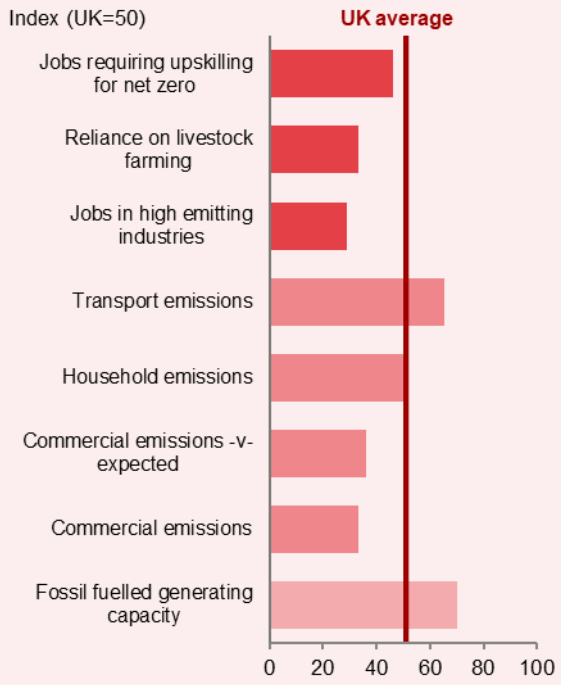
GVA	Jobs	Population	Emissions
£142 billion	2.8 million	5.4 million	28.6Mt CO_2
7% of the UK total	8% of the UK total	8% of the UK total	8% of the UK total

[19] See Appendix 4: Sources for regional economic indicators for details of the data sources used in this section.

10. SOUTH EAST

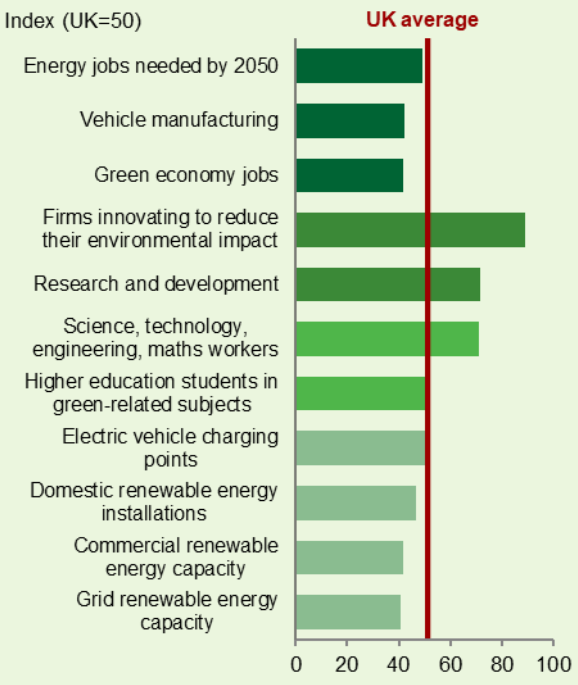
CHALLENGE INDEX 9th out of 10

Our Green Growth Challenge Index suggests the South East could face fewer challenges in the transition to net zero than most other parts of the UK. It has a relatively low dependence on carbon-intensive industries and rates of emissions from businesses are below the UK average. However, the South East still has a relatively large amount of fossil fuelled electricity generating capacity and transport emissions rates are above average.



OPPORTUNITY INDEX 4th out of 10

The South East is well placed to capitalise on green growth opportunities. The region has a strong base of innovation infrastructure and a skilled workforce with a high concentration of workers in science, technology, engineering, and mathematics occupations. There is, nonetheless, scope to further increase take up of renewable energy.



STRENGTHS

- The South East has a relatively low dependence on carbon-intensive industries, with its economy characterised by high levels of activity in high-value services, and below-average concentrations of agriculture and manufacturing. The region's industrial mix helps to explain its highly skilled workforce: almost 39% of workers are in science, technology, engineering, and mathematics occupations, the second highest share in the UK.
- Alongside its skills base, the region benefits from high levels of innovation. Research and development investment is equivalent to £770 per resident—the second highest in the UK.

Reducing environmental impact is an important driver of innovation for 10% of firms in the South East, the highest share in the UK.

- Emissions from businesses in the South East are the lowest in the UK outside of London, and the region's businesses are found to be relatively low emitters, even after controlling for differences in industrial structure.

INVESTMENT NEEDS AND OPPORTUNITIES

- Relative to its population the South East is below the UK average in terms of its renewable energy capacity, and the region still has a number of large natural gas-fired power stations. There is therefore scope for investment in grid renewable energy infrastructure to shift the focus away from fossil fuel power generation into low carbon sources and to introduce carbon capture, usage, and storage.
- We estimate that the South East has just over 26,000 green economy jobs, which is equivalent to 13% of the UK total. However, as a share of the region's employment this is slightly below the UK average. Similar to London, the South East may be well placed to build on its expertise in high value services to support green growth.
- Investment is needed to reduce emissions from transport: the South East has the second highest rates of transport emissions in the UK relative to its population. While the density of electric vehicle charging points is in line with the UK average, it is considerably lower than in London and Scotland.

KEY GREEN ECONOMY ASSETS

- The European Regional Development Fund supports the Low Carbon Across the South East (LOCASE) programme. LOCASE aims to support businesses in boosting their competitiveness and increasing their profitability in an environmentally sustainable manner. To do so, the programme offers grants and training to businesses with a green offering.
- Greentech South, which is shared with the South West, is part of a wider technology and innovation cluster and supports businesses with the commercialisation of low carbon initiatives by bringing together academia, industry, and public sector organisations.
- Growing Kent and Medway is a collaborative cluster bringing together businesses, academics, and entrepreneurs to conduct innovative research in the fields of horticulture, fresh produce packaging, and food and drink supply chains. They aim to catalyse environmentally friendly commercial technologies in these areas and to reduce waste.

ECONOMIC INDICATORS[20]

GVA	Jobs	Population	Emissions
£277 billion	4.8 million	9.1 million	42.7Mt CO_2
15% of the UK total	14% of the UK total	14% of the UK total	12% of the UK total

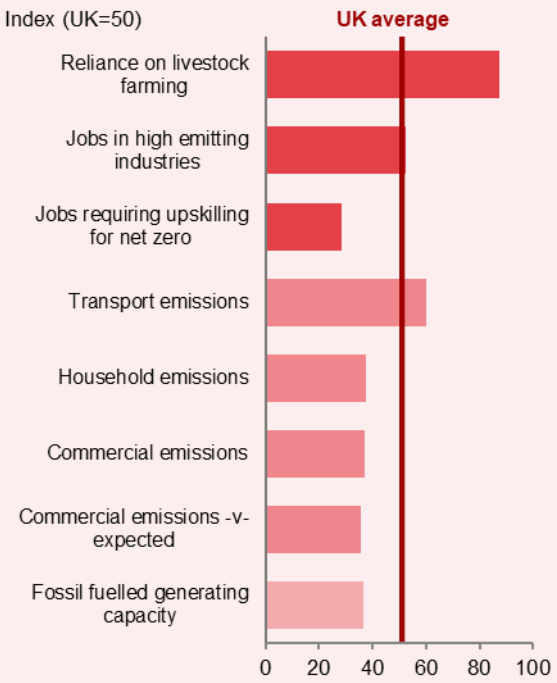
[20] See Appendix 4: Sources for regional economic indicators for details of the data sources used in this section.

11. SOUTH WEST

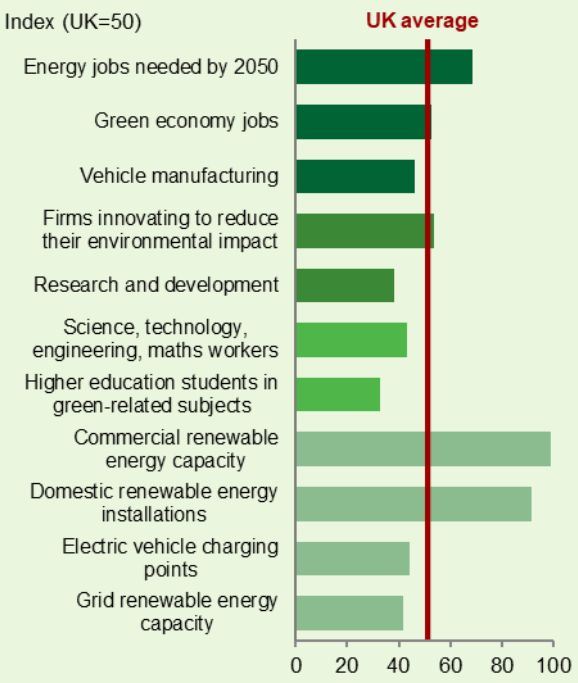
CHALLENGE INDEX 8th out of 10

OPPORTUNITY INDEX 3rd out of 10

Our Green Growth Challenge Index suggests that the net zero transition could present fewer challenges for the South West than for many other parts of the UK. Emissions rates are relatively low, with the exception of transport. One of the main areas of challenge may arise from the region's reliance on agriculture, which is set to undergo significant transformation due to reductions in meat consumption and the need to adjust land use patterns.



The South West appears well placed to capitalise on the opportunities that the green economy will present. The region leads the UK in terms of the take up of renewable energy installations amongst households and businesses. The energy sector is expected to be a further source of jobs growth over the coming decades. Greater investment in the innovation and skills needed for the net zero transition could enable the South West to further enhance its green growth prospects.



STRENGTHS

- The South West leads the UK in terms of the take up of renewable energy equipment amongst households and businesses. Some 4.8% of households have renewable energy installations, compared to the UK average of 3.0%. Along similar lines, businesses have installed 241 KW of renewables capacity per 1,000 jobs, compared to the UK average of less than 100 KW. These findings may, in part, reflect differences in climate, which mean that the South West is better suited to solar power than other parts of the UK.
- Current rates of emissions from businesses are the lowest outside of London and the South East, and the South West's businesses are found to be relatively low emitters, even after controlling for differences in industrial structure. Household emissions rates are the

second lowest amongst UK regions. This may be linked to relatively high rates of take up of renewables, and a warmer climate which implies less need for domestic heating.

INVESTMENT NEEDS AND OPPORTUNITIES

- There is scope for investment in grid renewable energy generating infrastructure: relative to its population the South West is below the UK average on this indicator, in contrast to the region's strong showing for renewables take up amongst households and businesses.
- There is scope to increase the density of electric vehicle charging points: there are currently 28 per 100,000 residents, which is just below the national average of 31.
- The South West already has a solid base of green economy activity: this is estimated to support around 17,000 jobs, or 9% of the UK total. To further unlock the region's potential there is a need to increase investment in research and development: the South West invests an average of £444 per resident at present, compared to a UK average of £558.
- Another area of potential focus is the region's skills base: both the share of workers in science, technology, engineering, and mathematics occupations and the density of higher education students in green-related subjects are slightly below the UK average.
- Investment in innovation and skills could also ensure the region is well placed to address some of its key challenges, such as how to best manage and enable the net zero transition in the agricultural sector and to reduce transport emissions.

KEY GREEN ECONOMY ASSETS

- Greentech South brings together academia, industry, and the public sector to collaborate on innovation and research. In doing so the network seeks to help small and medium businesses through the transition to net zero, and to help businesses to bring new low carbon goods and services to market. While the cluster is shared with the South East, it has become the South West hub of Clean Growth UK—a network of green-oriented businesses led by universities.
- The National Composites Centre, part of the UK's High Value Manufacturing Catapult, provides facilities, expertise, and collaboration opportunities to support innovation in composites engineering. This has important applications for sustainability, for example by making things lighter and more durable, and by reducing waste. Key sectors the Centre works with include aerospace, energy, transport, construction, and infrastructure.
- Bristol is also home to the Wind Blades Research Hub, a collaboration between the Offshore Renewable Energy Catapult and the University of Bristol. The hub is undertaking research into wind turbines, with aim of making them larger, more powerful, and more durable.

ECONOMIC INDICATORS[21]

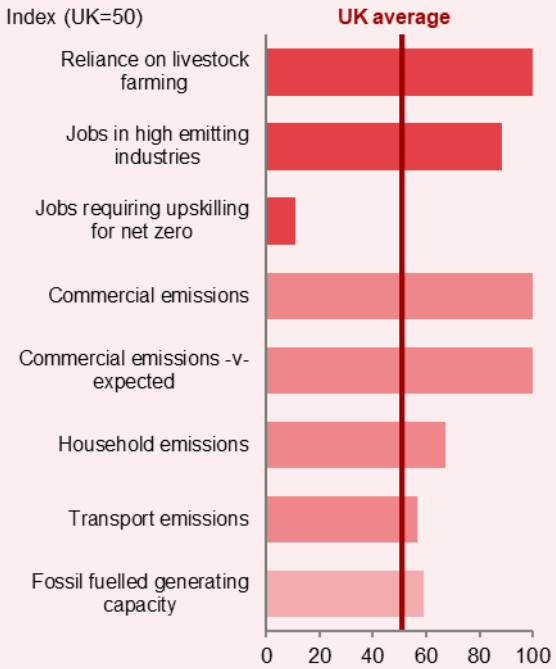
GVA	Jobs	Population	Emissions
£140 billion	3 million	5.6 million	26.7Mt CO_2
7% of the UK total	8% of the UK total	8% of the UK total	8% of the UK total

[21] See Appendix 4: Sources for regional economic indicators for details of the data sources used in this section.

12. WALES

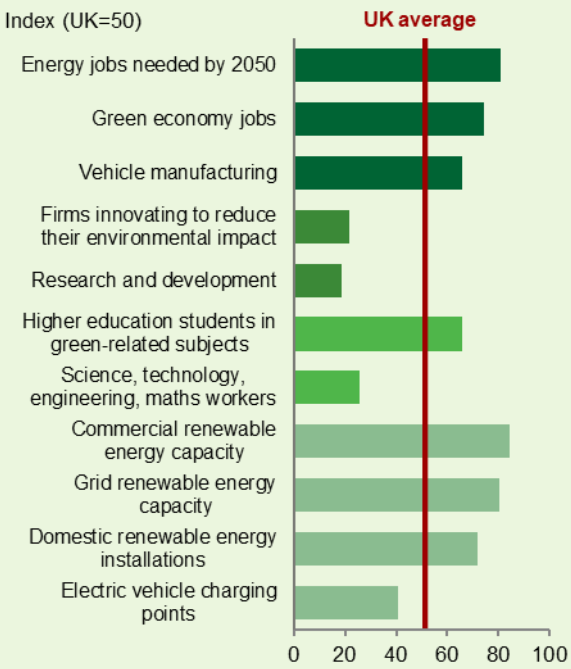
CHALLENGE INDEX 1st out of 10

The net zero transition could present important challenges for Wales. Emissions rates from businesses and households are relatively high, while a high proportion of jobs fall within the 10 highest emitting industries. This implies that significant efforts and investment will be needed to re-orientate activity and infrastructure to greener alternatives.



OPPORTUNITY INDEX 2nd out of 10

Despite the challenges of the transition, Wales has a considerable opportunity to capitalise on the green economy. Green jobs already represent a relatively high share of employment (Wales is second only to Scotland on this metric). Wales is one of the UK's most important areas for onshore wind power, which contributes to a strong existing base of capacity and skills in renewable energy, while the car industry presents opportunities to capitalise on the growing market for electric vehicles.



STRENGTHS

- Wales has a well-established renewable energy sector. Relative to its population, Wales has some of the largest amounts of renewable generating capacity in the UK. This includes power for the grid, as well as small installations amongst households and businesses. A particular specialism is onshore wind energy, of which Wales has more capacity than any other part of the UK except Scotland. The energy sector offers significant potential for further jobs growth over the coming decades.
- Automotive manufacturing is another important industry, employing 11,000 people in 2019. Key automotive employers include Toyota's Deeside Engine Plant, which produces hybrid

electric engines. Given this existing base of skills and expertise, Wales could be well-placed to take advantage of opportunities in the growing electric vehicle market.

- Wales benefits from a relatively high concentration of students in green-related subjects, which could offer an important source of future skills to support the nation's green growth.

INVESTMENT NEEDS AND OPPORTUNITIES

- A relatively high share of jobs in Wales are within the 10 highest emitting sectors. In part, this reflects that the manufacturing sector accounts for a relatively large share of the Welsh economy. There is therefore a need for investment and innovation to de-carbonise processes, for example through the increasing use of clean energy and the implementation of carbon capture, usage, and storage. Such changes will require a significant increase in investment in research and development: Wales current invests just £251 per person in these activities, the lowest amount across all UK nations and regions.
- The Welsh economy has a high degree of dependence on livestock farming. Reductions in meat consumption could therefore impact this part of the UK particularly strongly. There will be an important need to embrace changes in the agricultural sector, for example by changing land use to support efforts to remove emissions from the atmosphere.
- While almost 4% of households in Wales have renewable energy equipment, household emissions rates remain relatively high. This may reflect that Wales has a greater proportion of homes not connected to mains gas than England and Scotland, and that some of these homes rely on heating oil for domestic heating and hot water. As such there may be further scope to increase the take-up of renewable energy across Welsh households.

KEY GREEN ECONOMY ASSETS

- The South Wales Industrial Cluster brings together businesses in energy and heavy industry with the aim of achieving a net zero emissions cluster by 2040 through technologies such as low carbon power and carbon capture, usage, and storage.
- Wales has the vast majority of the UK's "pumped storage" power generation capacity, including the largest single facility at Dinorwig in North Wales. These facilities use excess electricity generated during periods when supply exceeds demand to pump water uphill. It is later released to generate electricity through hydroelectric turbines at times when demand exceeds supply. In this way pumped storage helps to smooth the peaks and troughs in energy supply which occur as the grid's reliance on renewables increases.
- Pembroke Dock is receiving a significant investment in the form of the Marine Energy Engineering Centre of Excellence, a collaboration between the Offshore Renewable Energy Catapult and Welsh universities. The Centre will deliver research, development, and demonstration activities to support the commercialisation of technologies in the wave, tidal, and offshore wind sectors.

ECONOMIC INDICATORS[22]

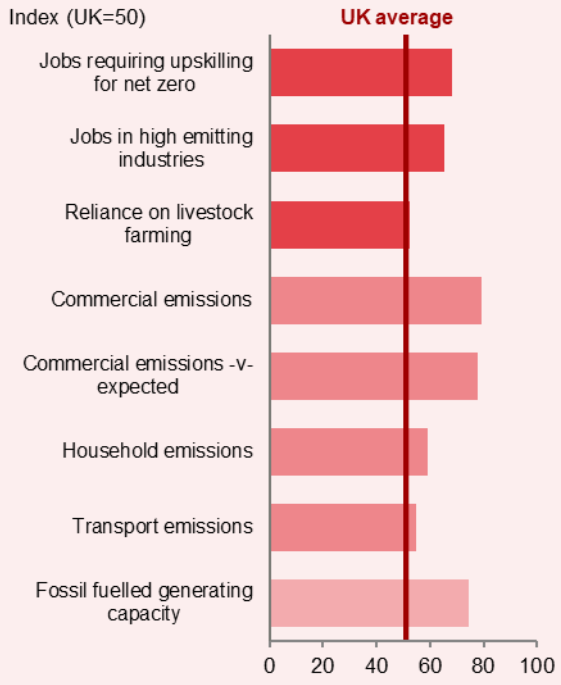
GVA	Jobs	Population	Emissions
£65 billion	1.5 million	3.1 million	23.6Mt CO_2
3% of the UK total	4% of the UK total	5% of the UK total	7% of the UK total

[22] See Appendix 4: Sources for regional economic indicators for details of the data sources used in this section.

13. YORKSHIRE AND THE HUMBER

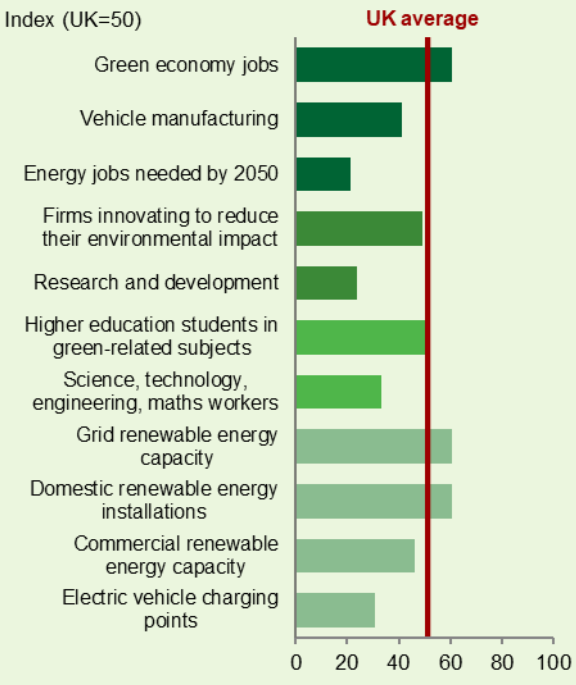
CHALLENGE INDEX 3rd out of 10

Our Green Growth Challenge Index suggests that Yorkshire and the Humber could face the highest degree of challenge from the net zero transition amongst English regions. Emissions rates from businesses and households are amongst the highest in the UK, while the region's economy is relatively reliant on carbon-intensive industry, and there remains a relatively large amount of fossil-fuelled electricity generating capacity.



OPPORTUNITY INDEX 8th out of 10

Yorkshire and the Humber has a relatively high share of renewables within its electricity generating mix, although prospects for future energy sector growth appear more limited than in some other regions. More broadly, the share of the region's jobs that are in the green economy is slightly above average, indicating a solid foundation for future growth. However, to maximise the region's green growth potential it will be necessary to boost investment in research and development and to increase the supply of workers with expertise in science, technology, engineering, and mathematics.



STRENGTHS

- We estimate that the green economy supports around 17,000 jobs in Yorkshire and the Humber, or around 8% of the UK total. This means that the green economy accounts for a slightly above-average share of the region's employment, which should provide a strong foundation for future growth.
- Relative to its population, Yorkshire and the Humber has the third highest concentration of grid renewable energy capacity in the UK, after Scotland and Wales. Yorkshire and the

Humber is leading the UK in terms of renewable energy generation powered by biomass: the Drax power station in North Yorkshire is fuelled by compressed wood pellets sourced from sustainably managed forests and waste from existing forestry work.

INVESTMENT NEEDS AND OPPORTUNITIES

- Yorkshire and the Humber has a relatively high share of jobs in high-emitting industries, partly reflecting an above-average reliance on manufacturing. Linked to this, an above-average share of workers will need re-training to meet the needs of the net zero economy.
- The region still has one of the highest amounts of natural gas-fired power capacity in the country. There is therefore further potential to invest to re-orientate power generation towards renewables, and to incorporate carbon capture technologies into existing facilities.
- There is scope to increase investment in research and development to support the innovations needed for the net zero transition. Yorkshire and the Humber spends £300 per person on research and development—the second lowest amount across the nations and regions of the UK.
- Around 3.4% of households have installed renewable energy equipment, slightly above the UK average of 3.0%. However, household emissions are slightly above the UK average, suggesting there is further scope to improve energy efficiency and increase the take up of renewables. There is also scope to invest in electric vehicle charging infrastructure: there are 19 charging points per 100,000 residents at present, compared to a UK average of 31.

KEY GREEN ECONOMY ASSETS

- In 2020, the National Grid and several major energy companies formed the Northern Endurance Partnership to develop offshore carbon dioxide transport and storage infrastructure in the North Sea. This infrastructure will serve the proposed Zero Carbon Humber (ZCH) project that aims to establish a decarbonised industrial cluster in Humberside. ZCH hopes to be commissioned by 2026 with a pathway to achieve net zero emissions through a combination of carbon capture, usage, and storage, and switching to fuels such as low carbon hydrogen.
- The University of Leeds is host to an office of the Connected Places Catapult. It enables innovation by connecting industry, academics, investors, and the public sector with the aim of accelerating innovation for cities, transport, and places. Leeds has also been chosen as the home of the new national infrastructure bank, which will support green investment, the transition to net zero, and the government's levelling-up agenda.
- The Advanced Manufacturing Research Centre, part of the High Value Manufacturing Catapult, has branches in Sheffield and Rotherham. This provides a further focal point of innovation facilities and expertise in sectors such as aerospace, transport, construction, and energy.

ECONOMIC INDICATORS[23]

GVA	Jobs	Population	Emissions
£124 billion	2.7 million	5.5 million	35.8Mt CO_2
7% of the UK total	8% of the UK total	8% of the UK total	10% of the UK total

[23] See Appendix 4: Sources for regional economic indicators for details of the data sources used in this section.

APPENDIX 1: METHODOLOGY

To develop the UK Green Growth Index we worked through a four-stage process as outlined below.

Overview of the development process

STEP 1: CONCEPTUAL FRAMEWORK

The future growth potential and location of the UK's green economy is extremely uncertain. Nonetheless, by looking across a wide range of indicators we can build up a broad indication of where challenges and opportunities may be greatest. Our UK Green Growth Index is constructed across two "domains" as follows:

- **Green growth challenge:** the degree to which the net zero transition could create economic challenges.
- **Green growth opportunity:** the degree to which the conditions are in place to capitalise on the growth of the green economy.

We identified a set of themes to reflect the main considerations that could affect an area's prospects in each of the two domains. These themes were informed by the literature review and consultations undertaken as part of the first phase of our research with Lloyds Banking Group.[24]

To consider the degree of challenge that different parts of the UK could face we identified the following three themes:

- **Dependence on carbon-intensive industry.** Parts of the UK that are more reliant on carbon-intensive industry may be more exposed to labour market and other economic disruption from scaling back or re-orientating such activity during the transition.
- **Emissions**. Parts of the UK with greater current emissions levels will need to make greater efforts and investments to adapt.
- **Fossil fuel power infrastructure.** Reaching net zero will drive greater demand for electricity and this will need to be generated from clean sources. Areas where there is still a large reliance on fossil fuels are likely to face a greater need for investment and adaptation.

For the green growth opportunity domain we identified four themes:

[24] Oxford Economics, *Green Growth: opportunities for the UK*, 2021

- **Base of green industry.** Parts of the UK with a current or expected future base of green activity may be better placed to capitalise on green growth opportunities.
- **Skills and training.** Areas with highly skilled workers in relevant fields may be better placed to adapt to and enable the innovation needed to drive the transition.
- **Innovation.** A stronger base of innovative activity may ensure a nation or region is better placed to develop the technologies and techniques needed to decarbonise their economy and capitalise on green growth opportunities.
- **Renewable energy.** Areas with a larger existing renewable energy sector may be more likely to have the skills, expertise and infrastructure to build on this in future.

It is important to acknowledge that there is a degree of overlap between the themes. For example, emissions are likely to be greater in parts of the country more reliant on carbon-intensive industry. Areas with more research, development, and innovation may also have a greater concentration of highly-skilled workers. And so on. Nonetheless, our intention is to take a broad perspective and capture as many considerations as possible. The statistical techniques applied within the scoring process take into account the scope for overlap and help us to avoid "double counting".

STEP 2: DEVELOPING LONG LISTS OF INDICATORS

With the themes in place we searched existing literature and data sources to identify potential indicators for each of the themes. Our search focused on identifying datasets which provided values for all nations and regions of the UK. The types of indicators identified in this initial search are outlined below.

Fig. 7. Overview of the types of indicators reviewed for the degree of challenge domain

Domain and theme	Types of indicator identified
Dependence on carbon-intensive industry	Data identifying the share of economic activity which relies on high emissions sectors; associated supply chains; and in occupations most likely to require upskilling.
Emissions	Measures of domestic, commercial and transport emissions.
Fossil fuel power infrastructure	Fossil fuel generating capacity.

Fig. 8. Overview of the types of indicators reviewed for the green growth opportunity domain

Domain and theme	Types of indicator identified
Base of green industry	Indicators of the current level of green economy activity; existing forecasts of green growth by nation or region.
Skills and training	Workers and higher education students in occupations and subjects expected to be most in demand to enable the net zero transition.
Innovation	Indicators of investment and activity linked to research and development, both overall and in specific fields of relevance to the transition.
Renewable energy	Indicators of domestic and commercial renewable energy installations; electric vehicle charging points; current and planned renewables capacity in the power sector.

The data points gathered are inevitably measured using many different units. We therefore normalised the data using z-scores, which express each nation or region's position relative to the UK average.

STEP 3: SHORTLISTING THE INDICATORS

The initial long lists of indicators in our database presented two main challenges. Firstly, many of the indicators were similar in nature and could have performed a similar job within the indices. And secondly, including too many indicators would make it difficult to identify the factors driving the results and explain rankings. We therefore worked through an iterative process to shortlist the indicators to be included in the final index. This comprised the following steps:

(1) We identified groups of indicators which were similar in nature, either conceptually or statistically. This assessment was based on correlation analysis and analysts' judgement.
(2) We created early experimental versions of the two indices using principal component analysis (PCA) to compare different combinations of substitute indicators. For each of these combinations we used the loading factors from the first principal component to derive weights. This iterative process guided further analysis into combinations which appeared unstable or which produced counter-intuitive results. In turn, this enabled us to identify and consider the removal of indicators which were problematic, for example because they included significant outliers which created distortions, or if further analysis identified concerns about the validity or robustness of the data source.
(3) We used PCA to identify the "explanatory power" of different combinations of indicators (measured in terms of the proportion of variance combination explained by the first principal component of each combination). Our final selections for each domain reflect the combinations of indicators and weights for which this explanatory power was high relative to other combinations tested. In making our final selection we also took into account the balance of weights across indicators: given our objective to look across a broad range of indicators in each domain we avoided combinations of variables in which the PCA allocated a very high weight to any single indicator.

The final lists of indicators included within each index are shown below, along with their respective weightings.

Fig. 9. Shortlisted indicators for the Green Growth Challenge Index

Theme	Indicators and rationale	Weight
Dependence on carbon-intensive industry	**Jobs in high emitting industries** *The share of jobs within the 10 highest-emitting industries. Examples of these industries include fossil fuel extraction and processing, utilities, transport, and agriculture. A greater reliance on such activities may indicate a greater risk of labour market disruption, as well as a greater need for investment and adaptation.*	18%
	Jobs requiring upskilling *The share of jobs that will require skills to be significantly adapted to meet the needs of the net zero economy (based on the Place-based Climate Action Network's Just Transition Jobs Tracker).*[25]	8%
	Reliance on livestock farming *The share of regional gross value added (GVA) which relies on livestock farming—the element of agriculture which may be most exposed to disruption from the transition.*	14%
Emissions	**Commercial emissions** *The overall level of emissions from industrial and commercial sources, relative to the size of the area's workforce.*	16%
	Commercial emissions -v- expected *The extent to which emissions are higher or lower than would be expected given the area's industrial structure. If emissions are lower than expected, this may indicate that the area is more advanced with the decarbonisation process or that the area's specialisms within industries are more orientated towards lower emitting activity.*	15%
	Household emissions *The level of emissions from domestic sources, relative to the area's population. A higher value may indicate a greater need to invest in lower emissions technologies for homes.*	15%
	Transport emissions *Emissions from transport, relative to the area's population. A higher value may indicate a greater need for investment or behaviour change to reduce transport emissions.*	10%
Fossil fuel power infrastructure	**Fossil fuelled generating capacity** *The overall scale of electricity generating capacity that relies on fossil fuels. A greater value implies a greater need to invest in cleaner replacement technologies. Considered in absolute terms since the power generated is assumed to be distributed nationally.*	3%

[25] Place-based Climate Action Network (PCAN), *Just Transition Jobs Tracker*, 2019.

Fig. 10. Shortlisted indicators for the Green Growth Opportunity Index

Theme	Indicators and rationale	Weight
Base of green industry	**Green economy jobs** *Current jobs in the low carbon and renewable energy economy relative to the overall size of the workforce. A strong existing base of green industry may provide a good foundation for future growth. Values for English regions have been imputed based on each region's sector mix.*	16%
	Energy jobs needed by 2050 *National Grid forecasts of the jobs needed in the energy sector and its supply chains to meet net zero.[26] Estimated as a share of current jobs.*	14%
	Vehicle manufacturing *Share of regional GVA which comes from motor vehicle manufacturing. Future growth in electric vehicle manufacturing might be expected to occur in areas where there is already a strong base of vehicle manufacturing.*	0.1%
Innovation	**Research and development** *The value of research and development expenditure, relative to the nation or region's population. Indicates the overall intensity of innovation activity.*	10%
	Firms innovating to reduce their environmental impact *Based on the BEIS UK Innovation Survey. Indicates the share of firms for which sustainability is already an important factor in the decision to innovate.[27]*	5%
Skills and training	**Science, technology, engineering, mathematics (STEM) workers** *The share of workers employed in STEM occupations. Indicates the degree to which an area already has a stock of workers in the types of occupations which may be most important to driving innovation and adaptation efforts.*	8%
	Higher education students in green-related subjects *The number of higher education students enrolled in green-related subjects, relative to the area's population. Indicates the potential future supply of highly-skilled workers in relevant fields.*	14%
Renewable energy	**Domestic renewable energy installations** *The share of households with renewable energy installations. Indicates the area's propensity to be an early adopter of domestic renewable energy.*	2%
	Commercial renewable energy capacity *Renewable energy capacity installed by businesses, relative to the size of the area's workforce. Indicates the propensity of businesses to be an early adopter of renewable technologies.*	13%
	Grid renewable energy capacity *Grid renewable energy capacity relative to population. Indicative of the existing base of green energy expertise and support infrastructure.*	17%
	Electric vehicle charging points *Number of charging points relative to population size. Indicates the uptake of electric vehicles and influences their desirability for potential new users.*	0.9%

[26] National Grid, *Building the Net Zero Energy Workforce*, 2020.

[27] Department for Business, Energy & Industrial Strategy, *UK Innovation Survey 2019*, 2020.

STEP 4: CALCULATING INDEX VALUES

We aggregated and weighted the z-scores for each indicator to calculate an overall index value for each nation and region in each of the two domains. We also re-based the values to generate more intuitive results using the following formula:

Re-based index value = 50 + (25 x z-score)

This re-basing means that a value of 50 is equivalent to the UK average, with values greater (less) than 50 indicating that prospects are above (below) the UK average. The index values also provide insight into the degree to which performance differs across nations and regions since 25 points is equivalent to one standard deviation. For example, a value of 75 is one standard deviation greater than a value of 50.

Index values are capped such that they could not fall below zero or exceed 100. An area which is two or more standard deviations above the UK average receives the maximum value of 100, while an area which is two or more standard deviations below the UK average receives the minimum value of zero.[28]

To produce theme and domain index values, we multiplied the re-based index values for each indicator by its associated weight, and summed these weighted index values across all indicators in a theme or domain.

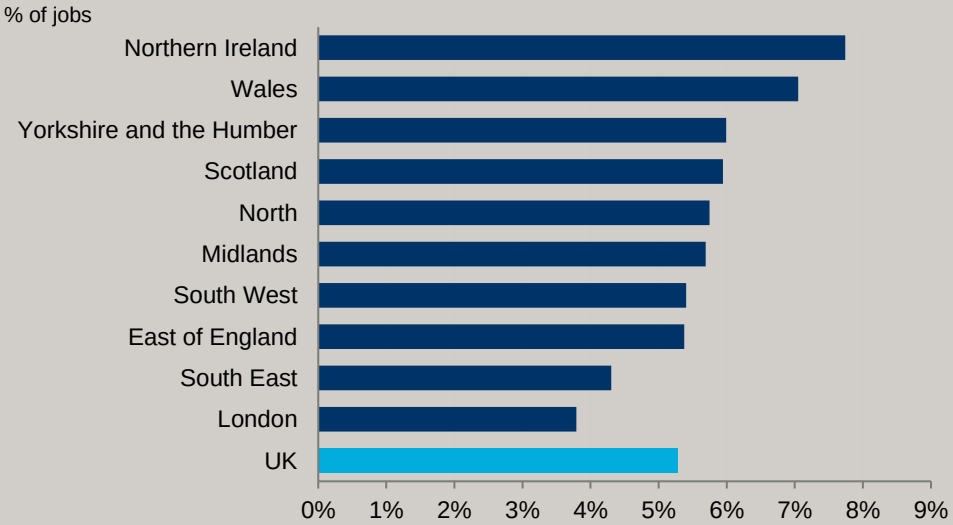
Once the indices were in place we undertook further sensitivity testing to ensure the resulting rankings were stable to alternative formulations.

[28] Our analysis suggested that constraining the index values in this way had very little impact on the final results.

APPENDIX 2: INDICATORS USED IN THE GREEN GROWTH CHALLENGE INDEX

DEPENDENCE ON CARBON-INTENSIVE INDUSTRY

Share of jobs in high emissions sectors, 2018



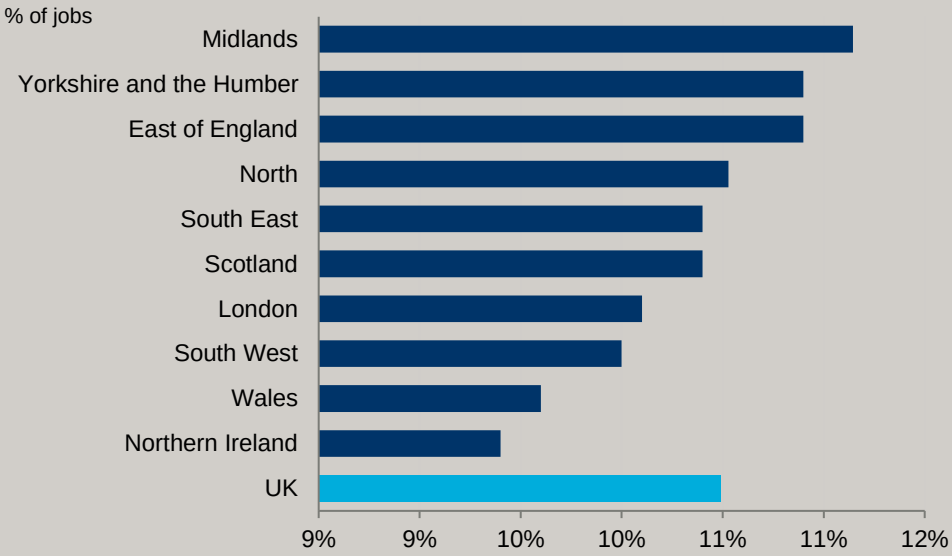
Source: Oxford Economics analysis of ONS data

We used data from ONS on total greenhouse gas emissions (GHG) emissions by 2-digit SIC industry to identify the top 10 highest emitting industries.[29] These were found to be:
(01) Crop and animal production, hunting and related service activities
(06) Extraction of crude petroleum and natural gas
(19) Manufacture of coke and refined petroleum products
(20) Manufacture of chemicals and chemical products
(23) Manufacture of other non-metallic mineral products
(24) Manufacture of basic metals
(35) Electricity; gas; steam and air conditioning supply
(38) Waste collection; treatment and disposal activities; materials recovery
(49) Land transport and transport via pipelines
(51) Air transport

We calculated the share of each nation and region's employment which falls within these 10 industries using our own estimates derived through a combination of the ONS Business Register and Employment Survey and ONS Workforce Jobs series.

[29] ONS, *Atmospheric emissions: greenhouse gases by industry and gas*, accessed July 2021.

Share of jobs requiring upskilling for net zero

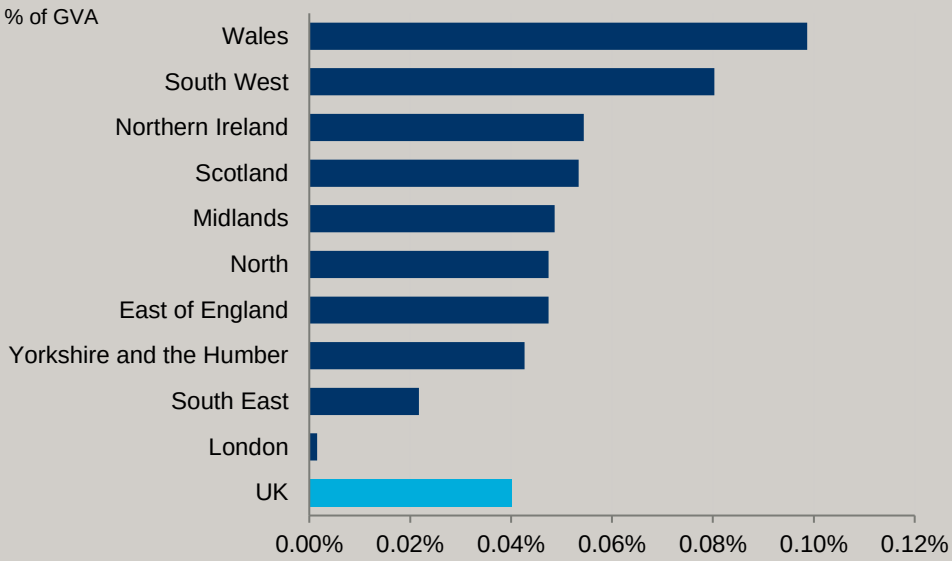


Source: Robins, N. et al.

These data were taken from a research paper by Robins et al.[30] The researchers drew on earlier research in the US which estimated the share of jobs in each industry that would be affected in different ways by the green transition. They then applied these findings to UK labour market data to estimate the share of jobs in each area that could be substantively impacted. Results for Northern Ireland are based on 2013 data and for England, Wales and Scotland they are based on 2011 figures.

[30] Robins, N. et al., *Investing in a just transition in the UK: How investors can integrate social impact and place-based financing into climate strategies*, 2019.

Reliance on livestock farming: share of GVA in livestock and livestock products, 2018



Source: ONS, DEFRA, Scottish Government, Welsh Government, DAERA Northern Ireland

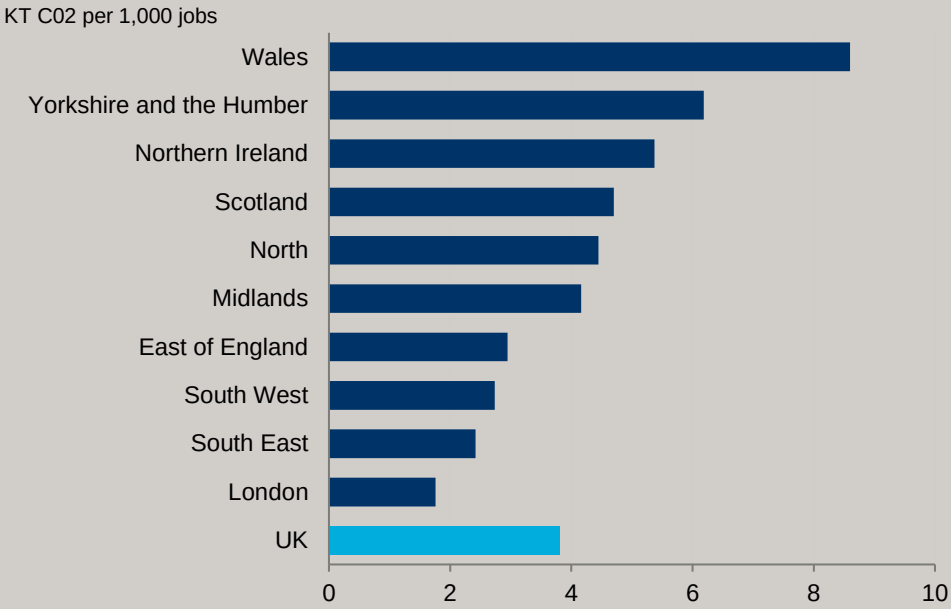
Data on GVA from livestock and livestock products were obtained from DEFRA for England, Welsh Government for Wales, Scottish Government for Scotland and DAERA for Northern Ireland.[31,32,33]

We converted these data to a share of each nation or region's GVA using data from the ONS Annual Business Survey. The data shown above therefore represent GVA from livestock farming as a share of total GVA in the non-financial business economy.

[31] Agriculture and Rural Economy Directorate, *Scottish agriculture tables – economic report: 2020 edition*, accessed July 2021.
[32] Statistics for Wales, *Aggregate agricultural output and income, 2020*, accessed July 2021.
[33] Department of Agriculture, Environment and Rural Affairs, *Statistical review of NI agriculture 2007 onward*, accessed July 2021.

EMISSIONS

Industry and commercial emissions, 2018



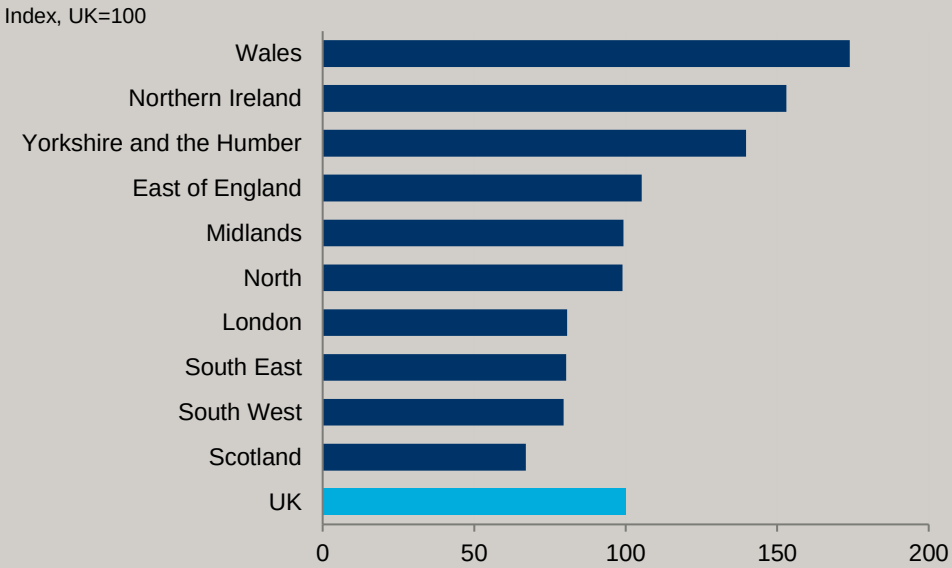
Source: Oxford Economics analysis of BEIS data

Industry and commercial emissions data were obtained from the UK local authority and regional carbon dioxide emissions national statistics dataset published by BEIS.[34]

We estimated emissions per 1,000 jobs by dividing emissions by our own employment figures which are derived using data from the ONS Business Register and Employment Survey and the ONS Workforce Jobs series.

[34] Department for Business, Energy & Industrial Strategy, *UK local authority and regional carbon dioxide emissions national statistics: 2005 to 2018*, accessed July 2021.

Commercial emissions relative to expected level given sector mix, 2018
A value greater (less) than 100 indicates that a nation or region has above (below) average emissions after controlling for its industrial structure.



Source: Oxford Economics analysis of BEIS data

These values were estimated by Oxford Economics using data from ONS and BEIS. To do so we divided two indices as follows:

*(Actual emissions per job index) / (Expected emissions per job index) * 100*

Actual emissions per job index:

- Actual industry and commercial CO2 emissions by region were sourced from BEIS.[35]
- We divided industry and commercial CO2 emissions by employment in each region to estimate the actual level of industrial and commercial CO2 emissions per job.
- We then divided each nation and region's value by actual industrial and commercial CO2 emissions per job in the UK to create an index. A value of less than 100 indicates actual industrial and commercial CO2 emissions per job are below the UK average.

Expected emissions per job index:

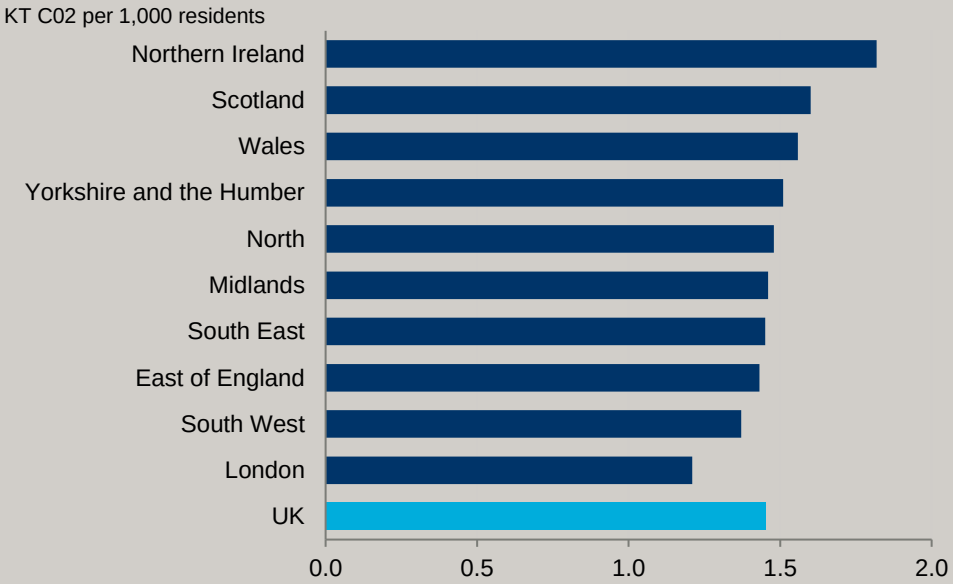
- We estimated average CO2 emissions per job in each 2-digit industry at the national level, using emissions by industry from the ONS[36] and our own employment figures which are derived using data from the ONS Business Register and Employment Survey and the ONS Workforce Jobs series.
- We then multiplied the results for CO2 emissions per job by the share of jobs in each industry in each nation and region to obtain an estimate of the expected level of CO2 emissions per job in each region.[37] These results represent the level of commercial and industrial CO2

[35] Department for Business, Energy & Industrial Strategy, *UK local authority and regional carbon dioxide emissions national statistics: 2005 to 2018*, accessed July 2021.
[36] ONS, *Atmospheric emissions: greenhouse gases by industry and gas*, accessed July 2021.
[37] We excluded emissions in the transport sector, since actual industry and commercial CO2 emissions excludes emissions relating to transport, which are measured separately.

emissions per job that would prevail in the area if CO2 emissions in each industry were in line with the UK average.

- We divided the expected level of CO2 emissions per job in each nation and region by the expected level of CO2 emissions per job in the UK to create an index. A value of less than 100 indicates expected CO2 emissions per job are below the UK average.

Household emissions, 2018



Source: Oxford Economics analysis of BEIS data

Domestic emissions data were obtained from the UK local authority and regional carbon dioxide emissions national statistics dataset published by BEIS and refer to CO2 emissions within the dwelling. Domestic emissions include those related to the domestic use of electricity, gas and other fuels.[38]

We estimated emissions per 1,000 residents by dividing emissions by the ONS Mid-Year Population Estimates.[39]

[38] Department for Business, Energy & Industrial Strategy, *UK local authority and regional carbon dioxide emissions national statistics: 2005 to 2018*, accessed July 2021.
[39] ONS, *Estimates of the population for the UK, England and Wales, Scotland and Northern Ireland*, accessed July 2021.

Transport emissions, 2018

Source: Oxford Economics analysis of BEIS data

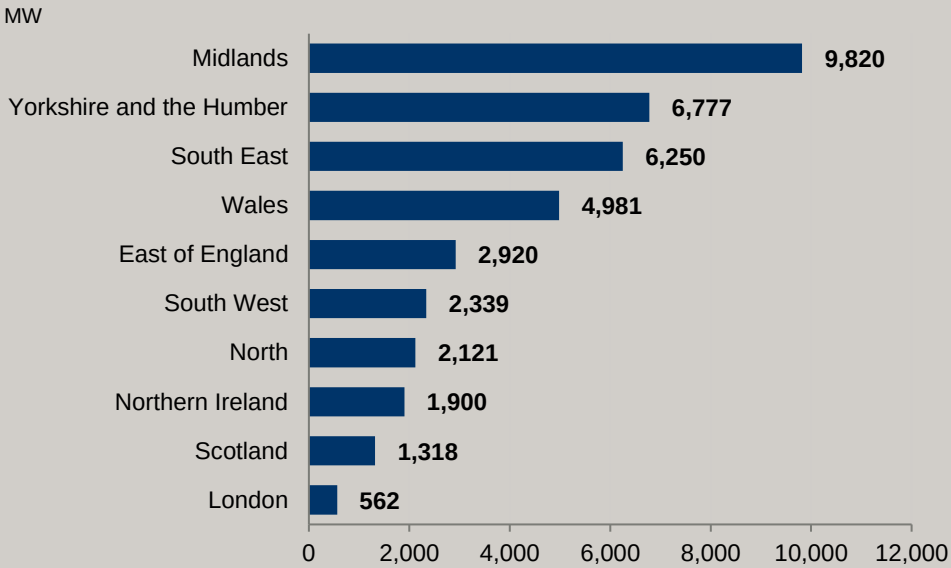
Transport emissions data were obtained from the UK local authority and regional carbon dioxide emissions national statistics dataset published by BEIS and refer to freight and passenger transport, for private and business purposes.[40]

We estimated emissions per 1,000 residents by dividing emissions by the ONS Mid-Year Population Estimates.[41]

[40] Department for Business, Energy & Industrial Strategy, *UK local authority and regional carbon dioxide emissions national statistics: 2005 to 2018*, accessed July 2021.
[41] ONS, *Estimates of the population for the UK, England and Wales, Scotland and Northern Ireland*, accessed July 2021.

FOSSIL FUEL POWER INFRASTRUCTURE

Fossil fuelled generating capacity, end of May 2020



Source: BEIS Digest of UK Energy Statistics 2020

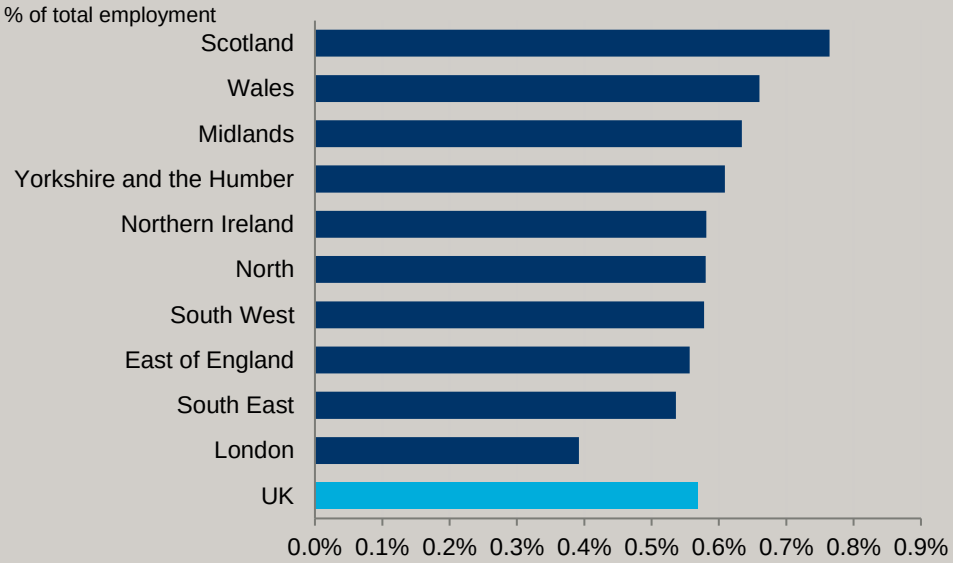
We used the BEIS Digest of UK Energy Statistics published in 2020 and aggregated the installed capacity of fossil fuel power stations operational at the end of May 2020 at the regional and country level to obtain an estimate of total installed capacity in the nation or region.[42]

[42] Department for Business, Energy & Industrial Strategy, *Digest of UK Energy Statistics (DUKES): electricity*, accessed July 2021.

APPENDIX 3: INDICATORS USED IN THE GREEN GROWTH OPPORTUNITY INDEX

BASE OF GREEN INDUSTRY

Current green economy jobs, 2019



Source: Oxford Economics analysis of ONS LCREE data

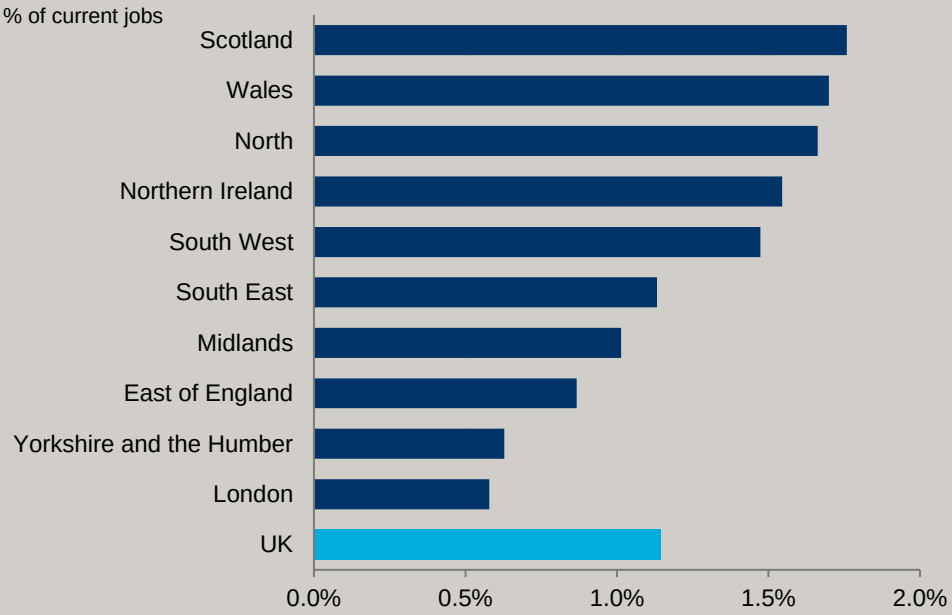
We used ONS estimates of jobs in the Low Carbon and Renewable Energy Economy (LCREE) and our own employment figures (derived using data from the ONS Business Register and Employment Survey and the ONS Workforce Jobs series) to estimate LCREE jobs relative to total employment in each UK country.[43]

Estimates for English regions were imputed using the share of employment in the UK that corresponds to an LCREE category at the industry level and then applying those shares to the industry mix of each region. We re-scaled the results to align with the reported LCREE figure for England.[44]

[43] ONS, *Low carbon and renewable energy economy estimates*, accessed April 2021.

[44] The ONS LCREE estimates are presented on a full-time equivalent (FTE) basis, whereas our total employment figures are only available on a headcount basis. Under the assumption that the relationship between FTE and headcount employment is relatively consistent across the UK, this slight discrepancy should not substantively impact on the operation of the index.

Energy jobs need by 2050



Source: National Grid, *Building the Net Zero Energy Workforce*, 2020

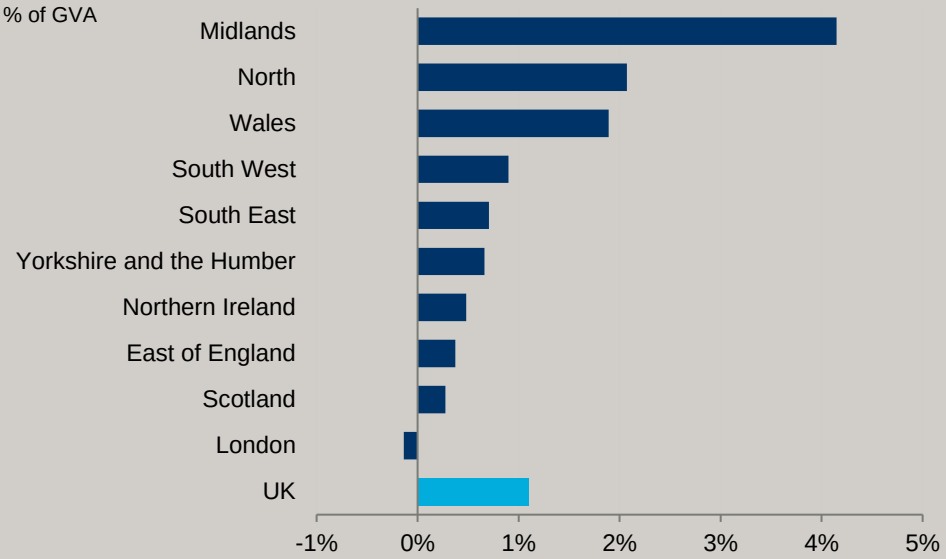
The National Grid estimated the future workforce required to support the UK energy sector in reaching net zero by 2050.[45] Their estimates of employment include direct activity in the energy sector—through the operation, generation, transmission, distribution, and retail of energy—as well as supply chain activity related to building, upgrading, maintaining, and operating infrastructure required to reach net zero.

The National Grid estimates include both the new jobs created in the energy sector, and the need to fill existing roles of those who will leave the workforce (e.g. through retirement). Their sub-national estimates were compiled using a range of sources, including existing employment and labour market trends, planned infrastructure through the development pipeline, desk-based research and independent future forecasts.

To reflect the relative opportunity within each nation or region, we considered future jobs as a proportion of current employment within each area, drawn from Oxford Economics' estimates of total employment, which are in turn based on ONS survey data.

[45] National Grid, *Building the Net Zero Energy Workforce*, 2020.

Motor vehicle manufacturing, 2018



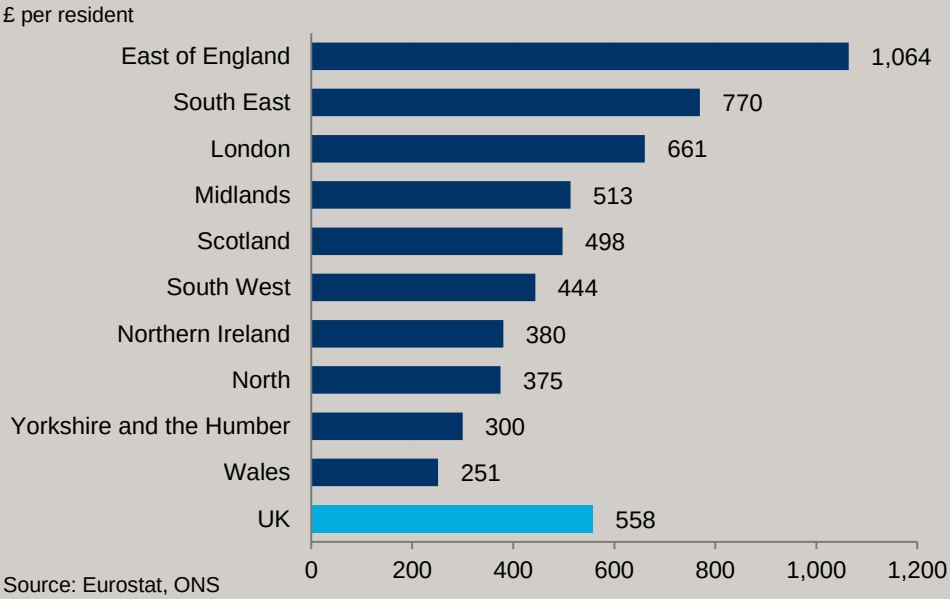
Source: ONS
Note: The ONS reports a negative GVA figure of minus £425 million for London's automotive industry. Firms participating in the ONS survey can report a negative GVA if they report larger values of purchases than their total turnover in the same period. ONS has noted that low levels of acitivity in this industry in London mean that the region's results are likely to be sensitive to the figures reported by a small number of firms.

These data were taken from ONS Annual Business Survey data for GVA at a 2-digit industry level in each nation and region of the UK.[46] The data show GVA from the manufacture of motor vehicles, trailers and semi-trailers as a share of total GVA in the non-financial business economy.

[46] ONS Annual Business Survey, *Non-financial business economy, UK regional results; sections A to S*, accessed July 2021.

INNOVATION

Research and development expenditure, 2018



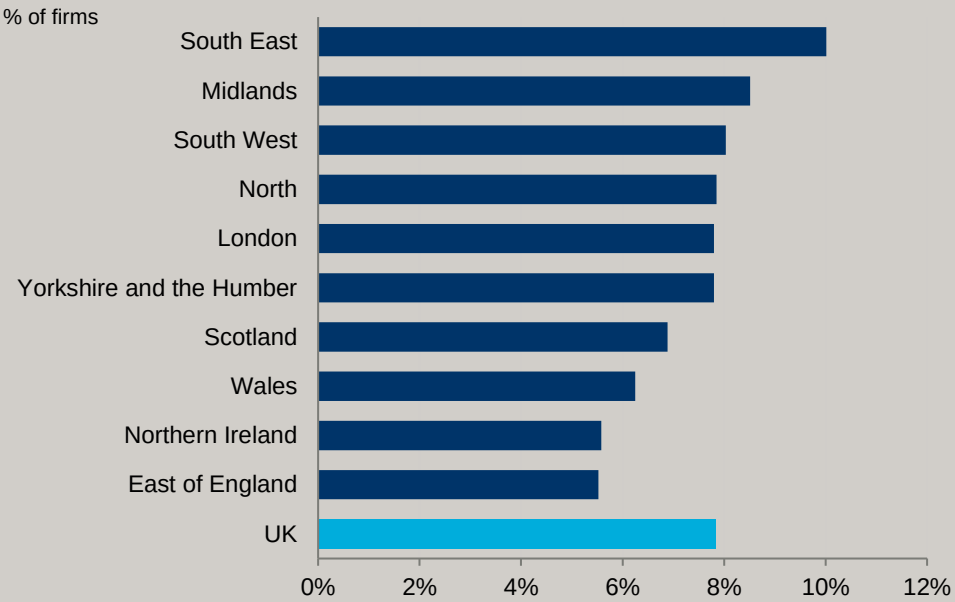
Source: Eurostat, ONS

These datapoints were calculated using Eurostat's Gross Domestic Expenditure on Research and Development (GERD) by sector of performance and NUTS 2 regions dataset.[47] We divided these data by ONS Mid-Year Population Estimates to obtain values per resident.[48]

[47] Eurostat, *GERD by sector of performance and NUTS 2 regions*, accessed July 2021.

[48] ONS, *Estimates of the population for the UK, England and Wales, Scotland and Northern Ireland*, accessed July 2021.

Firms innovating to reduce their environmental impact



Source: BEIS UK Innovation Survey 2016-18

These data were derived by combining two responses from the BEIS UK Innovation Survey.[49] The first was the share of firms identified as a "broad innovator" in each region or nation.[50] The second was the share of "broad innovators" who cited reducing environmental impact as highly important in their decision to innovate.

To obtain an indicator relative to the overall stock of firms in each part of the UK we multiplied the first data point by the second.

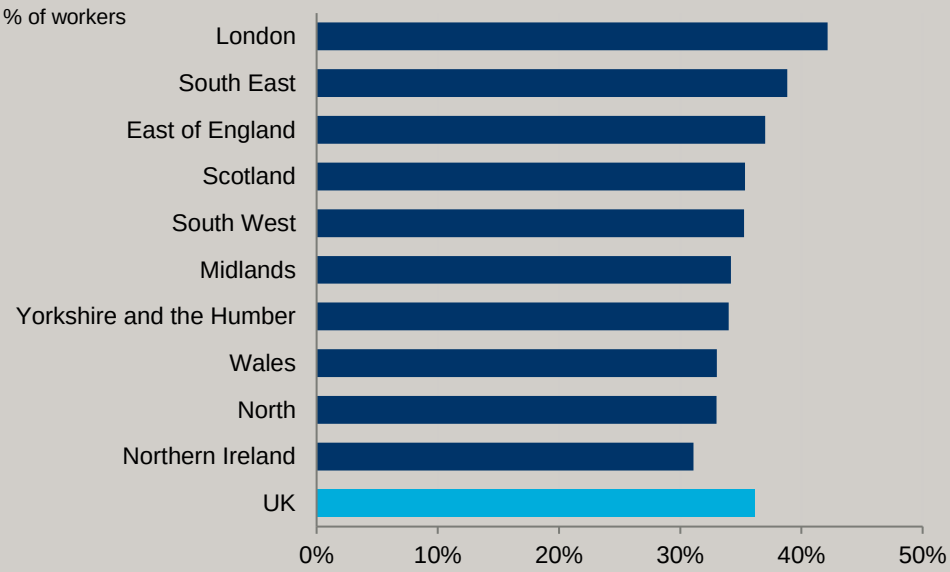
[49] Department for Business, Energy & Industrial Strategy, *UK innovation survey 2019: main report*, accessed July 2021.

[50] A business that has engaged in any of the following activities is defined as a "broad innovator":

- Introduction of a new or significantly improved product (good or service) or process
- Engagement in innovation projects not yet complete or abandoned
- New and significantly improved forms of organisation, business structures or practices and marketing concepts or strategies
- Activities in areas such as internal research and development, training, acquisition or external knowledge or machinery and equipment linked to innovation activities.

SKILLS AND TRAINING

Science, technology, engineering, maths (STEM) workers, 2020



Source: ONS

We combined the employment by occupation figures published by the ONS in its Annual Population Survey[51] with a separate list of Core STEM occupations published by the ONS[52]. The ONS classifies 27 occupations as core STEM and these include, for example, engineering professionals, conservation and environment professionals, and research and development managers.

[51] ONS, *Annual population survey – regional – employment by occupation*, accessed July 2021.

[52] ONS, *Employment in science, technology, engineering and mathematics (STEM) occupations and industries, Scotland, 2011 and 2017*, accessed July 2021.

Higher education students in green-related subjects, 2019/20

Students per 1,000 residents

Source: HESA, ONS

We used data from the Higher Education Statistics Agency on the number of Higher Education student enrolments in the academic year of 2019/20 by subject of study at the most detailed level available.[53] We analysed the full list of subjects available and identified those that are green-related, such as subjects within agriculture, food and related studies, mathematical sciences, engineering and technology, biology, and information technology.

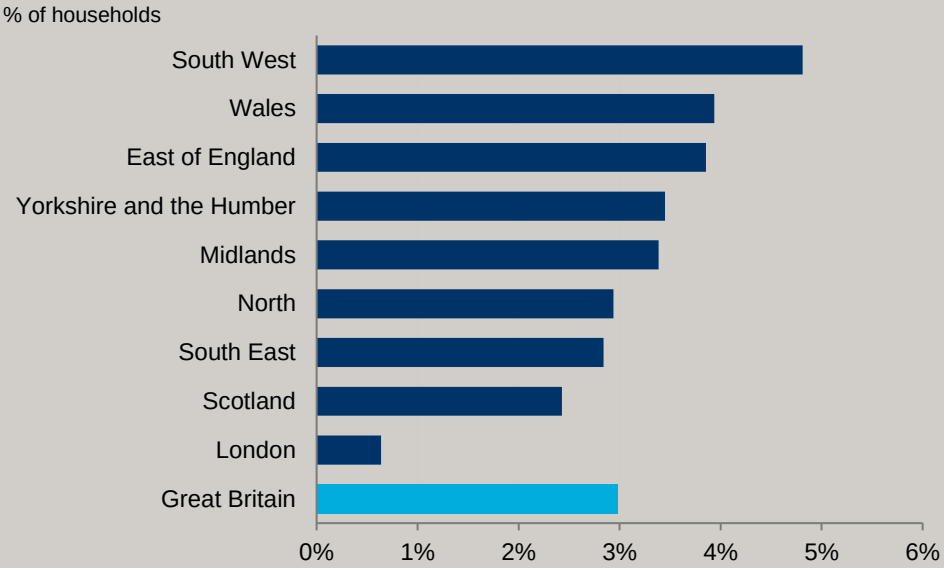
We present the data per 1,000 residents using ONS Mid-Year Population Estimates.[54]

[53] HESA, *HE provider and subject of study 2019/20*, accessed July 2021.

[54] ONS, *Estimates of the population for the UK, England and Wales, Scotland and Northern Ireland*, accessed July 2021.

RENEWABLE ENERGY

Domestic renewable energy installations, 2019

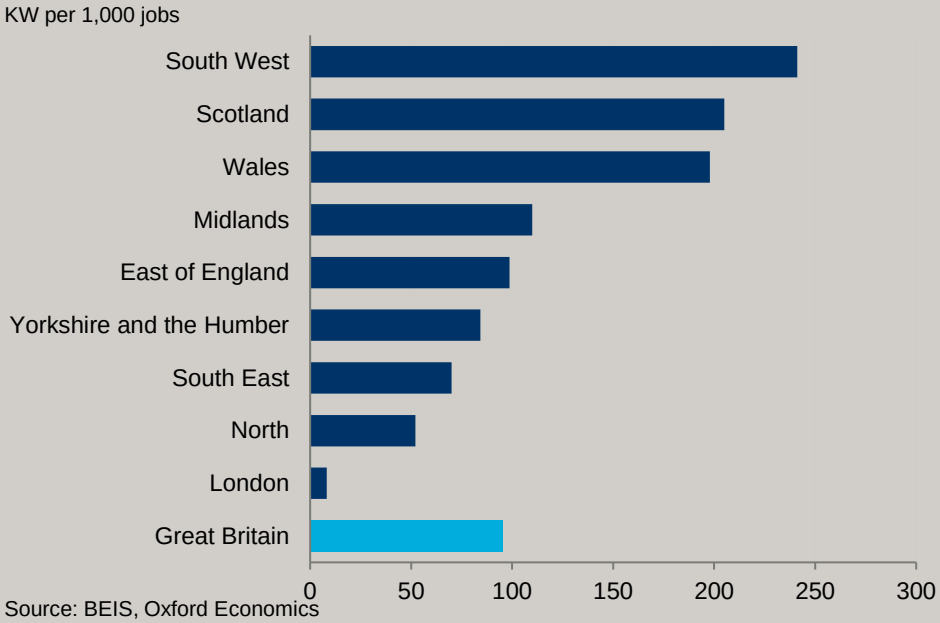


Source: BEIS
Note: Data unavailable for Northern Ireland. Within the scoring, NI was assumed to receive the GB average value to avoid distorting its score either positively or negatively.

We used the BEIS Sub-national Feed-in Tariff Statistics dataset which presents data on the number of domestic renewable installations registered in the Feed-In Tariff for England, Scotland, and Wales.[55] These include Photovoltaics, Wind, Hydro, Anaerobic Digestion, and Micro CHP installations. The number of households was obtained from household projections for 2019 from the Department for Communities and Local Government in England, the Welsh Government in Wales, and the National Records of Scotland in Scotland.[56]

[55] Department for Business, Energy & Industrial Strategy, *Sub-regional Feed-in Tariffs statistics*, accessed July 2021.
[56] Ministry of Housing, Communities & Local Government, *Live tables on household projections*, accessed July 2021.

Commercial renewable energy capacity, as at end of March 2019



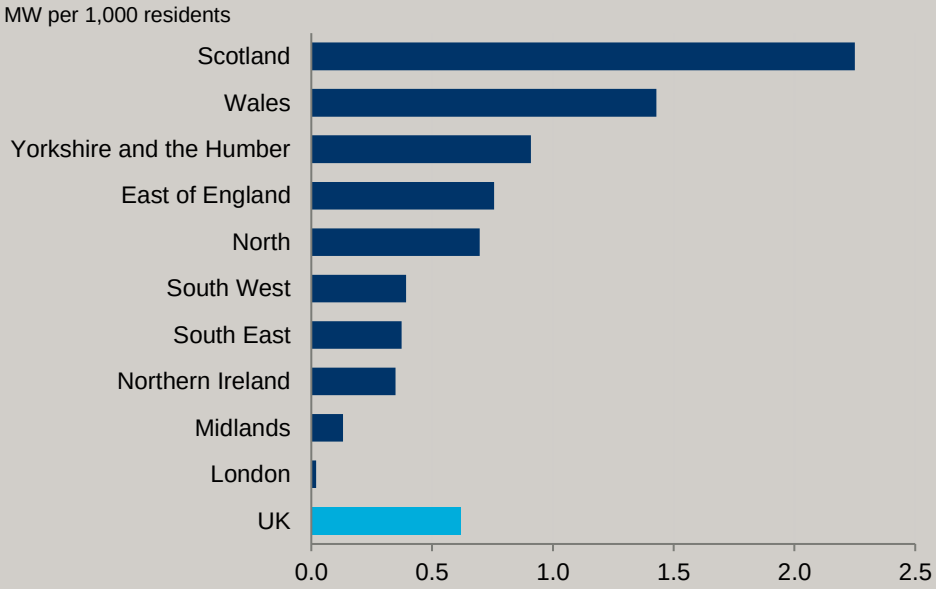
Source: BEIS, Oxford Economics

We used BEIS Sub-national Feed-in Tariff Statistics on the capacity of renewable non-domestic installations registered for the Feed-In Tariff in England, Scotland, and Wales at the end of March 2019. These include Photovoltaics, Wind, Hydro, Anaerobic Digestion and Micro Combined Heat and Power installations.[57]

We calculated the installed renewable non-domestic capacity registered in the programme per 1,000 jobs in each area using our own employment estimates derived through a combination of the ONS Business Register and Employment Survey and ONS Workforce Jobs series.

[57] Department for Business, Energy & Industrial Strategy, *Sub-regional Feed-in Tariffs statistics*, accessed April 2021.

Grid renewable energy capacity, as at end of May 2020

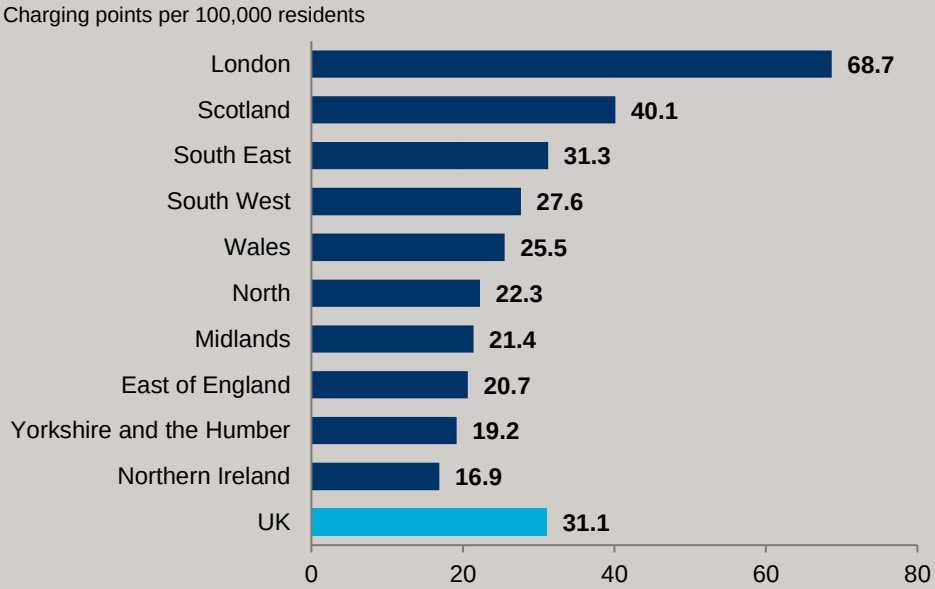


Source: BEIS Renewable Energy Planning Database, Oxford Economics

Data were based on the BEIS Digest of UK Energy Statistics published in 2020.[58] We aggregated to calculate the installed capacity of renewable source power stations operational at the end of May 2020 in each nation and region. We divided the installed renewable capacity measure by 2019 ONS Mid-Year Population Estimates by region.[59]

[58] Department for Business, Energy & Industrial Strategy, *Digest of UK Energy Statistics (DUKES): electricity*, accessed July 2021.
[59] ONS, *Estimates of the population for the UK, England and Wales, Scotland and Northern Ireland*, accessed July 2021.

Electric vehicle charging points, 2021



Source: Department of Transport, ONS

Data were taken from the Department for Transport's Electric Vehicle Charging Device Statistics which provide figures for the number of publicly available electric vehicle charging devices per 100,000 residents.[60] Population figures were sourced from 2019 ONS Mid-Year Population Estimates (the latest available at the time we undertook the analysis).[61]

[60] Department for Transport, *Electric vehicle charging device statistics: January 2021*, accessed July 2021.
[61] ONS, *Estimates of the population for the UK, England and Wales, Scotland and Northern Ireland*, accessed July 2021.

APPENDIX 4: SOURCES FOR REGIONAL ECONOMIC INDICATORS

GVA

Oxford Economics' estimates for 2018, which are derived using data from the ONS Regional Accounts.

JOBS

Oxford Economics' estimates for 2018, which are derived using data from the ONS Business Register and Employment Survey and the ONS Workforce Jobs series.

POPULATION

2018 ONS Mid-Year Population Estimates.[62]

EMISSIONS

Total emissions in 2018 from the UK local authority and regional carbon dioxide emissions national statistics dataset published by BEIS (the latest available at the time we undertook the analysis).[63]

[62] ONS, *Estimates of the population for the UK, England and Wales, Scotland and Northern Ireland*, accessed July 2021.
[63] Department for Business, Energy & Industrial Strategy, *UK local authority and regional carbon dioxide emissions national statistics: 2005 to 2018*, accessed July 2021.

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