CENTRE for ECONOMIC PERFORMANCE

Grantham Research Institute on Climate Change and the Environment

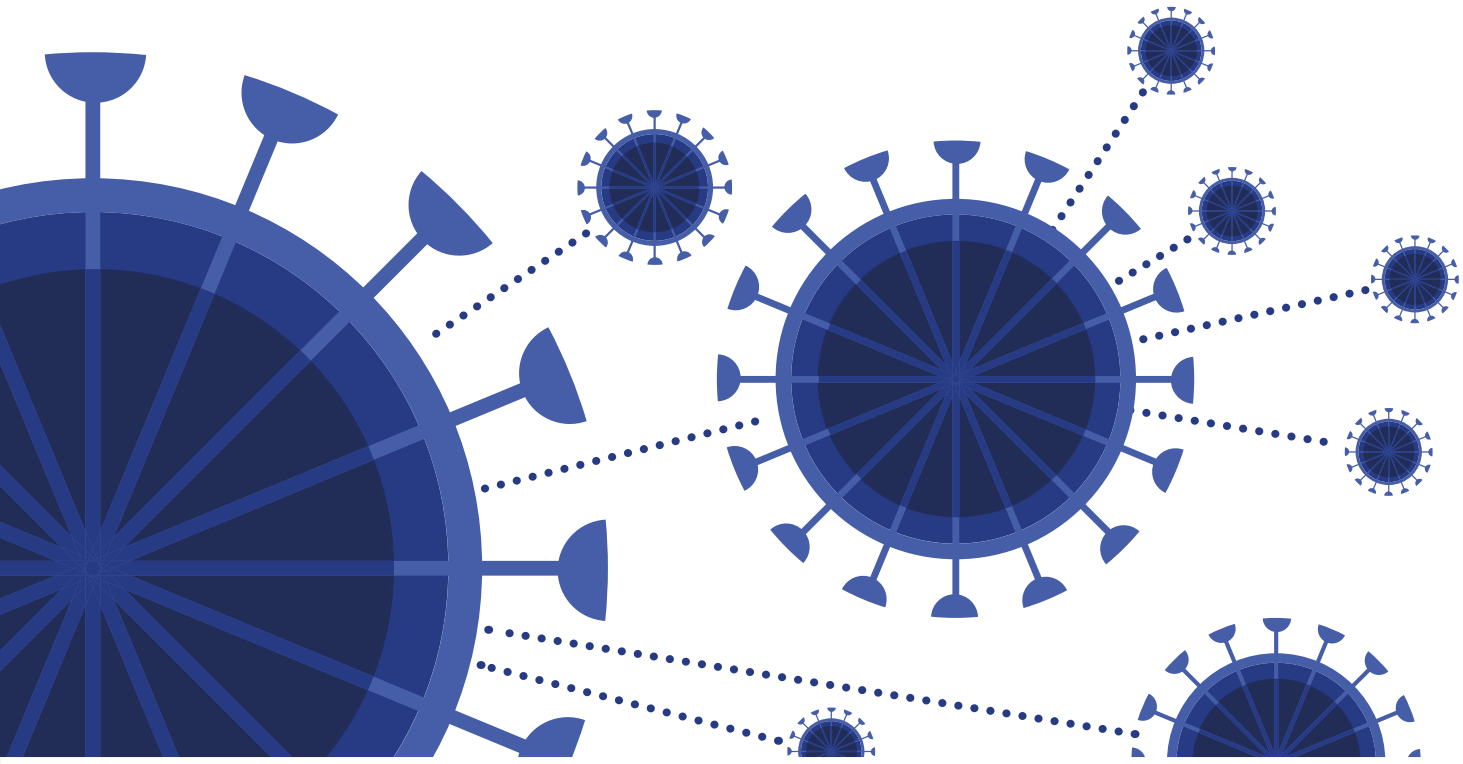
A series of background briefings on the policy issues arising from the Covid-19 pandemic

Jobs for a strong and sustainable recovery from Covid-19

Sam Unsworth
Pia Andres
Giorgia Cecchinato
Penny Mealy
Charlotte Taylor
Anna Valero

A CEP Covid-19 analysis

Paper No.010



LSE THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

UKRI Economic and Social Research Council

CENTRE *for* ECONOMIC PERFORMANCE

Jobs for a Strong and Sustainable Recovery from Covid-19[1]

CEP COVID-19 ANALYSIS

Sam Unsworth, Pia Andres, Giorgia Cecchinato, Penny Mealy, Charlotte Taylor and Anna Valero

October 2020

Foreword

The Covid-19 pandemic has inflicted a major shock on the UK economy, with the loss of many jobs, as well as illness and tragic loss of life. With the real risk of prolonged economic damage, only strong and timely action can increase consumer and business confidence, steer expectations and channel productive private and public investment into a sustainable, inclusive and resilient recovery across the UK.

Such a recovery can be achieved while the Government also tackles its other strategic challenges. Indeed, the investment needed for the recovery can be strengthened if it is part of a coherent medium and longer-term strategy. The UK was the first major economy to enter a commitment into law to achieve net-zero annual emissions of greenhouse gases by 2050, which requires transformative change across the economy. The Government has also made commitments to improving productivity, investing in infrastructure, 'levelling up' across the country and forging a new role as 'Global Britain'. The combination of these medium and longer-term commitments creates a whole-economy opportunity to drive economic recovery and growth through sustainable investment, innovation and creativity, while providing international leadership on climate change. By orienting the economy towards zero-carbon goods and services, the UK can seize economic opportunities from the global transition as demand rises for zero-carbon activities.

Investments in the transition to a zero-emissions and climate resilient economy can be made quickly, and would deliver significant benefits in terms of both generating employment and stimulating demand in the short term, while building productive capacity for innovation-led growth in the medium to longer term, and also helping to address climate risk and generate other attractive co-benefits. These investments are the focus of this paper which considers the evidence for the scale of job opportunities across key areas of the sustainable economy, including energy efficiency in buildings, natural capital projects, active travel equipment and infrastructure, renewable power generation and distribution, electric vehicle production and charging infrastructure, and carbon capture utilisation and storage and hydrogen production. The evidence gathered in this paper suggests that a portfolio of net-zero-aligned investments could create jobs across the UK in the short run, and growth opportunities into the medium and longer run.

The UK has made a strong start, setting out commitments to energy efficiency in buildings and offshore wind, but a step-change is needed given the scale of the challenge. The Prime Minister has announced his intention to produce a ten-point plan for a green industrial revolution, and this should also drive the UK's economic recovery, including the creation of new jobs for the future. This vision for a prosperous

[1] We are grateful to the following for their helpful comments on the draft: Alex Bowen, Henry Overman, James Rydge, Nicholas Stern, Andrew Sudmant, Victoria Sutherland, Bob Ward, Helen Ward and Dimitri Zenghelis.

Centre for Economic Performance
London School of Economics and Political Science
Houghton Street, London WC2A 2AE, UK
Tel: +44 (0)20 7955 7673
Email: cep.info@lse.ac.uk Web: http://cep.lse.ac.uk

LSE The London School of Economics and Political Science
UKRI Economic and Social Research Council

and sustainable economy can be realised through stronger and more co-ordinated policies, incentives and institutions across skills, infrastructure and innovation, brought together with a relaunched and long-term industrial strategy, and a new National Investment Bank to help leverage sustainable private sector investments in a robust and growing economy.

A well-designed programme for a sustainable recovery should help to redefine and strengthen the UK's place in the world. As the UK assumes the leadership of the G7 and works to deliver a successful and ambitious COP26 in 2021, a domestic economic recovery that is strong, sustainable, inclusive and resilient will provide added credibility to foster and lead collaborative efforts to build global sustainability and resilience, and accelerate the transition to zero-carbon economic growth.

Nicholas Stern
Co-Chair of the LSE Growth Commission
Chair of the Grantham Research Institute on Climate Change and the Environment

Summary

- The UK's future economic, social and environmental prosperity will be shaped by how it deals with, and recovers from, the impact of Covid-19. This paper sets out coordinated net-zero-aligned investments which the UK can place at the heart of its recovery plan. We provide evidence on the benefits they can deliver in generating employment and stimulating demand in the short term, and building capacity for innovation-led growth in the medium to longer term.
- We consider energy efficiency in buildings; natural capital projects; active travel equipment and infrastructure; renewable power generation and distribution; electric vehicle production and charging infrastructure; and carbon capture, utilisation and storage (CCUS) and hydrogen production.
- We set out evidence from a range of sources including ex-post evaluations and more forward-looking forecast-based studies; looking at short-run and long-run job creation and broader benefits. We also present new analysis on where these economic opportunities might lie. Together, these analyses can inform UK decisions on where to focus investment in the recovery from Covid-19.
- The evidence suggests that net-zero-aligned investments can play an important role in generating employment and other benefits across the UK:
  - Net-zero-aligned investments in sectors such as clean automotive, hydrogen and CCUS, renewable energy and housing energy efficiency can each generate tens of thousands of high wage jobs.
  - A portfolio of net-zero-aligned investments could create jobs across the UK in the short run.
  - In the medium to long run, there are several high -value, complex net-zero-aligned products that are relatively close to the UK's existing capabilities and can drive growth opportunities.
- In order to capture such benefits, government can:
  - Place net-zero-aligned investments at the heart of the UK's recovery plan;
  - Draw on diverse economic evidence to design recovery policies and investments seeking to create and sustain jobs, allowing for where in the UK jobs might be created in the short run, and sustained into the longer run, based on comparative advantage in production and innovation;
  - Ensure robust monitoring and evaluation for investments made in the recovery package, to expand the evidence base and inform future policy;
  - Complement net-zero-aligned investments with targeted re-skilling for those displaced in the current crisis and those that will be displaced by ongoing technological change and the zero-carbon transition; and
  - Accompany strategic investments with strengthened policies, institutions and regulation to direct private sector investment towards achieving societal goals such as net zero, starting with a robust, net-zero-aligned carbon price, a National Investment Bank and a relaunched, long-term Industrial Strategy with sustainability at its core.

Introduction

The UK's future economic, social and environmental prosperity will be shaped in large part by how it deals with, and recovers from, the impact of Covid-19. Alongside the Covid-19 shock, in the coming months the UK will have to adjust to existence outside the EU. These challenges occur against a background of weak growth in productivity and real wages since the financial crisis, and large inequalities across and within the UK's regions.

This paper highlights the opportunity for the UK to 'build back better' from the crisis via investment in a strong, sustainable, inclusive and resilient recovery that can embody the government's pre-articulated goals of reaching net-zero greenhouse gas emissions by 2050; boosting productivity; 'levelling up' across the UK; investing in infrastructure; and forging a new role for 'Global Britain' (Stern et al., 2020). In order to achieve these objectives, targeted public investments must be complemented with a coherent set of regulations and policies including an effective carbon price, a new National Investment Bank, and underpinned by a re-emphasised Industrial Strategy which can reduce uncertainty for businesses and hence encourage further necessary investments by the private sector.

The broader principles around strategy, investment and policy for a sustainable recovery are set out in Stern et al., (2020) including how sustainability objectives can be embedded in government support packages. Here, we focus on a series of proactive, coordinated net-zero-aligned investments that the UK can place at the heart of its plan for recovery:[2]

- Energy efficiency in buildings;
- Natural capital projects;
- Active travel equipment and infrastructure, such as bicycles and cycle lanes;
- Renewable power generation and distribution;
- Electric vehicle production and charging infrastructure; and
- Carbon capture, utilisation and storage and hydrogen production[3].

Investments in these technologies and capabilities are widely recognised as aligning with the critical decarbonisation actions which need to be taken by the UK to get on track for reaching net-zero emissions by 2050 and are consistent with those outlined by the Committee on Climate Change (CCC, 2020a). In this paper we set out evidence related to the economic and societal benefits these investments can deliver in the short term via generating employment and stimulating demand, and over the longer term by building productive capacity.

In the short term, there is an urgent and immediate demand for labour-intensive and hence job-creating investments, to address the large-scale labour market displacements as the Covid-19 crisis continues to unfold and crucially, to help avoid costly and damaging labour market scarring. As at September 2020, there were 673,000 fewer people in employment compared with March 2020 (ONS, 2020) and over 9 million jobs were still furloughed (HMRC, 2020). Redundancies have risen to their highest level since 2009 (ONS, 2020), and even with extra support announced by the Chancellor in the Job Support Scheme, further large-scale redundancies are expected in the coming months as many jobs are not expected to be viable once we emerge from the crisis (IFS, 2020).

[2] We note that the set of investments outlined here do not represent an exhaustive list but action here can catalyse and complement a broader programme of investments in other areas including, for example, electric heat pumps, energy efficiency in the IT sector and green ammonia.

[3] References to hydrogen production in this paper refer to both blue and green hydrogen, in line with the recommendations of the CCC (2019a).

The strategic investments in the areas we highlight can also build capacity for the economy of the future. Such investments, made alongside others such as 5G networks and superfast broadband, innovation and skills more broadly, are also crucial for achieving innovation-led sustainable growth via the production of zero-carbon goods and services for domestic consumption and export. Moreover, they will deliver a series of co-benefits, including cleaner air and smarter and more liveable cities (New Climate Economy, 2018) and hence improve resilience, inclusion and ultimately living standards and well-being. To meet net-zero targets and maximise the economic opportunities in the transition, government must avoid locking-in to carbon intensive infrastructure as occurred following the 2008 financial crisis.

There has been some progress in terms of committing resources towards a sustainable recovery in the UK. Within the £30bn 'Plan for Jobs' set out as part of the Chancellor's Summer Statement, around 3% of the total was dedicated to projects which will clearly align with net zero; most notably the Green Homes Grant, public sector and social housing decarbonisation, as well as specific projects within the Infrastructure Package (UK Government, 2020). New commitments to offshore wind have also been made, forming the first stage of the government's forthcoming ten-point plan for a 'green industrial revolution'.[4] However, packages of support for clean activity announced so far in key comparator countries France and Germany appear larger in magnitude.[5] The UK has an opportunity to build on its announcements to date by initiating a tranche of additional investments, marking the establishment of a coordinated, long-term approach to government spending to achieve net zero.

The rest of this paper is structured as follows. In section 1, we present the overarching rationale for making net-zero-aligned investments at this time where job creation potential is of particular importance. We set out the potential short- and longer-run employment opportunities associated with these investments. In section 2, existing evidence on the likely benefits and impacts associated with these types of investments is then summarised, considering ex-post evaluations of relevant policies in different contexts and more forward-looking analyses that consider potential economic benefits under different modelled scenarios.

We then present two new pieces of analysis in sections 3 and 4. The first draws on geospatial data to demonstrate that a portfolio of net-zero-aligned investments – predominantly in construction / installation - could create jobs across the country in the near term, aligning with the government's goal to 'level up'. The second sets out analysis more focused on manufacturing industries which could support jobs into the longer term as a result of UK-based production. This analysis finds a number of high-value, technologically sophisticated products which could support progress towards net zero, and which are relatively close to the UK's existing capabilities and which could be targeted by policies in the recovery as potential drivers of long-run growth. While 'green' goods and services can be found across the economy (Rydge et al., 2018), including sectors as diverse as education and financial services, this analysis highlights a selection of specific opportunities in the manufacturing sector for the UK.

We conclude with a summary of key themes that emerge from the evidence set out in this paper, which inform policies for recovery.

[4] See https://www.gov.uk/government/news/new-plans-to-make-uk-world-leader-in-green-energy.

[5] For comparisons of resources committed in Covid-19 recovery packages, specifically related to 'clean unconditional' (support for production or consumption of energy that is both low-carbon and has negligible impacts on the environment if implemented with appropriate safeguard), or 'clean conditional' (support the transition away from fossil fuels, but unspecific about the implementation of appropriate environmental safeguards), see https://www.energypolicytracker.org/.

1. The rationale for net-zero-aligned investments in the recovery

In response to a recommendation from the CCC, in 2019 the UK Government legislated the target to reduce aggregate greenhouse gas (GHG) emissions to net zero by 2050. Reaching net zero across the whole economy will be a monumental challenge, and to achieve it, emissions must fall rapidly over the coming decades. Priority actions for the 2020s include energy and materials efficiency, heat networks and heat pumps for buildings; scaling up the EV market in road transport (see Unsworth et al., 2020); largely decarbonising electricity through renewables, flexibility and coal phase-out; establishing industrial CCUS and hydrogen clusters in industry; and afforestation and peatland restoration in the land use sector (CCC, 2019a). Although the technologies exist to meet this ambitious emissions target, technology maturity levels vary and delivery must progress with far greater urgency if the UK is to stay on track (CCC, 2019b).

Though the long-term goal of delivering net zero remains unchanged, the UK must continue on this pathway in the context of the social, economic, and environmental disruption caused by Covid-19. There is an urgent need to restore confidence in the economy, made all the more difficult given current uncertainties over when and how the pandemic and associated restrictions might end. Fear of economic depression, or of continued recession, can become self-fulfilling as banks cut lending, businesses make redundancies or delay investments and individuals curtail spending (DeLong and Summers, 2012). Overleveraging and excess indebtedness after years of lower interest rates constitutes a potential threat to the financial system (Oxford Economics, 2020), especially if a further pandemic weakens the economy so that debts turn bad. Against this background, net-zero-aligned investments can stimulate demand in the short run by getting people back to work and boosting domestic spending. In the medium to longer term, investments in productive, environmentally sustainable and future-proof assets across infrastructure, innovation, skills, natural and social capital will expand capacity, foster productivity growth, reduce inequalities and build economic and environmental resilience (Stern et al., 2020; Bowen and Stern, 2010).

There are a broad range of net-zero-aligned investments to choose from, which can support both these short- and long-run objectives and keep the economy from sinking into protracted depression. Investments in areas which focus on generating short-run employment opportunities can be complemented by strategic investments geared towards achieving deep decarbonisation and long-run innovation-led growth. For instance, in relation to decarbonising the UK's housing stock, there is an opportunity to create immediate jobs across the country by implementing measures to improve energy efficiency (Committee on Climate Change, 2020b). The recovery programme can complement policies and investment related to achieving this short-run objective with policies and investment to direct innovation and skills development towards addressing longer-term, strategic challenges. For instance, R&D funding can be directed towards the supply of zero-carbon heat to buildings, an area which could sustain jobs into the medium to longer term (Hydrogen Taskforce, 2020).

Initial investments made in the recovery, led by the public sector, will be unlikely to catalyse a longer-term increase in investments at the scale necessary if they do not effectively leverage private investment. A consistent, long-term policy, institutional and regulatory framework is required in order to achieve this, helping to direct innovation in line with the government's long-term objectives or 'missions' (Mazzucato, 2014). A re-emphasised and strengthened UK Industrial Strategy, with sustainability at its core, would help to reduce policy uncertainty, and improve co-ordination across policymakers, industry and other stakeholders at the national and local levels. Pricing carbon in line with a pathway to net zero will be of central importance, supported by regulation in key areas such as road vehicle sales to direct private sector innovation and consumer purchasing behaviours in line with the government's long-term objectives. A new National Investment Bank will help crowd in private

sector investment in sustainable projects. Further details on the set of policies and regulation needed for a strong and sustainable recovery can be found in Stern et al., (2020).

Priority net-zero-aligned investments

The categories of investment considered in this paper are described in more detail in Table 1. These map into the UK's highest-emitting sectors,[6] and are investments where there are opportunities for job creation and associated multipliers in the short term, and potential for productivity gains in the longer term.

The investments set out here can be regarded as 'shovel ready' (Bounds, 2020) and are therefore potentially able to relieve the acute, short-term pressure for the recovery package to generate jobs as well as contribute to growth into recovery. Examples of where such gains might come from are given in Table 1. It must be emphasised that this is a non-exhaustive set of investments, and there are several other areas not included which will be essential to enable the UK to reach net zero. For instance, this initial set of investments does not include electric heat pumps and energy storage technologies, which are highlighted by the Committee on Climate Change as being an important technology for net zero (CCC, 2019a). Furthermore, investments can be made in the sectors which are already low or zero carbon, and where the UK has competitive strength, such as business services.

In this analysis, short-run opportunities typically relate to the construction and installation of technologies, whereas medium- to longer-term opportunities also relate to production and R&D related to these technologies.

In the medium to long run, employment opportunities must be considered in the context of a structural transition towards net zero, which will necessarily be of extraordinary scale and pace. Recovery from the Covid-19 pandemic represents a critical juncture at which the UK government can support the industries and jobs of the future, by investing in building the right kind of capacity now. However, careful consideration must be given to the localised impacts of this transition and who might be in need of the new jobs that arise.

Robins et al. (2020) demonstrate that the 10 most deprived constituencies across Great Britain, where thousands of workers are exposed to the risks of the transition, are also constituencies that would benefit from the new jobs and industries associated with the transition. It is estimated that an average of 13.5% of jobs in these 10 constituencies will require reskilling, higher than the national average of 10.5%, while at the same time, 14.2% of the jobs in these areas will be in higher demand in the transition, again above the national average of 10.3% (Robins et al., 2020). This highlights the potential role of net-zero-aligned investments in managing these longer-term structural transitions, as well as the importance of investment in skills. We highlight the geographic spread of potential job opportunities from net-zero-aligned investments in Section 3.

[6] In 2019, surface transport made the largest contribution to the UK's GHG emissions, accounting for 24% of total emissions, while industry contributed 21%, buildings 18% and power 12%. Investment aimed at decarbonising these sectors is, therefore, critical in setting the UK on a pathway to net zero.

Table 1: Categories of 'shovel ready' net-zero-aligned investments, with examples employment opportunities in the short and medium to long run

Category of investment which aligns with net zero	Example drivers of short-run employment in the recovery*	Example drivers of medium- to long-run employment beyond the recovery and towards net zero and sustainable growth*

Carbon capture, utilisation and storage (CCUS) and hydrogen	- Construction and operation of scale pilot projects for hydrogen production
	- Construction and operation of CCUS infrastructure in high emitting industrial clusters
		- Continued construction and operation of infrastructure
		- UK production of, and R&D related to:
		  - Steam reformer equipment
		  - Hydrogen electrolysis production equipment
		  - Hydrogen storage equipment
		  - Hydrogen transmission equipment
		  - Hydrogen-specific home heating equipment
		  - Hydrogen-specific industrial equipment
		  - Carbon capture equipment
		  - Carbon pipeline and transportation equipment
		  - Equipment for feeding carbon into industrial processes
		  - Carbon storage equipment

Renewable power generation and distribution	- Wind turbine and solar PV installation and operation
	- Distribution infrastructure installation and operation
	- Wind turbine and solar PV assembly
		- Continued construction and operation of infrastructure
		- UK production of, and R&D related to:
		  - Wind turbine and solar PV component production and operation
		  - Other emerging generation and distribution technologies (e.g. storage, demand side response)

Electric vehicles (EVs)	- Construction and operation of EV charging infrastructure	- Operation and maintenance of EV charging infrastructure
		- UK production of, and R&D related to:
		  - Raw materials for electric vehicles (e.g. lithium)
		  - Electric vehicle component production
		  - Electric vehicle assembly
		  - Electric vehicle charging infrastructure

Active travel equipment and infrastructure	- Construction and operation of:
	  - Walking infrastructure schemes and networks
	  - Cycling infrastructure schemes and networks
	  - Traffic calming schemes
	  - On-street cycle hire schemes
		- Continued construction and operation of infrastructure
		- UK production of, and R&D related to:
		  - Bicycle component and assembly
		  - Bicycle accessories
		  - Active travel infrastructure

Housing energy efficiency	- Installation of:
	  - Loft insulation
	  - Solid wall insulation
	  - Cavity wall insulation (filling)
	  - Floor insulation (draft proofing)
	  - High efficiency glazing
		- Continued installation of insulation equipment
		- UK production of, and R&D related to:
		  - Insulation equipment
		  - Smart home heating management

Natural capital	- Creating, maintaining or restoring:
	  - Non-woodland ecosystems (e.g. wetlands)
	  - Woodland ecosystems
	  - Saltmarshes and peatlands for carbon sequestration
	  - Parks and urban green space
	  - Sustainable drainage systems (SuDS)
		- Continued creation, maintenance and restoration of natural capital
		- Ecosystems services, such as ecotourism and agroforestry

Notes: This table is indicative. The categories are not mutually exclusive, and many of the areas described as driving long-run employment – typically in production as opposed to installation - may be capable of generating employment in the short run, if the UK has competitiveness in these areas. For a more detailed discussion of UK competitiveness, see section 4. Source: Authors' analysis

Consideration must also be given to the gender dimensions of new jobs created by the recovery package. As Table 1 demonstrates, many of the short-run employment opportunities associated with net-zero-aligned investments are related to manual labour. Based on current labour market structures, jobs in zero-carbon infrastructure construction would most likely be male-dominated. Yet women tend to work more in sectors where jobs are at risk from the current crisis (see for example Hupkau and Petrongolo, 2020 and McKinsey, 2020). Given evidence indicating that the skills for critical net-zero-relevant activities, such as housing energy efficiency retrofits, can be learned on the job (see Annex A of Stern et al., 2020), it will be important to ensure that job creation in the recovery does not follow pre-existing trends rooted in the existing skills and gender dimensions of the UK workforce. As such, this provides a key opportunity for the UK to 'build back better' from both an environmental and social perspective.

2. Existing evidence on net-zero-aligned investments

In 2009, the UK government missed a valuable opportunity to embed the transition to a zero-carbon economy in its response to the global financial crisis. Only 15% of the economic recovery package deployed was assessed at the time to be 'green' (HSBC, 2009). Though lessons can be learned from this experience, there is now more evidence available about green investment options and their job creation potential. The attractive short- and long-run features of a selection of sustainable investments (across active travel, energy efficiency and natural capital) are highlighted in Stern et al., (2020), particularly regarding speed of implementation, labour intensity and multipliers. We build on that previous analysis here.

Taken together, the evidence supports the argument that net-zero-aligned investments could have substantial positive impacts in terms of job creation in the short and longer run. Despite challenges relating to the comparability of studies and evidence gaps, there appears to be consensus across several sources that the number of new jobs associated with different categories of net-zero-aligned investments could be in the order of tens of thousands. There is also mounting evidence that these investments create more jobs than alternative brown investments (The Coalition of Finance Ministers for Climate Action, 2020; Zenghelis and Rydge, 2020).

2.1 Ex-post evidence

A growing body of ex-post evidence confirms that net-zero-aligned investments have some very appealing characteristics in a recession, making them desirable for inclusion in the UK's economic recovery package (Zenghelis and Rydge, 2020). In the short run, **renewable energy infrastructure** has been shown to be particularly labour intensive. A systematic literature review undertaken by the UK Energy Research Centre revealed that, in the short term, investing in new renewable generation capacity or greater energy efficiency creates more jobs than investing in an equivalent level of fossil-fuel-fired generation; the magnitude of the difference being of the order of 1 job per annual GWh produced (UKERC, 2014). While renewable energy requires less labour for operation and maintenance in the long run (Hepburn et al., 2020), the energy cost savings resulting from greater energy efficiency can lead to net employment gains in the wider economy (WRI, 2009), although the effects depend on the conditions in the aggregate labour market.

Construction projects, including **building active travel infrastructure, home energy efficiency retrofits, and planting trees and restoring wetlands** are recognised as being capable of delivering jobs at speed. These projects are not susceptible to offshoring, are less import-intensive than many traditional stimulus measures and can create jobs in all regions of the UK (Stern et al., 2020). Box 1

summarises evidence collected by the What Works Centre for Local Economic Growth (What Works Growth) on the employment effects of investment in these areas.[7]

Box 1: Rapid evidence review - Green investments

The What Works Centre for Local Economic Growth (What Works Growth) has recently conducted a rapid review of the available evidence on the economic costs, benefits and co-benefits of three green policy areas: active travel, energy efficiency and natural capital (forthcoming). The limited number of robust programme evaluations at level 3 or above on the Maryland Scientific Methods Scale for these policies necessitated the adoption of an alternative review methodology. The authors defined a minimum threshold for inclusion of a study in the review, which was met by 12 studies on active travel, 15 on energy efficiency and 10 on natural capital. Nine studies provide estimates on employment. The review's findings on employment effects can be summarised as follows:

Active Travel

Evidence from studies on active travel suggest that investment in this policy area creates between 7 and 14 jobs per USD 1 million. In comparing a range of travel infrastructure project scenarios, covering both active travel and more conventional, automotive-focused travel, a US study finds that the employment impacts of building and refurbishing bicycle-only infrastructure is the most labour intensive option, generating 11.4 in-state jobs per USD 1 million spent. Further, when supply chain-related employment in other states is added, each USD 1 million spent on bicycle-only infrastructure creates an additional 3 jobs. In contrast, the road-only infrastructure project scenario is the least labour-intensive option, creating just 7.8 jobs per USD 1 million invested. At the state level in the US, the state-wide economic impacts of active transport in New Jersey are estimated to have employment multipliers of 2.8 for construction, 1.3 for active transport-related business such as bicycle shops, and 1.6 for active transport-related events, such as bicycle races. Elsewhere, a study of the Linking Communities (2012-13) programme in England estimates that 6.9 FTE jobs were created per £1 million of investment.

Energy Efficiency

Studies on investments in energy efficiency show that spending in this policy area creates more jobs than does investment in fossil fuel industries. For the US, it is estimated that an average of 2.65 FTE jobs are created per USD 1 million of spending on fossil fuels, whereas 7.72 FTE jobs are generated from investing in energy efficiency projects, of which 4.59 are direct jobs and 3.13 are indirect. Another study found that in terms of jobs created per unit of energy produced (GWh), the average job-years per GWh for energy efficiency is estimated at 0.38, which is only surpassed by solar PV at 0.87, across estimates for renewable energy and fossil fuel technologies. Although it should be noted that these estimates include direct, indirect and induced jobs for energy efficiency, but only direct and indirect jobs for renewable energy and fossil fuels, with the majority (90%) of jobs created by energy efficiency investment assumed to arise from induced impacts. However, another study finds that energy efficiency gains reduce the employment growth rate, especially in energy intensive industries. In contrast, the study found that energy efficiency in the public sector leads to employment growth.

Natural Capital

The employment impacts of investment in natural capital remain unclear as the evidence base is sparse and mostly not of high quality. There is some evidence of significant multipliers from studies rated as medium-low. A study in Ontario, Canada finds that nearly 15 jobs could be created per CAD 1 million of investment, with a high return on investment resulting from the small costs of planting trees. Another study reviews 50 coastal restoration projects in the US and estimates that the projects created on average 17 jobs per million US$ spent but that most of these jobs were not permanent. However, a study on land change investments in Dorset finds small employment increases of 0.25%. The impact of natural capital investments on employment is understudied and should be addressed by future robust evaluations.

[7] It is important to note here that the extent to which a clear distinction should be drawn between gross and net job creation - a common question asked of economic impact assessments – varies depending on the context. At full employment, the priority should be to have the lowest number of jobs per unit output (i.e. the highest productivity). However, during a recession, where the priority is keeping spending going and there is spare capacity in the economy, the difference falls away.

This ex-post evidence review highlights that there could be potential in a number of areas, for example, a study on travel infrastructure building options in the United States, finds that building and refurbishing cycling infrastructure is the most labour-intensive option, and road-only infrastructure is the least intensive option. However, the analysis also reveals a relative lack of robust evidence on existing active travel, energy efficiency and natural capital investments.[8] This may be attributed to the fact that there has been comparatively less attention paid to them relative to more 'traditional' areas of investment such as health and education. Furthermore, previous evidence indicates challenges regarding this type of evidence on employment effects, such as the distinction drawn between 'direct' and 'indirect' jobs, and the number of jobs created in the stages of technical development, installation, and operation and maintenance (Bowen and Kuralbayeva, 2015).

The availability of ex-post evidence, verifying the economic impacts of net-zero-aligned investments, is even more limited for some of the other investment categories under consideration in this paper such as **clean hydrogen and CCUS for industry, and electric vehicle production and charging infrastructure**. Many of the relevant technologies are still developing and/or deployment is not yet widespread, meaning that there is not yet sufficient ex-post evidence to assess the job creation potential of investment in these areas. For this reason, ex-ante economic impact assessments, as well as other analyses that can provide an indication of economic potential (as we set out in Sections 3 and 4), can be used by policymakers as complementary resources alongside ex-post evidence.

2.2 Ex-ante evidence

Table 2 summarises a collection of studies, which have estimated the job creation potential of net-zero-aligned investments based on forecasts. This does not reflect an exhaustive review, but rather highlights a selection of ex-ante studies across net-zero-aligned investment categories, in order to provide an insight into the evidence available and draw attention to important features of the underlying studies.

It is important to note that by the nature of these studies, the scenario assumptions, methodology and timelines considered vary considerably and make direct comparisons of employment impacts across studies challenging. Appendix A provides some additional detail on the scenarios and methodologies employed in each study, and Appendix B provides further detail on three of these studies.

Overall, the ex-ante studies reviewed here suggest that net-zero-aligned investments can create a material number of jobs over the long term, with quantitative estimates stretching out to 2050. These studies also reflect job creation potential in both the short and the long term. For example, temporary jobs can be created immediately in the construction of hydrogen and CCS infrastructure (Turner et al., 2020), while in the same sector in the long term, operation and maintenance of this new and growing industry and its associated supply chain, creates permanent jobs through to 2035 and beyond (Hydrogen Taskforce, 2020). Although this review of ex-ante studies does not evaluate the strength of the evidence, some gaps are apparent – in particular - the availability of high-quality ex-ante evidence for active travel and natural capital investments is noticeably low.

[8] In particular, at level 3 or above on the Maryland Scientific Methods Scale - the level that the What Works Growth usually requires evaluations to meet to be included in the evidence reviews they undertake. For more details, see https://whatworksgrowth.org/resources/the-scientific-maryland-scale/

Table 2: Summary of ex-ante studies on economic benefits of net-zero-aligned investments

Report title, *Authors*	**Investment category**	**Activity**	**No. of jobs and timeframe**	**Short run / Long run?**
Seizing sustainable growth opportunities from zero emission passenger vehicles in the UK; *Unsworth et al., (2020)*	EV production	Production of electric vehicle powertrain components, charge points, fuel cell powertrain components and autonomous vehicle hardware and software	80 000 by 2030	LR
UK Electric Vehicle and Battery Production Potential to 2040; *The Faraday Institution (2020)*	EV production	Development of battery pack, battery cell and electrode manufacturing in the UK, including establishment, over the next 20 years, of ~7 battery production plants ('gigafactories') in the UK.	78 000 by 2040	LR
How is planned public investment to enable CCS likely to impact the wider UK economy?; *Turner et al. (2020)*	Hydrogen and CCUS for industry	Seismic surveys, appraisal of wells and engineering analysis; pre-FID (Final Investment Decision) Front End Engineering and Design (FEED) work; securing licencing and permits related activity, involving spending within public administration; design, procurement and fabrication of transport equipment (pipelines etc.) and transport and storage facilities, including repurposing of drilling platforms, from existing fabricated metal and transport equipment manufacturing sectors; construction and commissioning activity.	2021: 3850, 2022-2025: 2250- 2670, 2026: 1700	SR
Economic Impact Assessment: Hydrogen is ready to power the UK's Green Recovery; *Hydrogen Taskforce (2020)*	Hydrogen and CCUS for industry	Scaling up hydrogen solutions in production, storage, transmission and distribution, power generation, transport, heat and industry.	74 825 by 2035	LR
The economic benefits of carbon capture and storage in the UK; *TUC and CCSA (2014)*	Hydrogen and CCUS for industry	CCS plant construction and operation.	15 000 – 30 000 by 2030	Mixed
Sea Change: Climate Emergency, Jobs and Managing the Phase-Out of UK Oil and Gas Extraction; *OCI (2019)*	Renewable power generation and distribution, Housing energy efficiency	Wind power (fixed & floating offshore and onshore), marine renewables (wave and tidal stream), home energy efficiency retrofitting	170 000 by 2050	LR
Future UK Employment in the Offshore Wind Industry; *Cambridge Econometrics (2017)*	Renewable power generation and distribution	UK offshore wind power	60 000 by 2032	LR
Building the Net Zero Energy Workforce; *National Grid (2020)*	Renewable power generation; EV charging infrastructure; Hydrogen & CCUS	Building, operating, managing, maintaining and decommissioning the network of increasingly clean energy generation, transmission and distribution infrastructure.	400 000 by 2050 (Breakdown: 117,000 2020-2030, 152,000 2031-2040, 131,000 2041-2050)	LR
Jobs, growth and warmer homes: evaluating the economic stimulus of investing in energy efficiency measures in fuel poor homes; *Cambridge Econometrics & Verco for Consumer Focus (2012)*	Housing energy efficiency	Investment in energy efficiency measures (cavity wall insulation, loft insulation, internal insulation, external insulation, floor insulation, insulated doors, primary pipework insulation, double glazing, triple glazing, reduced infiltration measures, draught proofing, low energy light bulbs, heating controls, foam insulated DHW cylinder, condensing boiler replacement (gas), heat pump), prioritising the homes of the fuel poor and vulnerable.	129,400 by 2027	Mixed

These ex-ante estimates must also be assessed in the context of rising unemployment. The OECD has forecast that, in the case of a second Covid-19 spike, the UK unemployment rate could hit 14.8% in the fourth quarter of this year, up from 3.77% in the second quarter of 2020 (OECD, 2020). This would leave over 3.75 million more people out of work, compared with Q2. Though there is a clear gap between the estimated short-run job creation potential of net-zero-aligned investments and the scale and immediacy of the expected unemployment, it is important to keep in mind that green projects have been shown to create more jobs than alternative brown stimulus investments (The Coalition of Finance Ministers for Climate Action, 2020; Zenghelis and Rydge, 2020). Net-zero-aligned public sector investment alone will not be able to soak up all the unemployed but can kick-start demand and employment, increasing confidence for the private sector investment which will be

needed to further expand employment and, ultimately, lead to a more sustainable recovery. At the same time, such green investments have attractive co-benefits and advance progress towards climate targets and biodiversity protection.

Taken together, this review of ex-post and ex-ante studies indicates the opportunity that net-zero-aligned investments present for the UK government, both in terms of stimulating demand in the short term and building capacity and sustaining growth in the long term. However, this evidence is focused primarily on estimating the numbers of jobs and the scale of benefits. While this information is valuable, other new pieces of analysis can provide complementary inputs to inform policy design for the recovery. In the next sections, we present new analysis which can shed light on important aspects of the job creation potential of net-zero-aligned investments at a more granular geographic or sectoral/technological level.

3. New evidence on where jobs related to net-zero-aligned investments could be created in the short term

In this analysis we highlight the job-creation potential of net-zero-aligned investments through a spatial lens. Addressing the UK's uneven economic performance across and within regions has been an area of increased policy focus in recent years (Bernick et al., 2017) and with its 'levelling up' agenda the government has made this a key short-term priority. This objective has been made all the more urgent by Covid-19, which is already having an uneven impact on people and places - having a disproportionate impact on the most vulnerable, the poorest, the youngest, the least educated, and ethnic minorities (Bell et al., 2020). There is major uncertainty over the future of our cities, and this depends on when and how we might exit the pandemic, and the types of working patterns that might last in a new equilibrium (Nathan and Overman, 2020). Brexit is also expected to have differential impacts across local areas based on sectoral make-up (Dhingra et al., 2017).

Against this background it is of critical importance to understand *where* sustainable jobs could be created. The Committee on Climate Change have been one of the leading advocates pushing for net zero to be placed at the heart of the recovery, and their list of recommended measures shaped the investments considered in this paper (CCC, 2020b). A key criterion which they use in identifying investments is to consider their 'fairness', i.e. whether they 'have broadly equal benefits across society or could benefit (or could be targeted to benefit) communities, regions or sectors: hardest hit by the economic impacts of Covid-19; likely to be negatively impacted in the transition away from high-carbon activities; with relatively low levels of income' (CCC, 2020b). However, they highlight that this is one of the hardest criteria to measure. There is therefore value in geospatial analysis which seeks to plot where jobs might accrue across the country by making different types of investment.

Across our six categories of net-zero-aligned investments, we draw upon a range of geospatial datasets to estimate where the greatest demand is likely to be, by local authority across the UK. The focus is on short-run jobs, typically in construction and installation, as opposed to longer-run jobs related to operation, production and innovation activities. This indicative analysis is intended to give a rough estimate of where jobs may accrue, highlighting the fact that across the types of net-zero-aligned investments discussed in this report, jobs are likely to be spread across the country.

We note that this analysis does not consider the exact number or nature of jobs, or skills requirements associated with these – this type of more detailed analysis is left for future work. The broad areas of jobs and core assumptions used to highlight job creation potential in each investment category are summarised in Table 3.

Table 3: Spatial features that can indicate job creation potential across investment areas.

Investment Category	Indicative features of areas with high job creation potential
Energy efficiency in buildings	Comparatively high share of housing stock with the potential to improve efficiency through insulation measures
Natural capital projects	Comparatively high share of local area classified as wetlands / public parks / with tree planting potential
Active travel equipment and infrastructure	Comparatively high rate of cycling accidents, as normalised by cycling population; or comparatively low cycling rates where active travel infrastructure could be upgraded
Renewable power generation and distribution	Comparatively high number of approvals of pipeline solar PV and wind projects in place, per capita, which have not yet begun construction but could be moved forwards
Electric vehicle production and charging infrastructure	Comparatively few charge points per km of road, or per capita
Carbon capture, utilisation and storage and hydrogen production	Presence of large, high emission industrial facilities (e.g. cement, chemicals, iron and steel)

We set out example maps across four of the investment categories: energy efficiency in buildings, solar PV, EV charging infrastructure and CCUS and hydrogen in panels A to D of Figure 1 (the constituent parts of the UK included in each map are determined by the availability of consistent data). When shading local areas in these maps, those representing the highest opportunity (according to the criteria we set out in Table 3) are highlighted in the darkest green.

Panel A relates to energy efficiency in buildings. This shows that across the North of England, in Wales, the South West and parts of the midlands, there is clear progress to be made - and therefore it is reasonable to infer, an opportunity to create associated jobs. For local authorities in these regions, the average difference between current and potential energy efficiency ratings of the housing stock is relatively large – i.e. in the highest quartile of local authorities.

In contrast, there are fewer pipeline and associated projects for solar PV in the North of England, but these are mainly located in East Wales and North Eastern Scotland, and scattered across the Midlands and Southern England (Panel B). Wind projects are predominantly located in Western Scotland and Northern Ireland (see Appendix C).

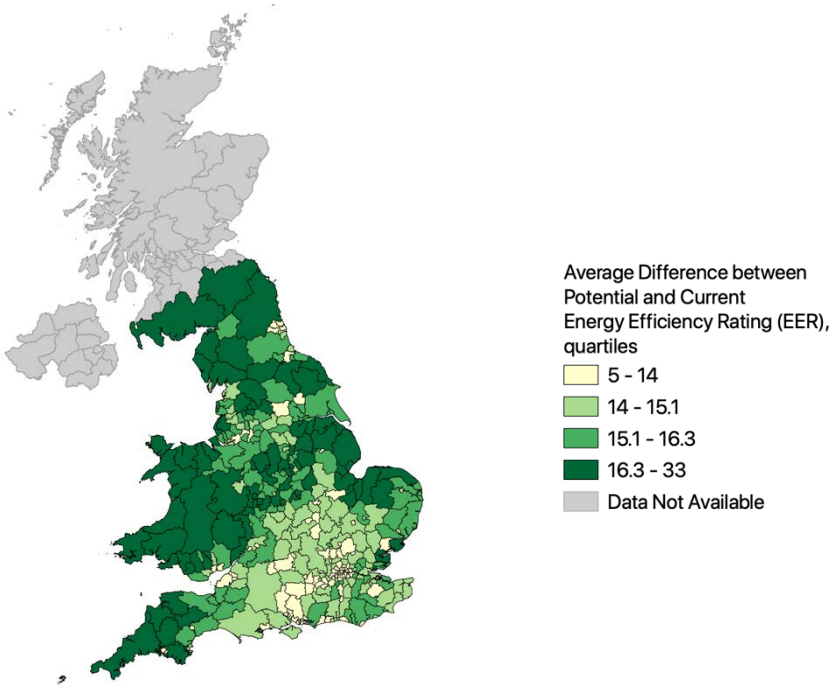
We present the density of electric vehicle charging points normalised by population in Panel C. This measure can indicate areas where there might be additional demand as a rising share of the population transitions to electric vehicles over the coming years. The areas of largest opportunity based on this measure (those currently in the lowest quartile) are spread across the Midlands, the East of England and South Wales. But another relevant measure to consider, on the supply side, is charge points per km of road. Targeting investments to areas that so far have fewer charging points per km of road can help to reduce range anxiety and improve the connectivity of these areas. On this measure, large areas of Scotland, Wales, the South West and Yorkshire and The Humber, for example, stand out (see Appendix C).

Finally, we plot the location of large, high emitting industrial facilities (across chemicals, iron and cement) in the UK that are suitable for CCUS and hydrogen trials at scale. These are clustered in industrial heartlands, around Glasgow and Edinburgh, in a band from Merseyside across to the Humber, in Teesside and South Wales.

Figure 1: Indicative spatial measures of job creation potential for selected investment categories

Panel A: Energy Efficiency in Buildings

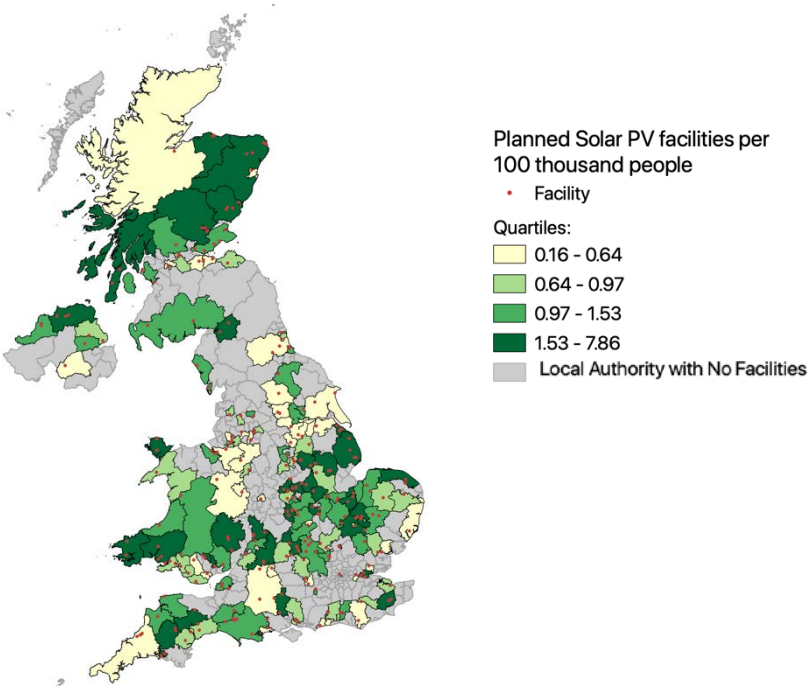
Indicative measure of potential: Difference between current and potential energy efficiency rating of housing stock by local authority



Data: Energy Performance Certificates by Output Area, 2016. CDRC

Panel B: Renewable Power Generation and Distribution

Indicative measure of potential 1: Pipeline solar PV project locations and projects per capita by local authority.

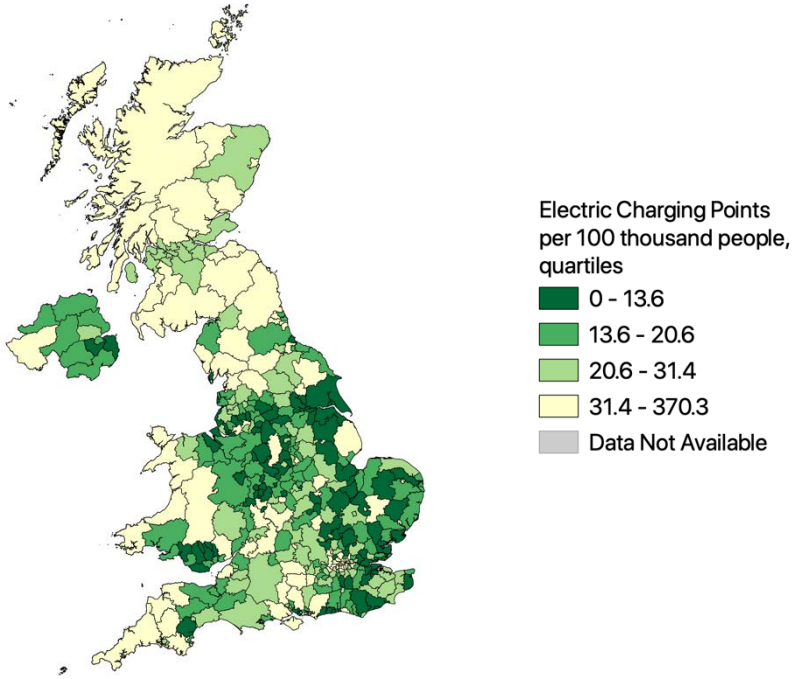


Data: Renewable Energy Planning Database, 2020.

Figure 1 (continued)

Panel C: Electric vehicle production and charging infrastructure

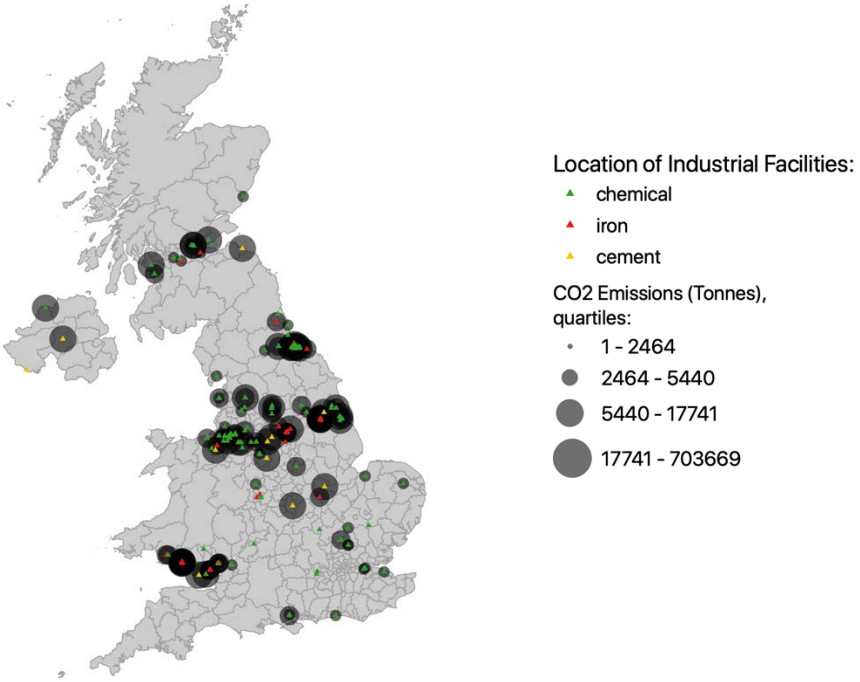
Indicative measure of potential: Areas with a relatively low density of electric vehicle charging points (per 100 thousand people) by local authority.



Data: Electric vehicle charging device statistics: July 2020. Department for Transport.

Panel D: Carbon capture, utilisation and storage and hydrogen production

Indicative measure of potential: Location of large, high emitting industrial facilities in the UK suitable for CCUS and hydrogen trials at scale



Data: Emissions from NAEI large point sources, 2018. National Atmospheric Emission Inventory.

In the Appendix we provide additional maps showing some alternative ways to consider potential for jobs related to natural capital restoration (share of local authority land in Ramsar wetlands, public parks or suitable for tree planting), and active travel infrastructure (areas with a high share of road casualties involving a cyclist normalised by the number of cyclists, or areas with a particularly low share of the population that are cyclists). On active travel, a number of urban local authorities have a high rate of cycling casualties, suggesting investments in cycling infrastructure are needed. In addition to a number of London areas where cycling rates are also high, Luton stands out as having a particularly high rate of casualties though a relatively low share of the population are cyclists there. Nonetheless, areas with a low rate of casualties may still be suitable for active travel infrastructure investment if the share of cyclists in the population is also low, demonstrating the importance of bringing together different geospatial datasets to inform investment. These can be complemented with other forms of data gathering at the local level to understand why people may be less inclined to use cycling as a means of transport in a specific place.

We consider this to be an indicative analysis, and emphasise the need for more detailed geospatial analysis of this nature in particular accounting also for the labour intensity of different types of activity. However, these maps do suggest that net-zero-aligned investments have the potential to create a balanced mix of job opportunities in regions across the UK. As such, this type of analysis can also help inform regional growth plans in the development of Local Industrial Strategies.

4. New evidence on UK competitive strengths and opportunities in net-zero-aligned products

Looking beyond the immediate crisis, the transition to a green economy offers extraordinary opportunities for growth (Rydge et al., 2018; Stern et al., 2020). With global demand for cleaner and more environmentally friendly products and technologies set to rapidly increase in the coming decades, countries that take early action to develop green production capabilities are likely to reap significant growth benefits. While labour intensity varies by product, those economies which establish competitiveness in green production capabilities will be best placed to sustain employment in manufacturing in these areas and related services.

Government recovery packages and industrial policies in response to Covid-19 are likely to play a key role in shaping which economies are better positioned in this ‘green race’ (Fankhauser et al., 2013), recognising that evidence from the 2008 financial crisis has shown how recovery packages can support future industries (Mundaca and Richter, 2015). A key challenge for policymakers is how to best target investments and design policies to promote the development of a given country’s competitive strengths, and avoid the pitfalls of attempting to ‘pick winners’. It can be challenging to identify a country’s existing comparative advantage in particular industries relative to other countries, and even more difficult to determine new markets or technologies a country might be able to successfully break into in the future.

A standard way to consider competitiveness is using data on imports and exports. If we observe that a given country exports a greater share of solar panels than the global average, we could infer that this country is likely to have some degree of competitiveness, or ‘revealed comparative advantage’ (RCA) in this product. However, not all products offer the same advantages in terms of growth potential and future diversification outcomes. Here we set out novel methodologies from the complexity and economic geography literatures which can provide helpful insights in this regard. These approaches aim to infer information about countries and regions’ productive capabilities based on data on what they are able to competitively produce.

One way to capture differences in the growth potential across products is through the Product Complexity Index (PCI) (Hidalgo and Hausmann, 2009). Products that measure more highly on the

PCI tend to be more technologically sophisticated and offer greater knowledge spillovers into other products. Countries that export products with higher PCI have also been shown to achieve higher economic growth rates. In applying these metrics to a dataset of traded 'green' products (products with environmental benefits[9]), Mealy and Teytelboym (2020) showed that green products tend to have higher PCI than average. They also demonstrated that countries that are competitive in a large number of technologically sophisticated green products exhibit higher green patenting rates, lower CO2 emissions and tend to have more stringent environmental policies.[10]

A key finding in the economic geography literature is that countries and regions find it easier to develop competitive advantage in a new product if it requires capabilities that are similar (or 'related') to those the place already possesses. One way to estimate this relatedness in capabilities between products is to consider the likelihood that a country is competitive in a product, given that it is competitive in another. For example, products that are frequently co-exported (such as cars and trucks) are likely to have greater similarity in requisite capabilities than products that are not (such as cars and cocoa beans). Based on these product-relatedness measures, we can also estimate how difficult it would be for a particular country to develop competitiveness in or transition into a new product, given its relatedness to all the products that the country is currently competitive in. Note that even within the set of products that the country does have a competitive advantage in, the average similarity to other competitive strengths can differ – in other words, the country may have comparative advantage in a product category which is somewhat distant from its overall productive strengths, though in general the distance will be smaller for those products than those for which a country has no comparative advantage.

Applying the approach introduced in Mealy and Teytelboym (2020) to bilateral trade data covering the period of 2013-2017,[11] in the analysis that follows we combine these complexity and 'difficulty transitioning' measures to highlight, across net-zero-aligned products (in categories consistent to those referred to elsewhere in this paper), where UK growth opportunities might lie. We split the analysis across products where the UK currently has comparative advantage and where it does not; and benchmark the UK internationally with equivalent analysis for Germany, France, the United States and Australia in the appendix.

In Figure 2 (left panel), we show some of the net-zero-aligned products that the UK is currently competitive in. In the right panel, we show net-zero-aligned products that the UK does not competitively export at the moment but potentially could do in the future (such products can be considered to be potential opportunities for the UK).

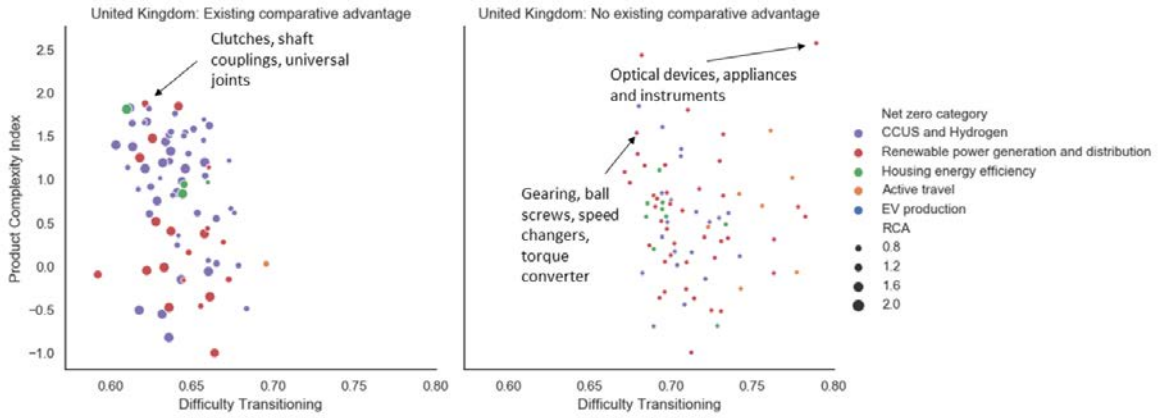
For example, in the left-hand panel, we highlight product category 'Clutches, shaft couplings, universal joints' which is within a red circle (relating to renewable power generation and distribution), and includes clutches and shafts used in wind turbines to produce electricity. For this product category, the UK has RCA 1.43, which suggests it currently has comparative advantage in this area.

[9] This is a list of products at the HS6 level compiled using lists of "environmental goods" created over the course of various trade negotiations aiming to lower barriers to trade in environmentally beneficial goods. For more information, please refer to Mealy and Teytelboym (2020).

[10] The analysis uses green products because those are of interest in the context of green industrial policy. Likewise, the analysis presented in this report uses a smaller indicative subset of products identified as net-zero-aligned. However, the methodology could be applied to any set of products.

[11] This database also underlies an interactive web tool which is being developed by Pia Andres (London School of Economics) and Penny Mealy (Monash and Oxford University) to allow users to undertake this type of analysis themselves and identify strategic priorities for green industrial policy using measures of complexity and relatedness. Please contact the authors for more information about this project.

Figure 2: Existing strengths and new opportunities for the United Kingdom



Notes: Bilateral trade data at the HS6 level was obtained from UN Comtrade's BACI database, and to mitigate the effect of outliers, export values for each country were averaged over the 5-year period 2013-2017.

On the other hand, also in renewables, product category 'Optical devices, appliances and instruments' is found in the very top right corner of the graph on the right-hand panel. This category includes solar heliostats which orient mirrors in concentrated solar power systems to reflect sunlight on to a concentrated solar power (CSP) receiver. The UK's current RCA here is 0.05 and the relative difficulty of transitioning into this is about 0.79. Given this product's high PCI, developing competitiveness in this product is likely to be advantageous. However, the gap in capabilities between the UK's current capabilities and those needed to produce this product is quite high, implying that transitioning into this product in the near term could be challenging.

Also in the right hand panel, product category, 'Gearing, ball screws, speed changers, torque converter', which includes gearboxes for wind turbines, is further to the left, suggesting it is more closely aligned with the UK's current competitive strengths, though this is somewhat lower in product complexity.

On the whole, there are quite a lot of technologically sophisticated green products that are relatively close to the UK's existing capabilities. These products cut across different categories of net-zero-aligned investments, with most relating to power generation, CCUS and hydrogen, although there are also examples of complex, proximate products related to housing energy efficiency and active travel. These 'green adjacent possible' (Mealy and Teytelboym, 2020) areas could be effectively targeted with industrial policy tools in the UK's recovery package, most notably through coordinated investment in infrastructure, innovation and skills. It is also noteworthy that alongside these opportunities, the UK currently has competitive advantage in a number of complex, net-zero-aligned products. This indicates that these are already sources of employment which can be nurtured by policymaking in the recovery.

In Appendix D we provide equivalent analyses for Germany, France, the United States and Australia. This shows that Germany is already competitive in the majority of net-zero-aligned products, and those in which it is not yet competitive tend to be closer to existing capabilities than in the UK. In contrast, Australia only has advantage in a limited number of products, and in areas where it does not yet have advantage, there is a clear positive correlation between complexity and the difficulty of transitioning. Moreover, the difficulty of transitioning tends to be higher in absolute terms across categories (please note that axis limits differ between countries to enhance readability). The picture for

France and US overall is similar to the UK, though in the categories where these countries do not yet have comparative advantage, the difficulty transitioning tends to be a bit lower than for the UK.

Conclusions

This paper draws together evidence on job-creation potential in net-zero-aligned investments from a diverse range of sources. Evidence gathered covers both ex-post and forward-looking studies, with contrasting areas of focus across short-run job creation and longer-term job creation and broader benefits. It also includes new quantitative approaches to identifying economic opportunities across geographies or traded products. A series of themes can be highlighted across the paper, informing a number of recommendations for the UK's recovery:

- Evidence from varied sources indicates that net-zero-aligned investments can play an important role in generating employment and economic growth benefits across the UK.

Recommendation: Place net-zero-aligned investments at the heart of the UK's recovery plan

- A diverse range of evidence is available to aid understanding of the potential economic impacts associated with making net-zero-aligned investments, beyond ex-post studies of previous projects and ex-ante estimates of potential job creation.

Recommendation: Draw on diverse economic evidence to design recovery policies and investments seeking to create and sustain jobs; allowing for where in the UK jobs might be created in the short run, and sustained into the longer run, based on comparative advantage in production and innovation

- The evidence base on benefits across different categories of net-zero-aligned investment is not of consistent quality and is not always comparable, reflecting the fact that many categories such as CCUS are relatively nascent and have been subject to limited empirical evaluation. However, it also relates to a deeper, long-standing challenge in 'the gap between aspiration and outcomes' in infrastructure policy and the constantly changing landscape of investments and projects over recent years (Helm, 2013), which can make it challenging to evaluate success.

Recommendation: Ensure robust monitoring and evaluation for investments made in the recovery package, to expand the evidence base and inform future policy

- There are complex short- and long-run trends that will shape labour market dynamics that net-zero-aligned investments need to take into account, and which will shape the skills which workers on net-zero projects will possess. In the short term, Covid-19 will have a devastating impact on a number of sectors – in particular in-person services including hospitality, whereas into the longer term the structural effects of transitioning towards net zero may disproportionately impact some sectors more than others.

Recommendation: Complement net-zero-aligned investments with targeted re-skilling for those displaced in the current crisis and those that will be displaced by ongoing technological change and the zero-carbon transition

- Investments made in the recovery, led by the public sector, will be unlikely to catalyse a longer-term increase in these kinds of investments if they do not effectively leverage private investment by demonstrating a path for the private sector to follow. Aligned incentives, improved policy certainty and a National Investment Bank can help reduce risk for long-term sustainable investments.

Recommendation: Accompany strategic investments with strengthened policies, institutions and regulation to direct private sector investment towards achieving societal goals such as net zero, starting with a robust, net-zero-aligned carbon price, a National Investment Bank and a relaunched, long-term Industrial Strategy with sustainability at its core

References

Bell B, Codreanu M and Machin S (2020) What can previous recessions tell us about the Covid-19 downturn? Centre for Economic Performance: CEP COVID-19 Analysis. http://cep.lse.ac.uk/pubs/download/cepcovid-19-007.pdf

Bernick S, Davies R and Valero A (2017) Industry in Britain – An Atlas. Centre for Economic Performance Special Paper No.34. http://cep.lse.ac.uk/pubs/download/special/cepsp34.pdf

Bounds A (2020) UK government issues urgent call for 'shovel-ready' projects. Financial Times. https://www.ft.com/content/2bc9f831-cc7d-42ae-b029-db01a0f9eaa6

Bowen A and Kuralbayeva K (2015) Looking for green jobs: the impact of green growth on employment. London: Grantham Research Institute on Climate Change and the Environment and the Global Green Growth Institute. https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2015/03/Looking-for-green-jobs_the-impact-of-green-growth-on-employment.pdf

Bowen A and Stern N (2010) Environmental policy and the economic downturn, *Oxford Review of Economic Policy* 26 (2) (Summer): 137- 163. https://doi.org/10.1093/oxrep/grq007

BVG Associates (2014) UK Offshore Wind Supply Chain: Capabilities and opportunities. https://assets.publishing.service. gov.uk/government/uploads/system/uploads/attachment_data/file/277798/bis-14-578- offshore-wind-supply-chain-capabilities-andopportunities.pdf

Cambridge Econometrics (2017) Future UK Employment in the Offshore Wind Industry. https://aura-innovation.co.uk/wp-content/uploads/2020/04/Cambride-Econometrics-Future-UK-Employment-in-Offshore-Wind-June-2017.pdf

Cambridge Econometrics & Verco (2012) Jobs, growth and warmer homes: evaluating the economic stimulus of investing in energy efficiency measures in fuel poor homes. Consumer Focus. https://www.bl.uk/collection-items/jobs-growth-and-warmer-homes-evaluating-the-economic-stimulus-of-investing-in-energy-efficiency-measures-in-fuel-poor-homes

Committee on Climate Change (2019a) Net Zero - The UK's contribution to stopping global warming. London: Committee on Climate Change. https://www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/

Committee on Climate Change (2019b) Reducing UK emissions- 2019 Progress Report to Parliament. London: Committee on Climate Change. https://www.theccc.org.uk/publication/reducing-uk-emissions-2019-progress-report-to-parliament/

Committee on Climate Change (2020a) Reducing UK emissions: 2020 Progress Report to Parliament. London: Committee on Climate Change. https://www.theccc.org.uk/publication/reducing-uk-emissions-2020-progress-report-to-parliament/

Committee on Climate Change (2020b) COVID-19 can be an historic turning point in tackling the global climate crisis. https://www.theccc.org.uk/2020/06/25/covid-19-can-be-an-historic-turning-point-in-tackling-the-global-climate-crisis/

Consumer Data Research Centre (2016) Energy Performance Certificates by Output Area. https://data.cdrc.ac.uk/geodata-packs

DeLong B and Summers L (2012) Fiscal Policy in a Depressed Economy. Brookings Institution: BPEA Article. https://www.brookings.edu/bpea-articles/fiscal-policy-in-a-depressed-economy/

Dhingra S, Machin S and Overman H (2017) The Local Economic Effects of Brexit. Centre for Economic Performance: CEP Brexit Analysis No.10. http://cep.lse.ac.uk/pubs/download/brexit10.pdf

Fankhauser S, Bowen A, Calel R, Dechezleprêtre A, Grover D, Rydge J and Sato M (2013) Who will win the green race? In search of environmental competitiveness and innovation, Global Environmental Change 23 (5): 902-913. https://doi.org/10.1016/j.gloenvcha.2013.05.007

Faraday Institution (2020) UK Electric Vehicle and Battery Production Potential to 2040. https://faraday.ac.uk/wp-content/uploads/2020/03/2040_Gigafactory_Report_FINAL.pdf

Helm D (2013) British infrastructure policy and the gradual return of the state. Oxford Review of Economic Policy 29 (2): 287–306. http://www.dieterhelm.co.uk/assets/secure/documents/Brit-infra-oxrep.pdf.

Hepburn C, O'Callaghan B, Stern N, Stiglitz J and Zenghelis D (2020). Will COVID-19 fiscal recovery packages accelerate or retard progress on climate change? Oxford Smith School of Enterprise and the Environment Working Paper No. 20-02 ISSN 2732-4214 (Online). https://www.smithschool.ox.ac.uk/publications/wpapers/workingpaper20-02.pdf

Hidalgo C and Hausmann R (2009) The building blocks of economic complexity. Proceedings of the National Academy of Sciences, 106 (26) (June): 10570-10575. doi: 10.1073/pnas.0900943106.

HMRC (2020), HMRC Coronavirus (COVID-19) Statistics, last updated 5th October 2020. https://www.gov.uk/government/collections/hmrc-coronavirus-covid-19-statistics

HSBC Bank plc (2009). Taking Stock of the Green Stimulus. https://publications.parliament.uk/pa/cm200910/cmselect/cmenergy/193/19305.htm

Hupkau, C. and Petrongolo, B. (2020). Work, care and gender during the Covid-19 crisis, A CEP Covid-19 analysis Paper, May 2020 http://cep.lse.ac.uk/pubs/download/cepcovid-19-002.pdf

Hydrogen Taskforce (2020) Economic Impact Assessment: Hydrogen is ready to power the UK's Green Recovery. London: The Hydrogen Taskforce Secretariat. https://www.hydrogentaskforce.co.uk/wp-content/uploads/2020/08/6-EIA-report.pdf

IFS (2020), New job support scheme next step in winding down of furlough support, Press Release, 24 September 2020, https://www.ifs.org.uk/publications/15044

Mazzucato M (2014) A mission-oriented approach to building the entrepreneurial state. Innovate UK. https://marianamazzucato.com/wp-content/uploads/2014/11/MAZZUCATO-INNOVATE-UK.pdf

McKinsey (2020), COVID-19 in the United Kingdom: Assessing jobs at risk and the impact on people and places, 11th May https://www.mckinsey.com/industries/public-sector/our-insights/covid-19-in-the-united-kingdom-assessing-jobs-at-risk-and-the-impact-on-people-and-places#

Mealy P and Teytelboym A (2020) Economic complexity and the green economy, Research Policy: 103948. https://doi.org/10.1016/j.respol.2020.103948.

Mundaca L and Richter J (2015) Assessing 'green energy economy' stimulus packages: Evidence from the U.S. programs targeting renewable energy. Renewable and Sustainable Energy Reviews, 42 (February). https://www.sciencedirect.com/science/article/pii/S1364032114008855

Nathan M and Overman H (2020) Will coronavirus cause a big city exodus? Economics Observatory https://www.coronavirusandtheeconomy.com/question/will-coronavirus-cause-big-city-exodus

National Atmospheric Emissions Inventory (2018) Emissions from NAEI large point sources. https://naei.beis.gov.uk/data/map-large-source

National Grid (2020) Building the Net Zero Energy Workforce. https://www.nationalgrid.com/stories/journey-to-net-zero/net-zero-energy-workforce.

New Climate Economy (2018) The New Growth Agenda. https://newclimateeconomy.report/2018/the-new-growth-agenda/

OECD (2020) Unemployment rate forecast (indicator). doi: 10.1787/b487f2cf-en (Accessed on 08 October 2020).

Oil Change International, Platform and Friends of the Earth Scotland (2019) Sea Change: Climate Emergency, Jobs and Managing the Phase-Out of UK Oil and Gas Extraction. Washington, DC: Oil Change International. http://priceofoil.org/2019/05/15/sea-change-report/

Office for National Statistics (2020) Labour market overview, UK: October 2020. file:///C:/Users/Anna/Downloads/Labour%20market%20overview,%20UK%20October%202020.pdf

Offshore Renewable Energy Catapult (2018) Tidal Stream and Wave Energy: Cost reduction and industrial benefit. https://s3-eu-west-1. amazonaws.com/media.newore.catapult/app/ uploads/2018/11/19142426/Tidal-Streamand-Wave-Energy-Cost-Reduction-andIndustrial-Benefit.pdf

Oxford Economics (2020) Global Risk Survey: Recovery may be longer and slower. http://blog.oxfordeconomics.com/coronavirus/recovery-may-be-longer-and-slower

Robins N, Tickell S, Irwin W and Sudmant A (2020) What Does the Low Carbon Transition mean for Employment? Forthcoming.

Rydge J, Martin R, Valero A (2018) Sustainable Growth in the UK: Seizing opportunities from technological change and the transition to a low-carbon economy. London: Grantham Research Institute on Climate Change and the Environment. https://www.lse.ac.uk/granthaminstitute/publication/sustainablegrowth/

Stern N, Unsworth S, Valero A, Zenghelis D, Rydge J, Robins N (2020) Strategy, Investment and Policy for a Strong and Sustainable Recovery: An Action Plan. Centre for Economic Performance: CEP COVID-19 Analysis. https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2020/07/Strategy-investment-and-policy-for-a-strong-and-sustainable-recovery.pdf

The Coalition of Finance Ministers for Climate Action (2020) Better recovery, better world: Resetting climate action in the aftermath of COVID-19. https://www.financeministersforclimate.org/sites/cape/files/inline-files/Better%20Recovery%2C%20Better%20World%20FINAL.pdf

TUC and Carbon Capture and Storage Association (2014) The economic benefits of carbon capture and storage in the UK. London: TUC. https://www.tuc.org.uk/sites/default/files/carboncapturebenefits.pdf

Turner K, Katris A, Race J and Stewart J (2020) How is planned public investment to enable CCS likely to impact the wider UK economy? University of Strathclyde Centre for Energy Policy.

https://strathprints.strath.ac.uk/72886/1/Turner_etal_CEP_2020_How_is_planned_public_investment_to_enable_ccs_likely_to_impact_the_wider_uk_economy.pdf

UK Energy Research Centre (2014) Low Carbon Jobs: The Evidence for Net Job Creation from Policy Support for Energy Efficiency and Renewable Energy. https://d2e1qxpsswcpgz.cloudfront.net/uploads/2020/03/low-carbon-jobs.pdf

UK Government (2020) A Plan for Jobs 2020. HM Treasury Policy Paper. https://www.gov.uk/government/publications/a-plan-for-jobs-documents/a-plan-for-jobs-2020

UK Government Department for Business, Energy & Industrial Strategy (2020) Renewable Energy Planning Database. https://www.gov.uk/government/publications/renewable-energy-planning-database-monthly-extract

UK Government Department for Transport (2020) Electric vehicle charging device statistics: July 2020. https://www.gov.uk/government/statistics/electric-vehicle-charging-device-statistics-july-2020

Unsworth S, Valero A, Martin R and Verhoeven D (2020) Seizing sustainable growth opportunities from zero emission passenger vehicles in the UK. London: Grantham Research Institute on Climate Change and the Environment. https://www.lse.ac.uk/granthaminstitute/publication/seizing-sustainable-growth-opportunities-from-zero-emission-passenger-vehicles-in-the-uk/

World Resources Institute (2009). A Green Global Recovery? Assessing US Economic Stimulus and the Prospects for International Coordination. Peterson Institute for International Economics, Policy Brief Number PB09-3. https://files.wri.org/s3fs-public/pdf/green_global_recovery.pdf

Zenghelis D and Rydge J (2020). Rebuilding to Last: designing an inclusive, resilient and sustainable growth strategy after COVID-19. Aldersgate Group. https://www.aldersgategroup.org.uk/latest#rebuilding-to-last-uk-must-not-go-back-to-the-old-normal

Appendix A: Selected ex-ante studies of potential economic benefits associated with net-zero-aligned investments – Additional Information

Report title	Investment category	Scenario	Methodology
Seizing sustainable growth opportunities from zero emission passenger vehicles in the UK; *Unsworth et al., (2020)*	EV production	Market development- electric vehicles account for 38% of new vehicle sales worldwide in 2030 and UK attains market share of its close European competitors, by component ('high market share' scenario).	Employment multiplier- value of projected UK market multiplied by existing estimate of the manufacturing jobs that could be sustained, for each component.
UK Electric Vehicle and Battery Production Potential to 2040; *The Faraday Institution (2020)*	EV production	Market development- assume aggregate vehicle sales in export markets grow by 1.4% per year over the 2020 to 2040 period. Make further assumptions about emissions regulations, the decline in EV battery costs and the increase in EV battery range. Central scenario projection is, therefore, that the UK will be producing nearly 1.6 million EVs per year by 2040.	Employment multiplier- use Faraday Institution battery demand forecasting model to project UK EV battery manufacturing capacity in 2040. Implied number of jobs based on existing estimates of the number of manufacturing and indirect jobs supported per GWh per annum.
How is planned public investment to enable CCS likely to impact the wider UK economy? ; *Turner et al. (2020)*	Hydrogen and CCUS for industry	Defined funding- £1.75 billion investment for development of 4 storage sites- Hamilton, Captain X, Viking A and Bunter 36 (as detailed in the Strategic UK CCS Storage Appraisal- storage development plans D10, D12, D13 and D14).	CGE- Use the UKENVI multi-sector computable general equilibrium (CGE) model of the UK economy (fully specified and detailed in previous peer-reviewed papers) to analyse two scenarios, both involving development of pre-identified potential CO2 storage sites.
Economic Impact Assessment: Hydrogen is ready to power the UK's Green Recovery; *Hydrogen Taskforce (2020)*	Hydrogen and CCUS for industry	Market development- project hydrogen demand by 2035 in four end-use sectors – transport, heat, industry and power generation.	Input / output macroeconomic modelling- create bespoke macroeconomic model to estimate the economic contribution from investing (and maintaining) the necessary hydrogen infrastructure, according to projected demand. Uses ONS Input-Output tables and Supply & Use tables, with demand mapped to each SIC classified industry.
The economic benefits of carbon capture and storage in the UK; *TUC and CCSA (2014)*	Hydrogen and CCUS for industry	Emissions target- translate CCSA's projection of CCS-installed capacity required in the UK by 2030 to meet UK emissions targets (10 GW - 20 GW), into number of CCS plant installations to 2030 (15- 25).	Employment multiplier- projected new CCS installations to 2030 multiplied by existing estimates of job generation per plant installation.
Sea Change: Climate Emergency, Jobs and Managing the Phase-Out of UK Oil and Gas Extraction; *OCI (2019)*	Renewable power generation and distribution, Housing energy efficiency	Net-zero target- achieving a fully renewable energy mix for the UK in line with a phase-out of fossil fuel extraction and use by 2050.	Input / output macroeconomic modelling- project capacity requirement in wind, tidal stream and wave, based on Mark Jacobson et al. model and multiply by scaled-up versions of existing job creation estimates from Cambridge Econometrics (2017), ORE Catapult (2018), BVG associates (2018), which use input/output macroeconomic modelling. Assume that a UK-wide energy efficiency programme retrofits every home in 20 years and multiply by existing labour intensity estimates.
Future UK Employment in the Offshore Wind Industry; *Cambridge Econometrics (2017)*	Renewable power generation and distribution	Market development- based on latest assumptions of UK and EU offshore wind capacity growth and the UK content of those value chains.	Input / output macroeconomic modelling- direct employment based on existing estimates of jobs created per MW capacity. Indirect and induced employment estimates based on input-output model, driven by assumptions about future UK and future world offshore wind capacity.
Building the Net Zero Energy Workforce; *National Grid (2020)*	Renewable power generation; EV charging infrastructure; Hydrogen & CCUS	Net-zero target- project clean energy mix required to reach net zero by 2050, based on CCC's Net Zero 2050 report and National Grid Electricity Systems Operator's Future Energy Scenarios report (FES) (July 2019).	Employment multiplier- project energy roadmap required to reach net zero by 2050; estimate rate at which different energy technologies are deployed across the UK annually, 2030-2050; derive estimates of the average number of construction and operational jobs required, per unit of installed energy generation capacity, across each energy technology; extrapolate to 2050, incorporating assumptions on annual productivity gains.

Jobs, growth and warmer homes: evaluating the economic stimulus of investing in energy efficiency measures in fuel poor homes; *Cambridge Econometrics & Verco for Consumer Focus (2012)*	Housing energy efficiency	Defined funding- estimate the total combined revenue generated through the EU ETS in Phases III and IV, and the introduction of a carbon floor price post-2013 to be £63.1bn in real terms (2013-2027). Assume just under 95% of these revenues are invested in energy efficiency for all fuel poor homes (9.1m households).	Input / output macroeconomic modelling - use Cambridge Econometrics' model of the UK economy, MDM-E3, to assess defined energy efficiency investment package.

Notes: The scenarios and methodologies employed can be grouped into categories, providing a framework for understanding the types of evidence available.

The scenario categories identified among this selection of studies can be defined as: (a) Investment driven - driven by assumptions on benefits triggered by a specific investment envelope; (b) Market development- driven by projections of market growth and UK market share; and (c) Emissions/ net-zero target- driven by the assumption that an emissions/ net-zero target is met.

The methodology categories are defined as: (a) CGE modelling[12]; (b) Input/output (I/O) macroeconomic modelling[13]; and (c) Employment multiplier modelling which multiplies projected capital or market size by ex-poste estimates of labour intensity.

[12] An analytically consistent mathematical representation of an economy, CGE modelling comprises a detailed database of economy-wide data, which captures the interdependencies across all sectors in the economy at a particular point in time, and a set of equations describing model variables. The model is solved computationally, with an equilibrium being characterised by a set of prices and level of production across all sectors, such that demand equals supply for all commodities simultaneously (UKERC, 2014)

[13] I-O modelling uses a set of IO accounts for an economy, which identify the monetary linkages between production sectors and between production sectors and consumers of output, to model the economy-wide impact of exogenous final demand disturbances (UKERC, 2014)

Appendix B: Selected case studies based on ex-ante analyses

Case study 1: Production of electric vehicle components could sustain 80,000 UK jobs in 2030

Author(s): Unsworth et al., (2020)

Context

This paper focuses on how the UK can seize opportunities from goods and services related to zero emission vehicles, against a broader context of sustainable growth. The paper argues that by being at the forefront of the development of zero-carbon products and services, the UK can seize economic opportunities from the worldwide transition towards net zero. The paper argues that zero emission vehicles offer both an opportunity to decarbonise road transport in the UK, but also to secure long-term jobs.

What kind of jobs, and how many?

The paper estimates that the UK could sustain nearly 80,000 jobs in 2030 in the production of electric vehicle powertrain components such as batteries, charge points, fuel cell powertrain components and autonomous vehicle hardware and software – if the UK is globally competitive in these technologies. The paper argues that this quantified estimate is only a small percentage of the total number of jobs that could be sustained by zero-emission vehicles across the innovation and value chain. Under such a scenario, there would be significant additional employment upstream and downstream of component production. For instance, upstream, EV component production would likely be underpinned by a competitive domestic chemicals supply chain. Downstream, car manufacturers would likely be more inclined to assemble vehicles in the UK if the country is manufacturing high-value components for zero-emission vehicles.

What are the key assumptions behind this estimate?

The number of jobs sustained is based on a scenario in which the UK has a high market share of key vehicle components, with 'high' defined as being equivalent to the market share of the European economies which are leading in each technology today (for instance, Germany in the field of battery production). The jobs estimate is also informed by an 'optimistic but realistic' global market projection for zero emission and autonomous vehicles, with electric vehicles accounting for 38 per cent of new vehicle sales worldwide in 2030. The analysis also assumes the UK brings the internal combustion engine sale ban forward to 2030, making all vehicle sales in the analysis zero emission. However, UK sales only sustain a relatively small share of the jobs estimate given the UK exports around 85% of the cars it produces. The paper does not make estimates of the jobs supported if a greater share of the domestic vehicle sales market was catered for by UK production, but it would presumably be higher.

Are any broader benefits described besides direct employment?

Under this 'high UK market share' scenario, the paper estimates that the market value for UK-produced components could be £16.8bn in 2030. Furthermore, the paper emphasises that areas outside London and the South East account for a large proportion of employment in vehicle manufacture. Motor vehicle production accounts for 18 per cent of total manufacturing jobs in the West Midlands and 15 per cent of manufacturing jobs in the North East. Securing jobs in these regions could therefore play a key role in protecting regional identities associated with automotive manufacturing and to spurring balanced growth across the UK.

What needs to happen now to plot a course towards securing these jobs?

The paper argues that the UK needs to improve its competitiveness producing zero emission vehicle components and chargers, such as batteries, in order to sustain these jobs. Furthermore, analysis of patent data indicates that the UK has a mixed track record in innovating relevant technologies such as batteries and control modules, suggesting the UK has ground to make up if it is to be a hub for both zero emission vehicle innovation and production. To address this, the paper recommends a mixture of policies across the following areas:

1) Spur domestic demand for zero emission vehicles, for instance by moving the ICE sale ban earlier than 2035
2) Step up incentives to support production in regions across the UK and direct innovation towards societal goals, such as through targeted R&D tax credits, export finance support and human capital tax credits
3) Secure close alignment with the European Single Market and EU emissions regulations
4) Use the above as a foundation to underpin discussions with major industry players

Case study 2: Building the net zero energy workforce

Author(s): National Grid (2020)

Context

This report focuses on understanding how the energy sector can build a Net Zero Energy Workforce able to transform the UK's energy system over the next 30 years. The report explores the employment opportunity and skills needed to the help the UK's energy sector reach its emissions target by 2050.

What kind of jobs, and how many?

The report argues that the UK will need to begin a significant recruitment drive, to meet the operational and construction requirements for net zero. It is estimated that the energy sector must recruit for 400,000 jobs by 2050. Of these, 260,000 will be new roles, while 140,000 will replace those who have left the workforce. The report estimates that 117,000 jobs will be created between 2020-2030, of which, 65,000 will be new roles such as data analysts to forecast energy demand and engineers with expertise in renewables, while the remaining 52,000 recruits will be needed to replace workers leaving the sector. Between 2031-2040, recruitment is projected to accelerate; an estimated 152,000 jobs will be required in renewable energy construction, delivery networks and transformation of home heating. A further 131,000 jobs will be created between 2041- 2050.

Roles included in the report's analysis are those involved in the operation, generation, transmission, distribution and retail of energy in the UK, as well as those in the supply chain related to building, upgrading, maintaining or operating infrastructure required to reach net zero. The report highlights that demand for net-zero roles will be spread across the country, requiring a range of skills and expertise. The bulk of new roles are expected to be created in the construction and upgrade of energy infrastructure, but over time new roles requiring cutting edge skills, such as carbon capture scientists, clean gas experts, engineers with renewable energy skills and heat pump and EV charge point installers, will be created.

What are the key assumptions behind this estimate?

The report projects the clean energy mix required to reach net zero by 2050, based on analysis of the supply trajectories described in the CCC's Net Zero 2050 report and National Grid Electricity Systems Operator's Future Energy Scenarios report (FES) (July 2019). The resulting energy roadmap defines

the specific contributions to the energy supply from each technology (e.g. onshore and offshore wind power, solar, marine energy and nuclear energy), on an annual basis up to 2050. Estimates of construction and operational job creation per unit of installed energy generation capacity, across each technology, are based on evidence from existing projects. A set of assumptions based on available data and literature also forms the basis of estimates of the replacement demand for construction-related and operational employment.

Are any broader benefits described besides direct employment?

Pointing to evidence suggesting that more than half of UK adults want to work for a company helping the country to reach net zero, the report argues that tapping into people's desire to choose a career that fights climate change can unleash a motivated workforce.

What needs to happen now to plot a course towards securing these jobs?

The report encourages cross sector collaboration on five key goals:

1. Inspire young people of all ages to choose and excel in STEM subjects so they can pursue a career in the Net Zero Energy Workforce.
2. Build a skills pipeline through A levels, degrees, technical education and apprenticeships.
3. Ensure a fair transition, whereby workers of all ages and backgrounds, from across the UK, can access training and retraining to be part of the Net Zero Energy Workforce.
4. Boost diversity within the energy sector to ensure the Net Zero Energy Workforce does not miss out on the best talent from every community.
5. Help the UK to become a world leader in people-powered climate innovation and technology by fostering research and investment in cutting-edge technologies.

Case study 3: Economic Impact Assessment- Hydrogen is ready to power the UK's Green Recovery

Author(s): Hydrogen Taskforce (2020)

Context

This report the impact that the scaling up of hydrogen solutions could have on the UK economy by 2035. In light of the economic upheaval and rising unemployment caused by the Covid-19 pandemic, the report argues that hydrogen offers the UK a pathway to deep, cost-effective decarbonisation, which also delivers economic growth and job creation, and should therefore be at the heart of a green recovery programme. The report considers the role of hydrogen in supporting decarbonisation across a range of sectors- production, storage, transmission and distribution, power generation, transport, heat and industry- and assesses the implications for the UK economy, in terms of GVA and job creation.

What kind of jobs, and how many?

The report estimates that the UK could unlock 74,646 jobs by 2035, along a hydrogen value chain spanning production, storage, transmission and distribution, and downstream appliances. This estimate includes, for each industry involved in developing and maintaining the necessary hydrogen infrastructure, both direct jobs in the producing industry, and indirect jobs in the wider supply chain, but not induced impacts. In terms of upstream production, the report argues that the UK has an opportunity to build a world-leading green hydrogen production industry that would support 18,096 jobs by 2035, as well as to develop a strong blue hydrogen production supply chain that would leverage existing expertise, sustaining 10,482 jobs by 2035. Midstream, conversion of the gas transmission and distribution grid to hydrogen, would generate 9835 jobs, while the construction of hydrogen storage facilities in salt caverns would create 5,602 jobs, as well as exportable technology

and expertise. The report's assessment of the role of hydrogen in decarbonising downstream energy sectors, suggests that development, deployment, operation and maintenance of end-use hydrogen technologies in transport, heat in buildings, industry and power generation would support 8,493, 9,591, 1,863 and 10,685 jobs, respectively. The estimated gross job creation by 2035 is cumulative, with these jobs expected to be permanent and increasing beyond 2035.

What are the key assumptions behind this estimate?

The estimated number of jobs sustained is based on bottom-up modelling from projected hydrogen demand in four end-use sectors – transport, heat, industry and power generation- by 2035, and the associated capital and operating costs of the necessary hydrogen supply and infrastructure. The report draws on a number of sources to estimate hydrogen demand and predict the key hydrogen technologies that are likely to be deployed by 2035.

In upstream production, it is assumed that the UK's blue hydrogen demand will be met by several autothermal reforming (ATR) installations with CCS, while the UK's global leading role in material science and advancements in cell components materials mean that it can be ambitious in deploying centralised green hydrogen from electrolysis (PEM). Midstream, it is assumed that a share of the existing gas transmission and distribution network will be repurposed to meet hydrogen demand, and that excess hydrogen will be stored in centralised salt cavern storage. For downstream applications, hydrogen demand is assumed to be met in transport by hydrogen vehicles, in building heating by residential and commercial hydrogen boilers, in industry by industrial hydrogen boilers and hydrogen heaters, and in power generation by First-of-a-Kind (FOAK), Second-of-a-Kind (SOAK) and Nth-of-a-kind (NOAK) hydrogen plants.

Are any broader benefits described besides direct employment?

The report estimates that scaling up hydrogen solutions in the UK could unlock £18bn in GVA by 2035. The report argues that, as the UK looks to bounce back from the Covid-19 crisis, investment in hydrogen offers a sustainable economic growth opportunity that would kickstart a green recovery.

What needs to happen now to plot a course towards securing these jobs?

This Economic Impact Assessment follows on from a previous report published by the Hydrogen Taskforce, which outlines the role of hydrogen in delivering net zero in the UK. This report lays out the possible contribution of hydrogen and calls for the Government to nurture the policy environment that will drive the next stage in scaling hydrogen solutions and enable industry to invest in hydrogen technologies in the UK. To achieve this, five policy recommendations are put forward:

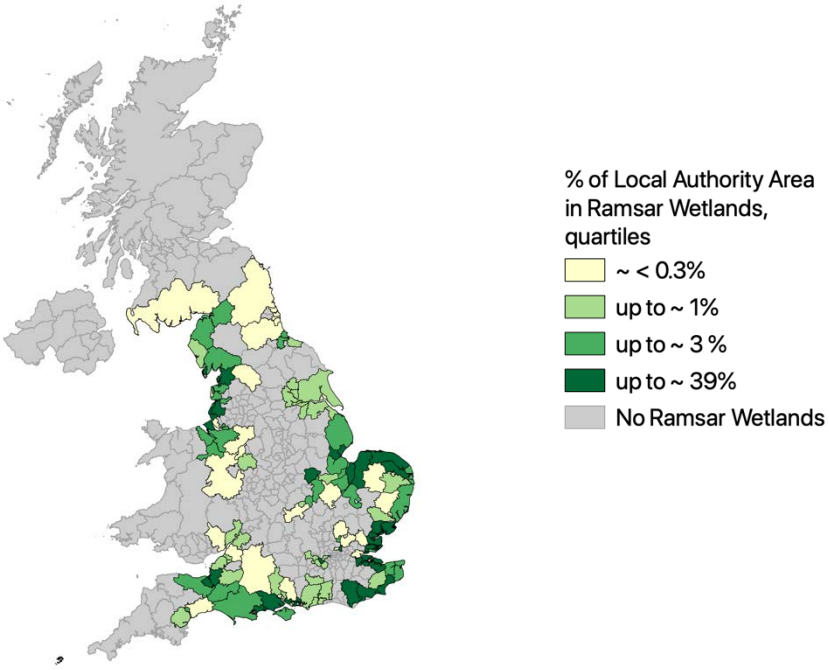
1) Development of a cross- departmental Hydrogen Strategy within UK Government.
2) Commitment by Government of £1bn over the next Spending Review period to hydrogen production, storage and distribution projects.
3) Development of financial support for the production of hydrogen for blending into the gas grid, industrial use, power generation and transport.
4) Amendment of Gas Safety Management Regulations (GSMR) to enable hydrogen blending into the UK Gas Grid and take the next steps towards 100% hydrogen heating through supporting public trials and mandating hydrogen-ready boilers by 2025.
5) Collaboration to establish 100 hydrogen refuelling stations (HRS) by 2025 to support the roll-out of hydrogen transport.

Appendix C: Additional Maps

Figure C1: Natural Capital Projects

Panel A - Wetlands

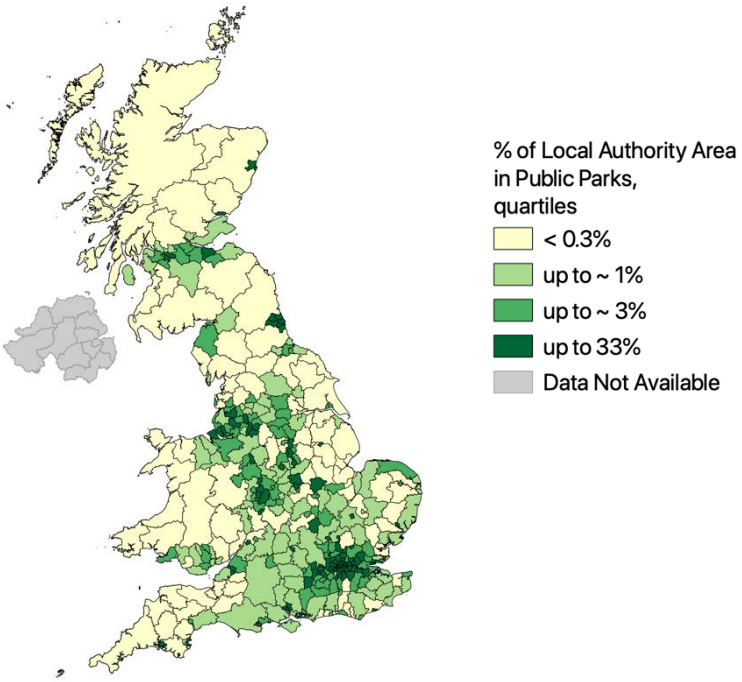
Indicative measure of potential 1: Percentage of Local Authority area in Ramsar Wetlands.



Data: Ramsar (England), 2020. Natural England Open Data

Panel B – Public parks

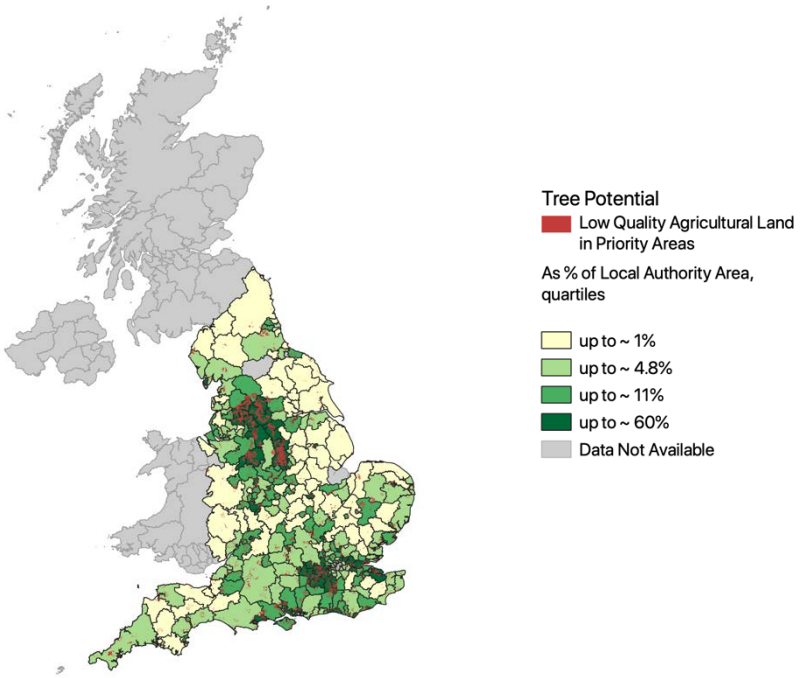
Indicative measure of potential 2: Percentage of Local Authority area in Public Parks



Data: OS Open Greenspace, 2020. Ordnance Survey.

Panel C – Tree potential

Indicative measure of potential 3: Tree Potential (Low Quality/Grade 4 Land in Priority Area)

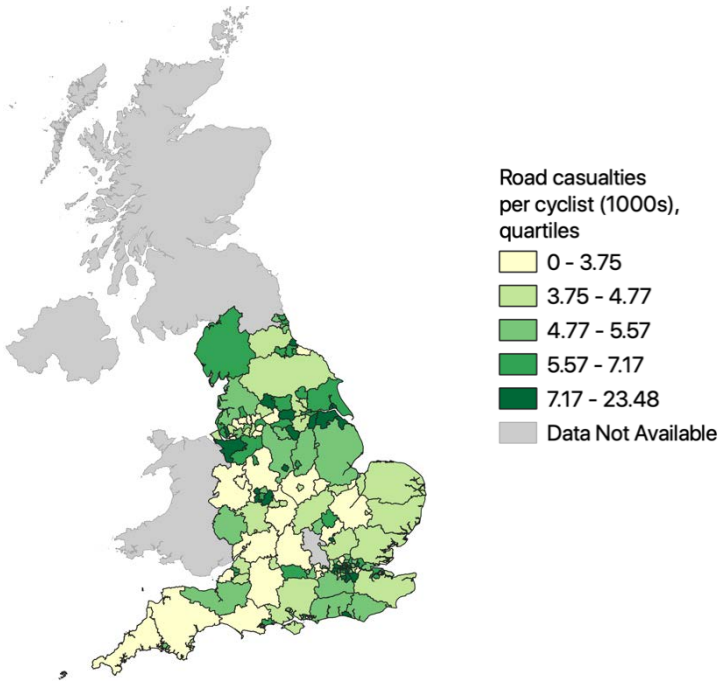


Data: Priority Areas for England, 2016; National Forest Inventory, 2018; Provisional Agricultural Land Classification, (ALC), 2020. Natural England. Methodology adapted from Friends of the Earth, 2020.

Figure C2: Active Travel Infrastructure

Panel A - Road casualties per cyclist

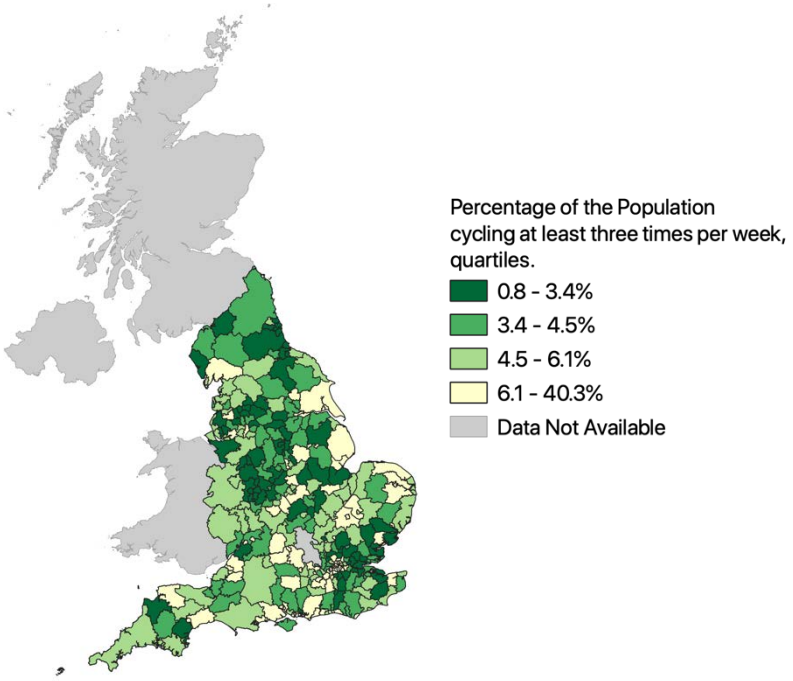
Indicative measure of potential: Road casualties per cyclist (1000s), quartiles.



Data: Tables cw0302 (Walking and Cycling Statistics, 2020), and ras30043 (Reported Road Casualties, 2019). Department for Transport. Cyclist: person who cycles at least three times per week. Casualty: fatal and not fatal.

Panel B – Cyclists as a percentage of the population

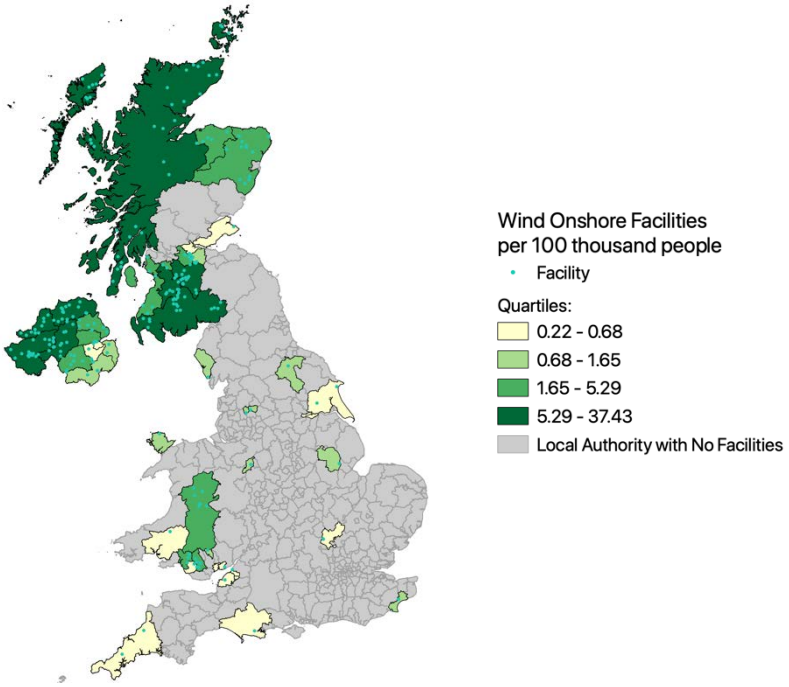
Indicative measure of potential: Road cyclists (at least three times per week) as percentage of total population.



Data: Tables cw0302 (Walking and Cycling Statistics, 2020), Department for Transport.

Figure C3: Renewable Power Generation and Distribution

Indicative measure of potential 2: Pipeline Wind Onshore project locations and projects per capita by local authority.



Data: Renewable Energy Planning Database, 2020.

Appendix D: Additional Charts

Legend for the charts which follow:

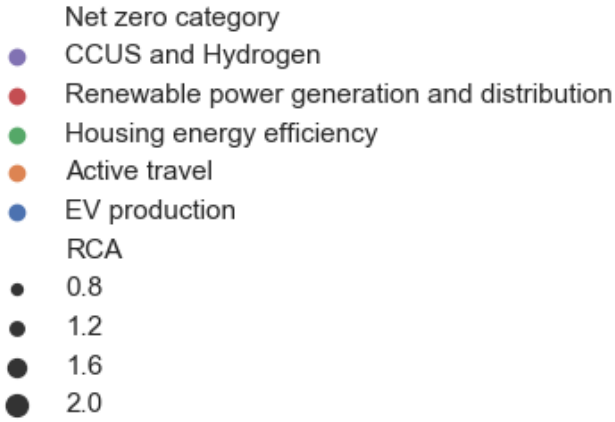


Figure D1: Existing strengths and new opportunities for the United Kingdom

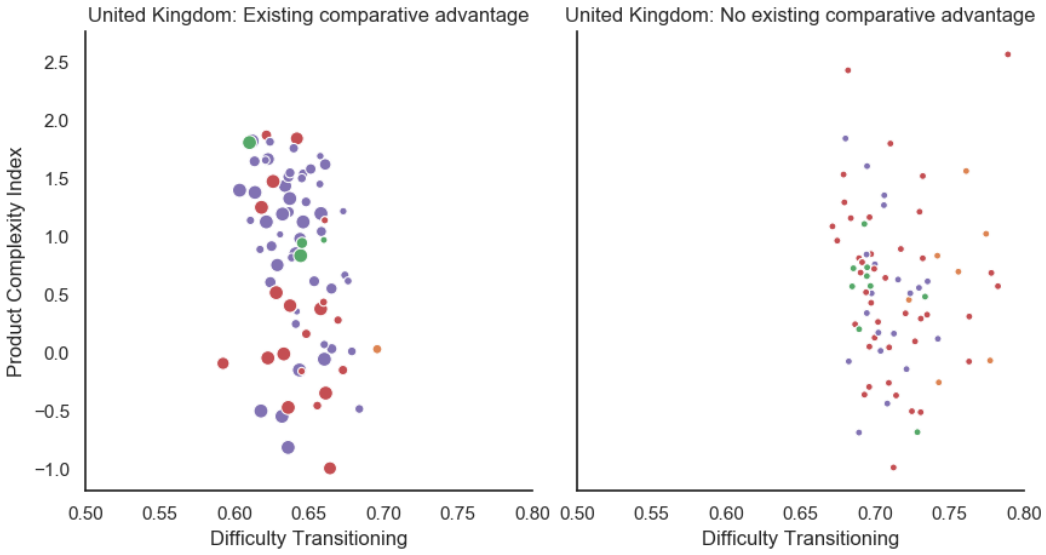


Figure D2: Existing strengths and new opportunities for Germany

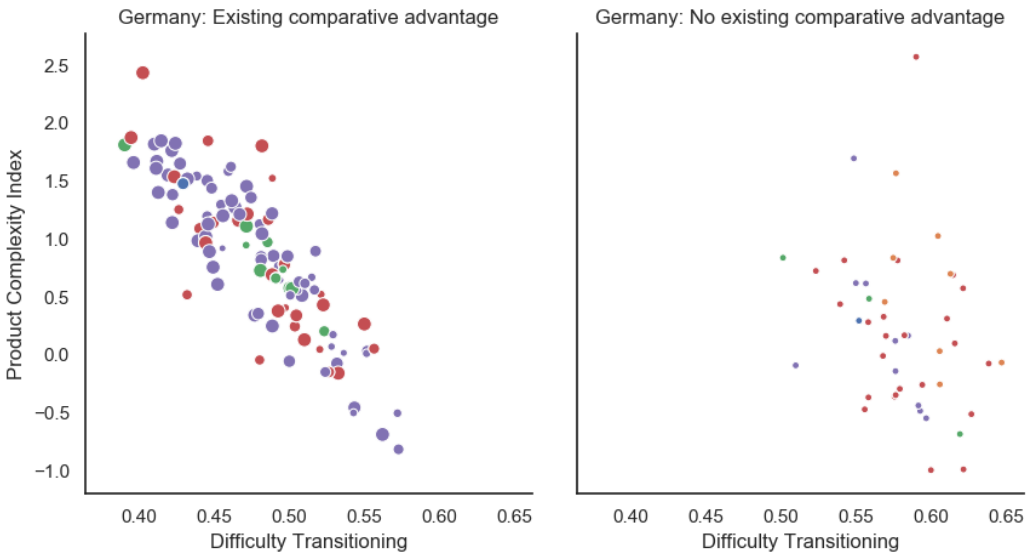


Figure D3: Existing strengths and new opportunities for France

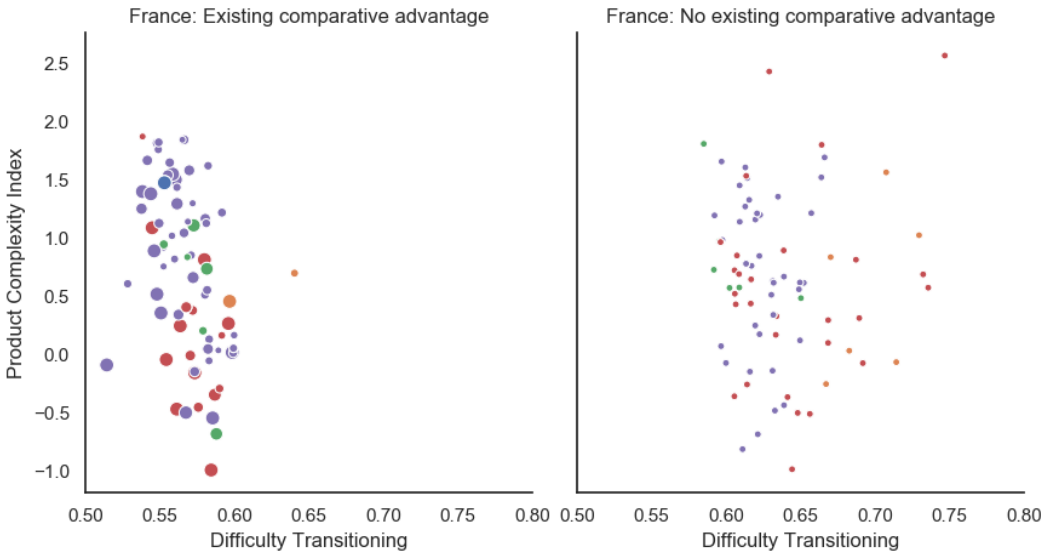


Figure D4: Existing strengths and new opportunities for the United States

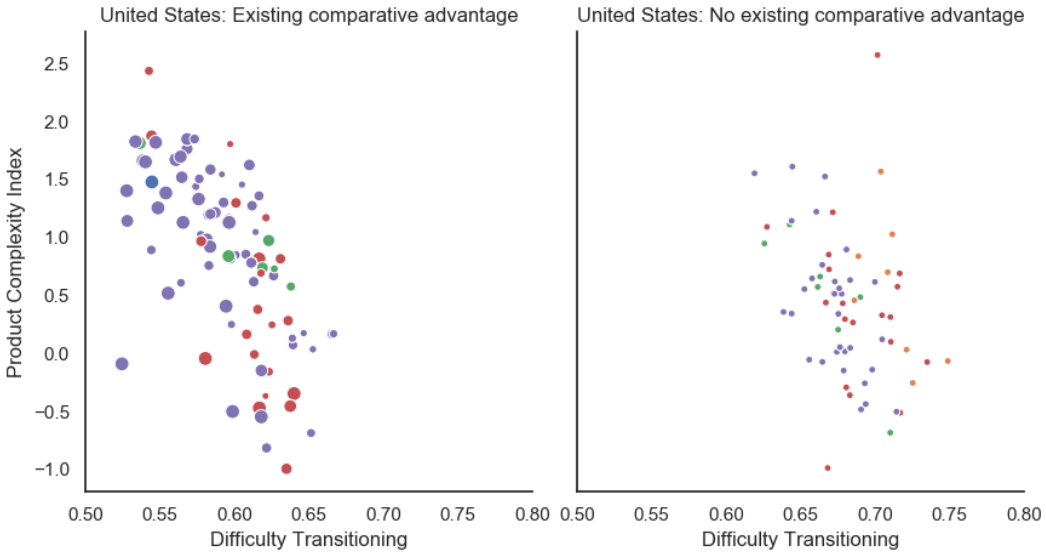
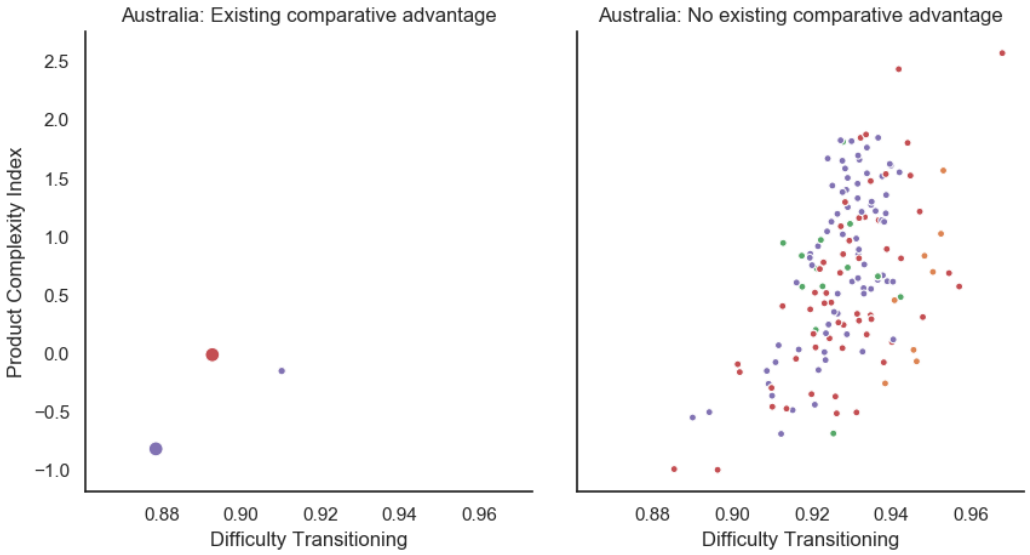


Figure D5: Existing strengths and new opportunities for Australia



About the Authors

Sam Unsworth is a Policy Analyst at the Grantham Research Institute.

Pia Andres is a Research Student at the Grantham Research Institute

Giorgia Cecchinato is a PhD student in Environmental Economics at the London School of Economics

Penny Mealy is a Research Fellow at SoDa Labs, Monash University and affiliated with the Institute for New Economic Thinking at the Oxford Martin School and the Oxford Smith School of Enterprise and Environment.

Charlotte Taylor is a Policy Analyst at the Grantham Research Institute

Anna Valero is ESRC Innovation Fellow at the Centre for Economic Performance.

For further information contact:

Sam Unsworth, s.unsworth@lse.ac.uk

Pia Andres, p.andres@lse.ac.uk

Giorgia Cecchinato, g.g.cecchinato@lse.ac.uk

Penny Mealy, penny.mealy@monash.edu

Charlotte Taylor, c.a.taylor@lse.ac.uk

Anna Valero, a.a.Sivropoulos-Valero@lse.ac.uk

Helen Ward, communications manager, CEP: 07970 254872, h.ward1@lse.ac.uk

Romesh Vaitilingam, press and public relations, CEP: romesh@vaitilingam.com

We are grateful for support from the Grantham Research Institute on Climate Change and the Environment, and the CCCEP/ESRC at the LSE. Financial support from the ESRC via the Centre for Economic Performance, and in addition under grant ES/S001735/1 is gratefully acknowledged.

CENTRE *for* ECONOMIC PERFORMANCE

The Centre for Economic Performance is a world-leading economics and policy research institute. CEP studies the determinants of economic performance at the level of the company, the nation and the global economy by focusing on the major links between globalisation, technology, the educational system and the labour market and their impact on productivity, inequality, employment, stability and wellbeing. It is part-funded by the Economic and Social Research Council and based at the London School of Economics and Political Science.

cepinfo@lse.ac.uk | cep.lse.ac.uk/ | @CEP_LSE

UKRI Economic and Social Research Council

LSE THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE