THE ECONOMY 2030 INQUIRY
SHAPING A DECADE OF CHANGE

Net zero jobs

The impact of the transition to net zero on the UK labour market

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June 2022

Centre for Economic Performance

Resolution Foundation

Funded by Nuffield Foundation

Acknowledgements

We thank Torsten Bell, Mike Brewer, Rui Costa, Jesse Kozler, Stephen Machin, Jonny Marshall, Josh Martin, Sabrina Muller, Henry Overman, Alex Beer and seminar participants at the Resolution Foundation and LSE Centre for Economic Performance for comments and discussion. We thank Juliana Oliveira-Cunha and Viet Nguyen for inputs. Financial support from the ESRC under grant ES/T002506/1 that has enabled some of the data work upon which we have built here, and for the Programme on Innovation and Diffusion (POID) is gratefully acknowledged. All errors remain the authors' own.

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Citation

If you are using this document in your own writing, our preferred citation is:

M Broome, S Cellini, K Henehan, C McCurdy, C Riom, A Valero & G Ventura, *Net zero jobs: The impact of the transition to net zero on the UK labour market,* The Resolution Foundation, June 2022

The Economy 2030 Inquiry

The Economy 2030 Inquiry is a collaboration between the Resolution Foundation and the Centre for Economic Performance at the London School of Economics, funded by the Nuffield Foundation. The Inquiry's subject matter is the nature, scale, and context for the economic change facing the UK during the 2020s. Its goal is not just to describe the change that Covid-19, Brexit, the Net Zero transition and technology will bring, but to help the country and its policy makers better understand and navigate it against a backdrop of low productivity and high inequality. To achieve these aims the Inquiry is leading a two-year national conversation on the future of the UK economy, bridging rigorous research, public involvement and concrete proposals. The work of the Inquiry will be brought together in a final report in 2023 that will set out a renewed economic strategy for the UK to enable the country to successfully navigate the decade ahead, with proposals to drive strong, sustainable and equitable growth, and significant improvements to people's living standards and well-being.

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Summary

The Government's commitment to achieving net zero emissions by 2050 will mean investment, and change, across the economy: from the decarbonisation of buildings and surface transport, to shifts in diet, aviation and industry. This means that the next stage of the pathway to net zero is set to bring more change to the UK public both as consumers, and as workers, change that will be felt by some more than others.

It's understandable that the latter – net zero's impact on workers – can bring with it fear and uncertainty: the UK's experience of structural change through deindustrialisation during the 1970s and 1980s drove up unemployment, concentrated among particular parts of the population, and left deep scars on some parts of the country. However, it does not follow that the net zero transition will follow the same path as these previous episodes of change.

The net zero transition involves the invention and diffusion of new technologies across and within sectors of the economy, with the Climate Change Committee (CCC) estimating that 84 per cent of decarbonisation to 2035 will involve new technologies or low carbon fuels, either alone or in conjunction with behaviour change (and the remainder involving behaviour change alone). Indeed, the Government has stated its intention to lead the world into a new 'Green Industrial Revolution', by investing in clean technologies such as wind, carbon capture, hydrogen and others. High-carbon industries, in particular, will see significant change in terms of technologies, processes and demand, with implications for those that work in them.

But unlike the 1980s, net zero does not generally imply closing down whole sectors in the UK (other than phasing out fossil fuel extraction entirely). Instead, it means decarbonising processes within sectors and across systems, creating some new roles and changing the way that certain jobs are done. In this note, prepared as part of the Economy 2030 Inquiry, we assess the likely scale – and nature – of labour market change brought on by the net zero transition over the next decade.

The net zero transition won't repeat the job destruction of deindustrialisation, but 4 per cent of UK workers in brown jobs – as well as another 13 per cent in green jobs – face direct change in the nature of their work

We identify sets of 'green' and 'brown' jobs that we expect to face significant change in their nature of work. Broadly, our green jobs relate to activities consistent with delivering the net zero transition: we classify a set of 'core green task' jobs which contain significant green task content and can therefore be considered 'directly' green (based on a mapping from detailed occupational classifications carried out in the United States by O*NET). Occupations that are currently prevalent in the most emissions-intense sectors, and

therefore those that require significant change to be consistent with net zero, are classified as 'brown changers'.

Our approach identifies 34 'brown changer' occupations (which together represent 4 per cent of people employed in 2019, or 1.3 million workers) for whom these types of changes are likely to apply. Within this group, some brown occupations whose primary function directly contributes to the generation of greenhouse gas emissions are likely to experience further decline: an obvious example would be coal mining operatives, which now only accounts for 0.01 per cent of employment (or just 2,700 workers overall). This is the group of workers that tend to be discussed as being particularly at risk due to the transition, given the previous negative experience of UK regions diversifying out of high carbon activities.

Workers in other brown jobs, like large goods vehicle drivers, will still be required in a net zero world, but may need to adapt to new, lower-emissions technologies and new ways of working. Others still will require significant change in both the technologies they use and the skills they deploy; for example, ship builders will need to learn to build lower-emissions vessels. Indeed, some of the brown jobs we identify already involve new green tasks and skill – such as energy plant operatives or production managers in mining and energy – but it is likely that further change will be required, given the urgent need to further decarbonise this decade.

Change will be felt for people already in green occupations, too. 'New' occupations, like wind turbine engineers, already involve green tasks, and will likely see further technological advances and changes in skill or task requirements over time (while also seeing increases in demand). In other relatively widescale and pre-existing occupations, tasks and associated skills are likely to change somewhat; for example, operations managers will need to take on the environmental sustainability of their business's operations. Our approach identifies 41 occupations (representing 13 per cent of employment, or 4.3 million workers) in what we label 'core green task' occupations (we define these as the occupations that are the most likely to involve new green tasks and skills). Other 'indirectly green' jobs (such as chemists or materials scientists), that may see increased demand due to the net zero transition, but no change in tasks or skills, are not included as green jobs for the purposes of this change-focused analysis. As a shorthand, this note refers to 'core green task' and 'brown changer' jobs as 'green' and 'brown' jobs, respectively. However, other studies have used different, and in some cases more expansive, definitions for green jobs and brown jobs than the ones we have applied here.

Green jobs are concentrated in London and the South East, whereas brown jobs are in areas in Wales, Scotland and the North of England including Barrow-in-Furness and Burnley

Using our definitions, 40 per cent of workers in both green and brown jobs work in either construction, manufacturing, agriculture or energy sectors, compared to 20 per cent of workers overall. In addition, green jobs (but not brown) are also overrepresented in the professional, scientific and technical sector: 14 per cent of employment in this sector is classed as green, compared to 8 per cent nationally.

When it comes to how green and brown jobs are distributed across the UK, specifically looking at Travel to Work Areas (TTWAs), we find green jobs to be particularly concentrated in parts of the South East (for example, 17 per cent of employment in the High Wycombe and Aylesbury Travel to Work Area), London (16 per cent) and also in Malton, a market town in Yorkshire (20 per cent). By contrast, areas in Wales, Scotland and Northern England see a greater concentration of brown jobs: for example, 16 per cent of employment in Barrow-in-Furness is in a brown job, as is 11 per cent of cent of employment in Newport and 9 per cent in Aberdeen.

Green jobs are particularly concentrated among higher-qualified workers and centred on non-routine analytical tasks; brown jobs are concentrated among mid- and lower-qualified workers, and are more likely to require manual and physical tasks

To understand what the net zero transition will mean for workers, we need to understand central differences between the sets of green and brown occupations we have defined.

In terms of occupational characteristics, green jobs tend to be concentrated in higher-paid occupational groups, with green jobs comprising 40 per cent of employment in managerial occupations, 14 per cent in professional occupations and 21 per cent in associated professional occupations (compared with 13 per cent of employment overall). Brown jobs are all but absent in these occupational groupings (comprising just 1 per cent of employment in associate professional occupations, compared with 4 per cent of total employment) but are instead highly concentrated in process and plant operative occupations, where more than one-in-four (27 per cent) of workers are in a brown job.

Men are more likely than women to work in both green (18 versus 8 per cent) and brown jobs (8 versus 2 per cent). There are differences across ethnic groups too, with White workers being the most likely to be found in green jobs (14 per cent), and significantly more likely than Black workers (8 per cent).

When it comes to factors like pay and qualifications, more significant differences between green and brown jobs emerge, with graduates being much more likely to work in a green job than someone with a GCSE-equivalent qualification (16 per cent of graduates are in a green job, compared to 11 per cent of those qualified to at most GCSE-level) and the reverse being true for brown jobs (3 per cent of graduates work in a brown job, compared with 6 per cent qualified to GCSE-level). Moreover, core green task jobs appear to command a wage premium of around 8 per cent on average, even after controlling for worker education and experience.

Examining the nature of these groups of green and brown jobs in terms of task content we find that, on average, they tend to require very different sets of skills and tasks from one another: core green task occupations are more likely than others to require non-routine analytical and personal tasks (which tend to be more prevalent in higher skilled occupations), and our set of brown jobs are much more likely to require routine manual and especially non-routine physical tasks.

The overall share of workers in green and brown jobs hasn't shifted much over the past decade, but meeting emissions targets will require significant green jobs growth in the next

To help us think about whether the scale of change coming is likely to be manageable, it is helpful to consider the experience of change over the last decade. On aggregate, there's been little change in the relative size of green and brown occupations over the past decade; the share of employment in green jobs grew by just 1.3 percentage points and the share in brown jobs hasn't changed (remaining at 4 per cent of employment). The small net growth in green jobs has been largely driven by higher-paid roles, like marketing and sales directors, and business management professionals. Occupations that we classify as brown have – on average – tended to remain much more static as a share of employment.

However, significant change will be required over the next decade if the UK is to meet its emissions targets. Several studies have set out what this means in terms of demand for jobs and skills. For example, the Offshore Wind Industry Council estimates that the UK could employ around 70,000 in offshore wind (direct and in supply chains) by 2026 (compared to around 26,000 in 2021), the National Grid estimates there will be an additional 260,000 energy workers needed by 2050 to get to net zero, and research from the Construction Industry Training Board estimates that the UK will need 60,000 workers for heat pump installation in domestic and non-domestic buildings over the next seven years (compared to 900 installers in 2019). To understand how the UK labour market will be able to meet this future demand, we look at the very recent past in order to understand where workers in green jobs tend to come from, whether workers in brown

jobs are likely to transition into green jobs, and whether workers in brown jobs that are at risk are any more likely than average to move into unemployment over the longer term.

In recent years, green job entrants have tended to be middle-aged and higher-qualified, and only a small – but growing – number of people have moved from brown to green jobs

The limited growth in green jobs over the past decade has been driven more by workers moving from non-green jobs into green jobs, rather than by young workers who recently left education or workers who were previously out of employment. A wide range of green jobs have been filled by previously non-green workers, but workers moving into green jobs tend to be highly educated, and tend to move from jobs that are more similar to green occupations, for example requiring a significant amount of analytical tasks. They also come from jobs with relatively high hourly pay, but they still obtain a significant pay increase of around 10 per cent after moving into a green job (there is an even larger proportional rise for those leaving brown jobs and joining green ones).

The share of brown job workers moving to green jobs has been low, although it has increased over the period considered (from only 0.3 per cent of brown workers in 2013 to 2.8 per cent in 2019). The rarity of these moves is unsurprising given that the occupational content of and the skills required in an average green occupation are different from those in an average brown job, and this makes it hard to make a direct transition. Indeed, only 1 in 7 occupational moves cover the average distance in task content that would be needed to make the switch from the average brown job to the average green job. Workers who actually performed these hard-to-make transitions from brown to green tend to be much more educated than average, and to come from brown jobs with a high content of analytical tasks (and hence more similar to green occupations to start with).

The experience to date, and broader lessons from transitions in the past, can help inform larger-scale change that is coming this decade

Although some brown jobs will change as existing workers build new green skills and take on green tasks, we certainly can't rely on it happening naturally in the future: those people who have moved over the past decade have been highly educated, and have moved into fairly similar jobs (when assessed with the sort of tasks they perform). This is worrying, given both the need to see an increase in green jobs over the next decade and the need to manage transitions for those displaced from brown jobs, or finding it hard to adjust.

Transitions out of, and reskilling of brown jobs – together with ensuring that the skills needs of green jobs are met – will likely require extra effort from firms, the Government

and workers themselves, and such efforts are likely to vary across places, sectors and demographic groups. While our analysis has shown that on average green jobs have tended to be more prevalent amongst graduates, it is likely that many of the new skills required can also be delivered via on-the-job training and via the further education system. Targeted workforce training programmes can help to facilitate the adoption of new technologies and practices for net zero within occupations, and transition displaced workers into new occupations or areas where demand is growing. In some ways, the successes – and failures – of past attempts to manage change will prove instructive. For example, the relative success in transitioning Germany's Ruhr region away from coal and towards technology and education, as compared to the less successful experience in the Welsh valleys, was due, in part, to better coordination between national and local policy, investments in skills and complementary assets, and a focus on good jobs and environmental activities.

In the transition to net zero, there will be a key role for policy at the national and local levels in terms of helping businesses and workers to adapt to changes in technology, and addressing frictions that create mismatches between skills supply and demand. There might also be challenges ensuring that new opportunities for good quality green jobs are accessible to groups that have so far been under-represented in green jobs to date, such as women and some ethnic groups.

Looking forward, policy makers should be prepared to manage the variety of changes that the net zero transition will bring to the UK workforce, and though these changes may not look like a return of 1980s deindustrialisation, they will indeed require a concerted effort to ensure that people, places, and firms have the assistance and skills to adopt to new technologies, new tasks, and demand for entirely new jobs. These policy challenges will be discussed in greater detail in forthcoming work as part of the Economy 2030 Inquiry.

The transition to net zero will bring change to the labour market, but it won't be a repeat of the 1980s deindustrialisation

It's often feared that the net zero transition will grow higher-paid, 'green' sectors and shrink less-well-paid 'brown sectors,' leaving a large group of workers out in the cold

The UK's commitment to achieving net zero emissions by 2050 implies significant change for firms, consumers and workers. The country has made substantial progress in reducing emissions over recent decades: cutting territorial carbon emissions in half between 1990 and 2020, largely via decarbonising electricity generation. Although continued decarbonisation in the energy sector is required, this next phase will look different, requiring substantially increased investment and action across the economy including

in the decarbonisation of buildings and surface transport, and changes in diet, aviation and industry. Such system-wide change across energy, transport, cities and transport and the changing nature of decarbonisation will bring with it a new set of challenges and opportunities, as set out in previous reports for the Economy 2030 Inquiry.[1]

Our ability to make those shifts will both rest on – and also cause – changes in the UK labour market. On the one hand, delivering net zero will create new jobs and change the skill and task requirements in many existing jobs. On the other hand, demand for some jobs could fall, and others could become obsolete. Uncertainty about the impacts of this type of structural change inevitably causes fear, and this is not unfounded: during the 1970s and 1980s, there was major structural change in the UK, with the decline in heavy industries like steel, coal mining and ship building resulting in a sharp employment shock. This drove unemployment up among a large share of working-age men, most of whom were unable to transition towards the parts of the economy growing fastest: higher-paid roles in the service sector.[2] The scars caused by this shock are visible still today in some of the geographical inequalities in economic outcomes.[3]

However, it does not follow that the net zero transition will follow this type of path. The net zero transition involves the invention and diffusion of new technologies across and within sectors of the economy – with the CCC estimating that 84 per cent of decarbonisation to 2035 will involve new technologies or low carbon fuels, either alone or in conjunction with behaviour change (and the remainder involving behaviour change alone). Indeed, the Government has stated its intention to lead the world into a new 'Green Industrial Revolution', by investing in clean technologies such as wind, carbon capture, hydrogen and others.[4] High-carbon industries, in particular, will see significant change in terms of technologies, processes and demand, with implications for workers.

But, unlike the 1980s, net zero does not generally imply closing down whole sectors in the UK (other than phasing out fossil fuel extraction entirely). Instead, it means decarbonising industrial processes, changing the way that certain jobs are done: for example, large goods vehicle (LGV) drivers will need to change the types of vehicles being deployed and related work practices, but we do not expect this occupation to substantially shrink due to net zero (though it might be subject to change due to automation). In parallel, green jobs are set to rise in number including both 'new' occupations involved in producing green products and services themselves (such as wind turbine engineers or solar voltaic installers). It will also mean the greening of many existing, relatively widespread jobs

1 J Marshall & A Valero, The Carbon Crunch: Turning targets into delivery, Resolution Foundation, September 2021; and B Curran et al, Growing Clean: Identifying and investing in sustainable growth opportunities across the UK, Resolution Foundation, May 2022.
2 S Clarke, Forging ahead or falling behind? Devolution and the future of living standards in the Sheffield City Region, Resolution Foundation, January 2017;
3 C Beatty et al. The real level of unemployment 2022: the myth of full employment across Britain. Sheffield Hallam University, Centre for Regional Economic and Social Research.
4 BEIS, 10 Downing Street, The Ten Point Plan for a Green Industrial Revolution, November 2020.

as firms across the economy improve the sustainability of their own operations – for example, sales managers and manufacturing production managers will take on new tasks and have to learn new skills. As in any period of technological and structural change, there are likely to be winners and losers, across and within countries. Identifying these and managing change fairly will be a key component for achieving future growth that is not only more sustainable, but also inclusive.

In this note we assess the likely scale and the nature of the labour market change brought on by the net zero transition over the next decade. We do this by considering the levels of change seen over the past decade, before enhanced decarbonisation commitments were made with the UK's Net Zero target,[5] describing key features of jobs that can be considered to be currently green and brown, and the workers that hold them. We analyse mobility patterns of individual workers that have moved in and out of these types of jobs, before considering how active government investments and policy, and private sector investments that will result from these, are likely to turn the dial even further this decade and beyond. We conclude by assessing what these changes imply for policy.

We take a 'bottom-up' approach to classifying green and brown jobs, identifying occupations that involve new green tasks as green, and those that are particularly prevalent in emissions-intense sectors as brown

There is no single or commonly agreed definition of a green job, with various studies using different measures depending on the context and research question. Some of these can be considered as 'top down', based, for example, on counting all employment in sectors that provide environmental goods or services,[6] or in sectors with low emissions; other approaches are 'bottom up', focused on using organisation or occupation-level information to classify employment.[7]

In this note, we employ a bottom-up approach to classifying green jobs: we define 'core green task' occupations as those that involve green tasks, according to granular classifications developed by the Occupational Information Network (O*NET) in the United States, which we map into UK occupations. We also classify occupations as 'brown changer' based on the prevalence of occupations within emissions-intense sectors, which we consider will need to change either via the adoption of new tasks or

5 The UK's net zero target commits the country to bringing greenhouse gas emissions to net zero by 2050, compared with the previous target of at least 80% reduction from 1990 levels. Accelerated action is required this decade to remain on track for achieving net zero by 2050. We finish our analysis in 2019 to avoid the impacts of Covid-19.

6 For example, this is the approach taken by the ONS in the Low Carbon and Renewable Energy Economy (LCREE) Survey which counts all jobs in firms identified as being in such sectors, and estimates that the LCREE accounted for around one per cent of total UK non-financial employment in 2020.

7 For a summary and comparison of different approaches applied to the US and European economies, see: A Valero et. al., Are 'green' jobs good jobs?, Centre for Economic Performance, London School of Economics, October 2021. See also: ONS, The challenges of defining a "green job", April 2021. More recent ONS work has estimated the time spent on green tasks in UK occupations, based on a mapping from O*NET task-level data, see: ONS, Research into "green jobs": time spent doing green tasks, UK, 1997 to 2019, March 2020.

technologies, or via being phased out. Jobs that are not classified as either 'core green task' or 'brown changer' are classified in "other" for purposes of our analysis. By focusing on occupation-level classifications, our work here builds on previous UK analysis conducted at the LSE,[8] in a way that is broadly consistent with more recent international analysis conducted by the IMF;[9] but contrasts with some other UK-based studies that combined sectoral and occupational approaches in different ways.[10]

Because the objective of this note is to analyse change for workers, we focus on the green jobs that involve new green tasks that arise due to the transition to zero carbon, which have been called 'directly green' jobs in previous studies.[11] These are the jobs most likely to require new skills; this will have implications for skills policies, and may also mean that transition programmes are needed for those displaced by the need to decarbonise or via other shocks and changes, such as automation. In particular, our green jobs classification is based on two types of 'core' or 'directly green' occupations identified by O*NET: the first is referred to as 'green new and emerging', which relates to relatively new occupations with specific green tasks and associated worker requirements. Examples include wind energy engineers, solar voltaic installers or chief sustainability officers. The second is labelled 'green enhanced skills' and refers to existing occupations where new tasks, skills and knowledge are required for decarbonisation. Examples include a general and operations manager for whom specific green tasks relate to managing the sustainability of operations, or a marketing manager for whom a new green task might be developing business cases for environmental marketing strategies. Importantly, we exclude a third category of 'indirectly green' occupations as classified in O*NET referred to as 'green increased demand': these are occupations that will not experience a change to their tasks or worker requirements due to decarbonisation but are likely to see increased demand; these include chemists and material scientists, for example.[12]

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8 A Valero et al., Are 'green' jobs good jobs?, CEP Paper Number CEPSP39, October 2021. See also: A Bowen and B Hancke, The Social dimensions of 'Greening the Economy', European Commission, 2019.

9 Chapter 3. A Greener Labor Market: Employment, Policies and Economic Transformation in IMF, World Economic Outlook, April 2022.

10 For example, by considering employment in the ONS Low Carbon and Renewable Energy Economy sectors as total 'green' employment while highlighting occupations with new skills needs using the Green Enhanced Skills category (obtained from a sector level mapping of green jobs from the US); and considering as 'brown' jobs all those jobs in sectors with particularly high emissions intensity or accounting for two per cent of UK emissions overall. See: T Christie-Miller and A Luke, Qualifying for the race to net zero: How to solve the net zero skills challenge, Onward, July 2021; and T Christie-Miller & A Luke, Greening the giants, Onward, March 2021.

11 See, for example, A Bowen et al., Characterising green employment: The impacts of 'greening' on workforce composition, Energy Economics 72: 263-275, 2018.

12 This is a more conservative approach than reports which have utilised O*NET green job classifications in the past in order to estimate the quantity of green jobs in the economy, and describe how they differ from non-green jobs in the US, UK or the broader international context. See: A Valero et. al., Are 'green' jobs good jobs?, Centre for Economic Performance, London School of Economics, October 2021. But a focus on 'directly green' jobs is consistent with studies that focus on task differences between green and non-green jobs, for example: D Consoli et al., Do green jobs differ from non-green jobs in terms of skills, human capital?, Research Policy 45 (5), 2016; F Vona et al., Environmental Regulation and Green Skills: An Empirical Exploration, Journal of the Association of Environmental and Resource Economics, 5(4), October 2018; and Chapter 3. A Greener Labor Market: Employment, Policies and Economic Transformation in IMF, World Economic Outlook, April 2022.

Given that there are over 1,000 O*NET occupations, but only 369 in the UK in the UK's occupational classification system, we calculate a measure of 'core greenness' in UK occupations that have either or both of these two categories of green job mapped to them, and consider those above a certain threshold to be green (Box 1). This means that some of the occupations that we do not identify as green will also contain green tasks to some extent; our focus on those whose greenness lies above a certain threshold allows us to look at what we may consider the most 'directly green' in terms of tasks and skills requirements. Moreover, the information we rely on from O*NET does not vary over time, so our approach will not capture changes in greenness within occupations over time (or new green jobs that might have emerged), which particularly more recently (given enhanced national and international commitments to net zero) are likely to have become more widespread. Box 1 provides more detail on our methodology and assumptions.

TABLE 1: **Core green jobs account for approximately 13 per cent of employment**

Share of 16-69-year-old employment in 'core green' occupations, at four-digit SOC 2010 level: UK, 2019

Green jobs	Employment share		
Sales mgrs	1.50%	Construction supervisors	0.22%
Mfg production mgrs	1.00%	Purchasing mgrs	0.22%
Marketing/sales directors	0.85%	R&D mgrs	0.21%
Business mgmt prof	0.85%	Care mgrs	0.20%
Construction trades	0.76%	PR profs	0.19%
Construction production mgrs	0.64%	Procurement officers	0.19%
Finance mgrs	0.54%	Transport & dist assts	0.18%
Plumbing and heating engrs	0.53%	Brokers	0.18%
Solicitors	0.39%	Architects	0.17%
Shopkeepers	0.36%	Roofers, tilers	0.17%
Warehousing mgrs	0.35%	Enviro profs	0.15%
Regulatory profs	0.34%	Science technicians	0.14%
Engr technicians	0.32%	Electrical technicians	0.11%
Chief execs	0.29%	Electronics engrs	0.10%
Transport & dist mgrs	0.29%	Planning technicians	0.09%
Financial inst. Mgrs	0.28%	Physical scientists	0.09%
Civil engrs	0.27%	Town planners	0.07%
Construction project mgrs	0.25%	Conservation profs	0.05%
Routine inspectors	0.24%	Sheet metal workers	0.05%
Mech engrs	0.24%	Conservation assoc. prof.	0.03%
Business , research prof	0.22%		
		Total	13.3%

NOTES: Green jobs classifications based on a cross walk from O*NET into UK SOC2010, under various assumptions as set out in Box 1. Green job flag is our 'core green task' binary green variable used in this briefing note. Green job flag including crossovers includes the 10 occupations that are also brown, and considered brown for the purposes of this briefing note. Mean core green is the average overall greenness (GNE and GES) across jobs. Mean core green (employment weighted) is the average using US and UK employment weights in the crosswalk from O*NET into UK SOC 2010. Mean core green task share uses information from O*NET on the share of occupational tasks that are green.
SOURCE: Analysis of ONS, Labour Force Survey, classifying 'core green task' jobs as set out in Box 1.

This approach identifies 41 occupations at the SOC 2010 four-digit level as 'core green task', accounting for just over 13 per cent of working age employment in 2019 or 4.4 million workers (see Table 1) and we refer to these as green jobs for the purposes of this briefing note. Some of the most prevalent of these relate to managerial roles, but technicians, engineers and other professionals also feature. We note also that some green occupations are disproportionately found in sectors with the highest emissions intensity – such as energy plant operatives or production managers in mining and energy; and we label such 'crossover' occupations as being in the 'brown changer' category, as discussed below.

BOX 1: **Classifying 'core green task' occupations**

Our approach to classifying green jobs is based on green occupations identified in the O*NET database.[13] O*NET classifies any occupation that will be positively affected by greening as a green job, and in particular sets out those occupations that will involve new green tasks, which are classed as 'directly green', under two categories:

- Green new and emerging (GNE): The transition to a sustainable economy leads to the creation of new occupations with unique tasks and worker requirements.
- Green enhanced skills (GES): The transition to a sustainable economy significantly alters tasks, skills and knowledge requirements of these existing occupations.

A further category, considered to be 'indirectly green' does not involve new green tasks:

- Green increased demand (GID): The transition to a sustainable economy creates higher demand for these occupations but there are no significant changes in tasks or worker requirements due to greening.

We draw on previous work where O*NET occupation were mapped into the more aggregated UK occupations, making the assumption that what is considered a green occupation in the US is also a green occupation in the UK. The occupational mapping is complex due to the 'many to many' correspondences – i.e. O*NET occupations tend to be mapped to more than one UK occupation, and

13 O*NET refers to the 'greening' of occupations as 'the extent to which green economy activities and technologies increase the demand for existing occupations, shape the work and worker requirements needed for occupational performance, or generate unique work and worker requirements'. For more detail on green jobs in O*NET see: E Dierdorff et al., Greening of the World of Work: Implications for O*NET-SOC and New and Emerging Occupations, Office of Workforce Investment, 2009.

vice versa. We rely on a detailed crosswalk provided using 'LMI for All', an online data portal funded by the UK's Department for Education.[14]

Our green job identifier is based on a simple average of the 'greenness' across O*NET occupations mapped to each UK occupation, focusing on the directly green occupations (GNE and GES). Other recent studies using O*NET green jobs identifiers have also focused on this subset of 'directly green' jobs, either in the US context, or via mapping these to international contexts. This measure of greenness takes values between (and including) zero and one depending on the share of occupations that are directly green. Because we want to examine job transitions in and out of green jobs, we generate a discrete green marker based on this, such that an occupation is considered 'core green task' if its core greenness is greater than 0.33. For example, if one UK occupation has two US occupations mapped to it, one of which is GNE, and one which is not green; that UK occupation would obtain a core green mean index of 0.5 and we would classify it as a 'core green task' job. Under this approach, 51 occupations are classified as green, ten of which are considered 'brown changer' under the steps we document below, leaving us with 41 core green task occupations used in this report.

We favour this simple and transparent approach, but also consider alternative methods of allocating greenness to UK occupations, including using employment weights when mapping O*NET to UK occupations and task shares. Annex 1 shows that the basic characteristics of green jobs are not altered much when we consider alternative measures of greenness. Using the employment-weighted greenness as the basis for the discrete core green job marker generates a similar list of green jobs, though it picks up some extra and excludes others.

Ultimately, our objective is to create a list of jobs most likely to be newly created or changed with new tasks or skills due to net zero (rather than occupations that will need to grow without changing their nature), noting the limitations in defining such a list given the mapping exercise and assumptions involved. Further limitations apply given that the O*NET classifications were generated in 2010 and a group of sectors that were considered key for the transition at that time, and in the US labour market. It might miss jobs that have emerged more recently, additions of new green tasks in these groups or broader groups of occupations over time, or green jobs that might exist in other countries where the occupational mix and transition needs are different. Moreover,

14 Department for Education, LMI for All.

such approaches consider an occupation as being equally green regardless of the firm it occurs in. Ideally, it would be possible to combine information on occupations within firms with firm-level information on zero-carbon products, services or processes. Building datasets that would enable such an approach is left to future research.

We identify 'brown changer' jobs as those that are likely to experience either reduced demand or a particularly urgent need for change in the transition to net zero. To do this, we first identify the most emissions-intense sectors as those above the 90th percentile of greenhouse gas emissions per worker. We then define occupations to be 'brown changer' where their employment share in emissions-intense sectors is over five times as high as the share of employees in these sectors across all occupations. This means that our concept of brown jobs relates to those disproportionately found in emissions-intense industries and are therefore particularly subject to change or disruption in the transition to net zero. Again, a number of assumptions are required in this classification, and more detail can be found in Box 2. Using this approach, we identify 34 occupations as being currently 'brown' (see Table 2); together, these account for just under 4 per cent of working-age employment in 2019, or 1.3 million workers.

As noted above, 10 of these 34 brown occupations also meet our criterion for being a green job, already involving green tasks; examples include energy plant operatives and large goods vehicle drivers. However, given their prevalence in currently emissions-intense sectors, we consider that these occupations are likely to require significant change and potentially disruption in the transition to net zero, either in terms of the technologies or the skills, knowledge and tasks deployed, and so we classify these roles as brown for the purposes of this briefing note.

TABLE 2: **LGV drivers are the most prominent 'brown job' according to our measure**

Share of 16-69-year-old employment in 'brown' occupations, at four-digit SOC 2010 level: UK, 2019

Brown jobs	Employment share		
LGV drivers	0.94%	Instrument maker	0.06%
Engnr prof	0.38%	Pilots	0.06%
Elementary process ops	0.29%	Boat builder	0.06%
Metal working machine ops	0.19%	Weighers & graders	0.05%
Air travel asst	0.19%	Waste & enviro services	0.05%
Electrical engr	0.19%	Ship officer	0.05%
Welders	0.17%	Air transport ops	0.04%
Production engr	0.17%	Crane drivers	0.04%
Mobile machine drivers	0.16%	Street cleaners	0.03%
Quality control engr	0.13%	Metal process ops	0.03%
Debt process ops	0.11%	Pipe fitters	0.03%
Refuse & salvage	0.11%	Energy plant ops	0.02%
Aircraft maintenance	0.09%	Importer/exporter	0.02%
Machine ops	0.08%	Marine/waterway ops	0.02%
Leisure & travel service	0.08%	Metal plate workers	0.01%
Debt collector	0.07%	Coal mining ops	0.01%
Mining mgrs	0.07%	Moulder	0.01%
		Total	4.0%

SOURCE: Analysis of ONS, Labour Force Survey, classifying 'brown changer' jobs as set out in Box 2. Note, 'brown changer' jobs include 'crossover' occupations which already include core green tasks.

BOX 2: **Classifying 'brown changer' occupations**

We identify a set of 'brown changer' occupations (referred to interchangeably as 'brown') which are occupations that are particularly prevalent in sectors with high emissions intensity, following an approach that is consistent with previous work on the US which has also been applied (via crosswalks to more aggregated occupations) in more recent international analysis. [15] This identifies a different set of jobs than work that counts all sectoral employment in high emissions sectors as brown.[16]

We first assemble a dataset combining two ONS UK-level sources containing information at two-digit Standard Industrial Classification (SIC) group: total yearly greenhouse gas emissions (carbon dioxide, methane, nitrous oxide, hydro-fluorocarbons, perfluorocarbons, nitrogen trifluoride, sulphur

15 See, for example: Chapter 3. A Greener Labor Market: Employment, Policies and Economic Transformation in IMF, World Economic Outlook, April 2022.

16 For example, total employment in twelve carbon intensive industries represents nearly a quarter of total UK employment, see: T Christie-Miller & A Luke, Greening the Giants, Onward, March 2021.

hexafluoride) in CO2 tonnes equivalent, up to 2019;[17] and annual employee and employment estimates from the Business Register and Employment Survey (BRES) up to 2019.[18] We consider emissions-intense industries as those in the 90th percentile of greenhouse gas emissions per worker using the earliest available values. The earliest information we use for most industries is from 2011; in case of missing values, we use the earliest estimate available up to 2013. The resulting group includes eight sectors which are still the top polluters using the latest values (2018/19): mining of coal and lignite; crude petroleum and natural gas; manufacture of coke and refined petroleum products; manufacture of basic metals; electricity, gas, steam and air conditioning supply; waste collection, treatment and disposal services, materials recovery services; water transport services; and air transport services.

As a next step, we identify as 'brown changer' jobs as jobs within occupations that are most prevalent in these emissions-intense sectors. More specifically, brown changer occupations are those where the share of employees in these high emitting sectors is at least five times larger than the share of employees in polluting sub-sectors across all occupations. We consider occupations to be brown changer if this is the case either at the beginning or at the end of our data horizon of 2011-2019 (or both). Using this approach, we identify 34 occupations as being currently brown. Within this, 10 occupations also meet the threshold for being a green job –they already contain green tasks to some extent. Such 'crossover' occupations include mining managers; waste and environmental managers; electrical engineers; production engineers; engineering professionals; quality control and planning engineers; pipe fitters; energy plant operatives; large goods vehicle drivers and refuse and salvage occupations. Given their prevalence in currently emissions intense sectors, we consider that these occupations are likely to require significant changes as well as disruption in the transition to net zero, in terms of the technologies and/or the skills, knowledge and tasks deployed, and we classify these roles as 'brown changer' for the purposes of this briefing note.[19]

17 ONS, Atmospheric emissions: greenhouse gases by industry and gas, September 2021; accessed April 2022.
18 ONS, Industry (2, 3 and 5 – digit SIC) – Business Register and Employment Survey (BRES): Table 2, November 2021; accessed April 2022.
19 Other assumptions are justifiable depending on the research question. Here, we want to compare the occupations most likely to experience change in this next phase of decarbonisation. But previous work that sought to quantify and describe green jobs across the economy – considering all jobs that had some element of 'greenness' attached to them and without attempting to classify 'brown' jobs – took a broader approach. See: A Valero et. al., Are 'green' jobs good jobs?, Centre for Economic Performance, London School of Economics, October 2021.

We consider that the net zero transition will bring three types of change to the brown occupations we have identified. First, some of the brown jobs are inconsistent with net zero, including occupations, like coal mining operatives and mining managers, whose core function is a direct contribution to carbon emissions. Such jobs make up a relatively small, and declining share, of UK employment, and we expect further decline in the net zero transition.

Second, there is a set of currently brown jobs where demand is not likely to decline as a direct result of decarbonisation, but which will require a change in the type of technology deployed in order to reduce their emissions. This includes LGV drivers, who will perform relatively similar roles but using zero emissions vehicles and may experience some changes in working practices (for example, planning routes to minimise emissions).

Finally, there are a set of currently brown jobs which will remain necessary in future but will require a change in both the technologies they use and significant changes to the skills they deploy; for example, ship-builders will need to learn to build lower-emissions vessels, and welders, metal workers and electrical engineers will need to adapt to new technologies and, in all likelihoods, significantly altered tasks.

The dividing lines between these categories are not absolute; there may be occupations which experience more than one type of change set out above. For example, air travel assistants might see reduced demand for their services, but those that continue might require new skills as technologies and working practices change.

To understand how the transition to net zero will affect workers and places, we first need to understand the main differences between green and brown jobs

Above, we have identified a large share of UK employment – just over 17 per cent of 16-69-year-old workers in 2019, including 13 per cent in green roles and 4 per cent in brown roles – as being in a job that is particularly exposed to some sort of change or disruption during the transition to net zero.

The changes affecting green jobs tend to come via less disruptive means (such as occupational growth or low-risk task alteration), but those affecting brown jobs may require more policy support, such as helping firms and workers to adjust to new technologies and skills that are essential for the UK to meet its emissions targets, or in a small number of cases, adjust to sector decline. These are relatively nuanced, but important distinctions: in order to ensure that policy can support the UK's transition to net zero without risking job loss, it's important to understand key differences between

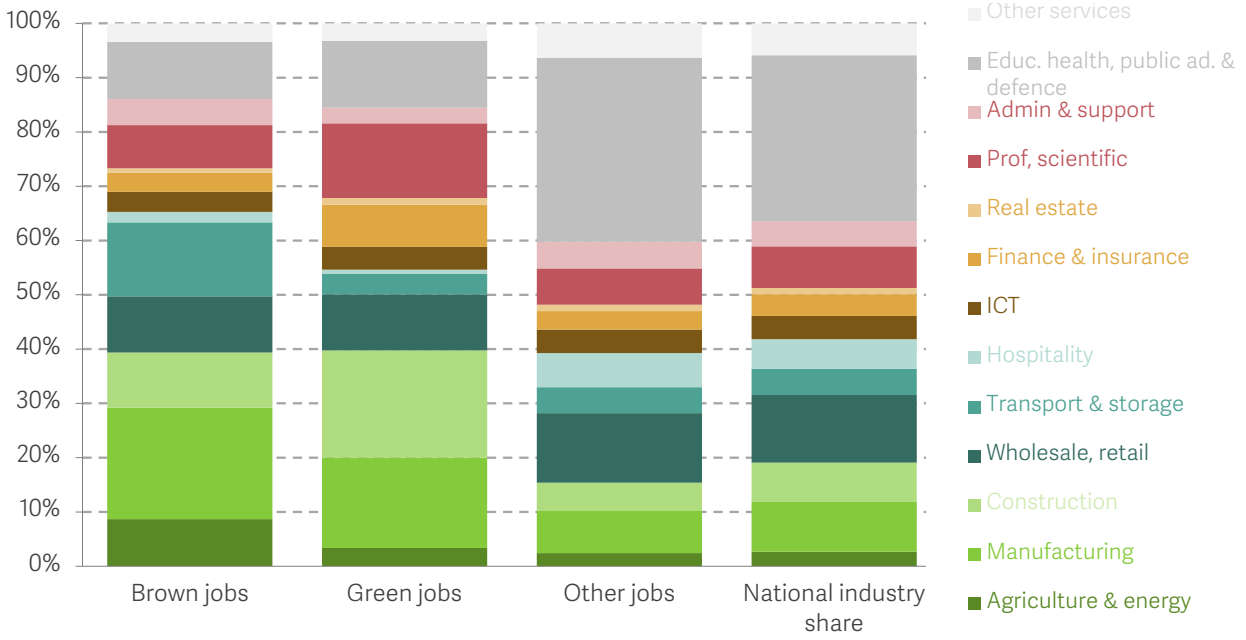
the characteristics of people – and places – exposed to change in core green and brown jobs. We do that in this section.

Both green and brown jobs are concentrated in construction, manufacturing, agricultural and energy sectors, although green jobs are also highly concentrated in the professional and technical sector

At a high level, it appears that green and brown jobs tend to be prevalent in the same industries. Figure 1 shows that two-in-five (40 per cent) workers in green and brown jobs are in the construction, manufacturing and agriculture or energy sectors, the overall share of workers that are in these sectors (20 per cent). As previous work has highlighted, these particular sectors tend to have relatively high greenhouse gas emissions.[20]

FIGURE 1: **Both green and brown jobs are concentrated in construction, manufacturing and agriculture and energy**

Proportion of workers aged 16-69 in green or brown jobs, by broad industrial grouping: UK, 2019



NOTES: Green jobs refer to 'core green task' jobs (based on a mapping of occupations from O*NET, see Box 1) and brown jobs refer to 'brown changer' jobs (occupations particularly prevalent in emissions-intense sectors, see Box 2).
SOURCE: Analysis of ONS, Labour Force Survey.

20 A Valero et. al., Are 'green' jobs good jobs?, Centre for Economic Performance, London School of Economics, October 2021.

Male workers are more likely to be found in both green and brown jobs, but green jobs are better paid, and White workers are more likely than other ethnic groups to be in a green job

Although both green and brown jobs tend to be concentrated in these emissions-intense sectors, Figure 1 also shows that green jobs are also somewhat overrepresented in the low-emitting professional, scientific and technical sector: 14 per cent of employment in this sector is classed as green, compared to 8 per cent nationally.

Although these are broad sectors (and there are significant differences in green and brown activity within these sectors), viewing green and brown jobs through the lens of these high-level groupings provides a useful benchmark for how green and brown jobs compare to all other occupations (those that are not in our brown or green groups of occupations) and the national industry share.

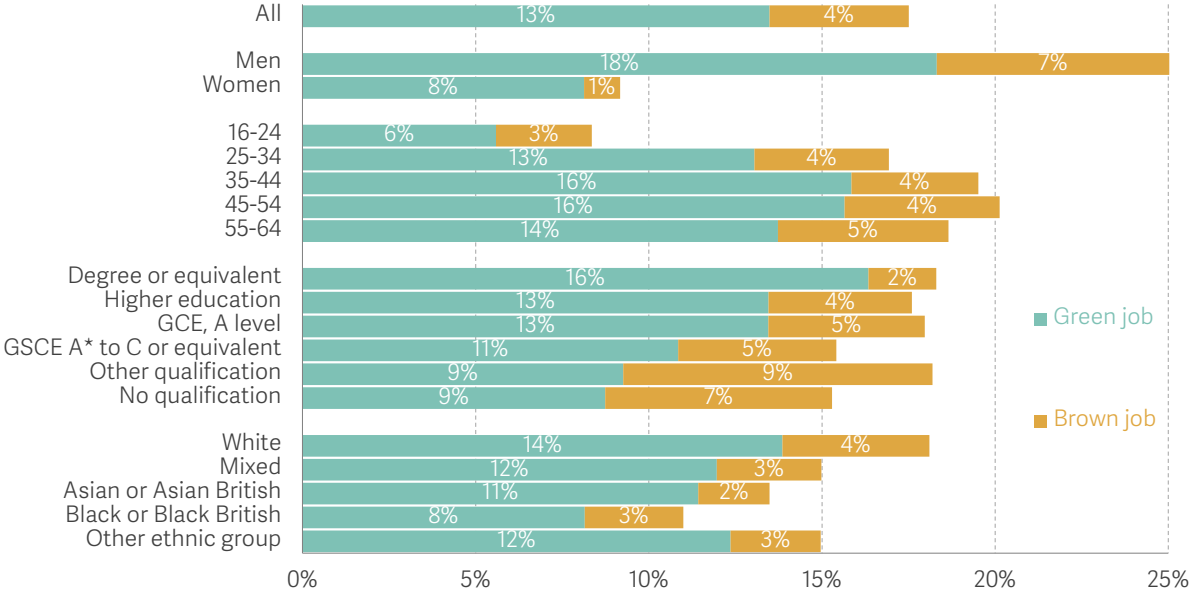
As Figure 2 makes clear, employment in green and brown jobs is unevenly distributed across the UK workforce. In some instances, brown and green jobs are similar: both are male dominated, though the imbalance is greater among brown jobs. For example 7 per cent of male workers are employed in brown occupations compared to just 2 per cent of female workers; 18 per cent of men work in green jobs, but only 8 per cent of women.

However, green and brown jobs look different from one another in other dimensions. Green jobs, for example, are most concentrated among those aged 35-54 (where 16 per cent of workers are in green jobs), with a substantially lower share of younger workers aged 24 or under (6 per cent) employed in green jobs. There is far less variation across the age distribution for brown jobs. Green jobs are particularly prominent for workers that hold university degrees (16 per cent of graduates work in an occupation we class as green) more than found among workers with no qualifications (9 per cent) and those with GCSE-equivalent qualifications (11 per cent), whereas brown jobs are most concentrated for workers with 'other' qualifications (like trade apprenticeships, where one-in-ten work in brown jobs) or no qualifications. Brown jobs are particularly unlikely to be held by workers with degrees (2 per cent of graduates work in a job that we class as brown).

White workers are more likely to be in a green jobs that other ethnic groups, with 14 per cent of workers of White ethnicity workers are in a green job, with and with workers of Black ethnicity workers being the least likely, at 8 per cent. Although White workers are also more likely than other groups to be in a brown job, the differences between White workers and those from other ethnic backgrounds are much smaller (for example, 4 per cent of White workers and 3 per cent of Black workers are in a brown job).

FIGURE 2: **Green and brown jobs are male-heavy, and those in green jobs tend to be more educated, and not from ethnic minorities**

Proportion of workers aged 16-69 in green or brown jobs, by personal characteristic: UK, 2019



NOTES: Inverting the brown and green job figures shows that 27 per cent of green job employment is held by women, and just 12 per cent of brown job employment. 44 per cent of employment in green jobs is held by workers whose highest qualification is a degree or higher, followed by A level-equivalent qualifications (22 per cent) and GCSE-equivalent (15 per cent). 24 per cent of employment in brown jobs is held by those with A level-equivalent qualifications, followed by GCSE-equivalent (21 per cent), and degrees or higher and other qualifications (17 per cent each). 91 per cent of employment in green hobs is held by White workers and 5 per cent by Asian workers; 93 per cent of employment in brown jobs is held by White workers and 3 per cent by Asian workers. Green jobs refer to 'core green task' jobs (based on a mapping of occupations from O*NET, see Box 1) and brown jobs refer to 'brown changer' jobs (occupations particularly prevalent in emissions-intense sectors, see Box 2).
SOURCE: Analysis of ONS, Labour Force Survey.

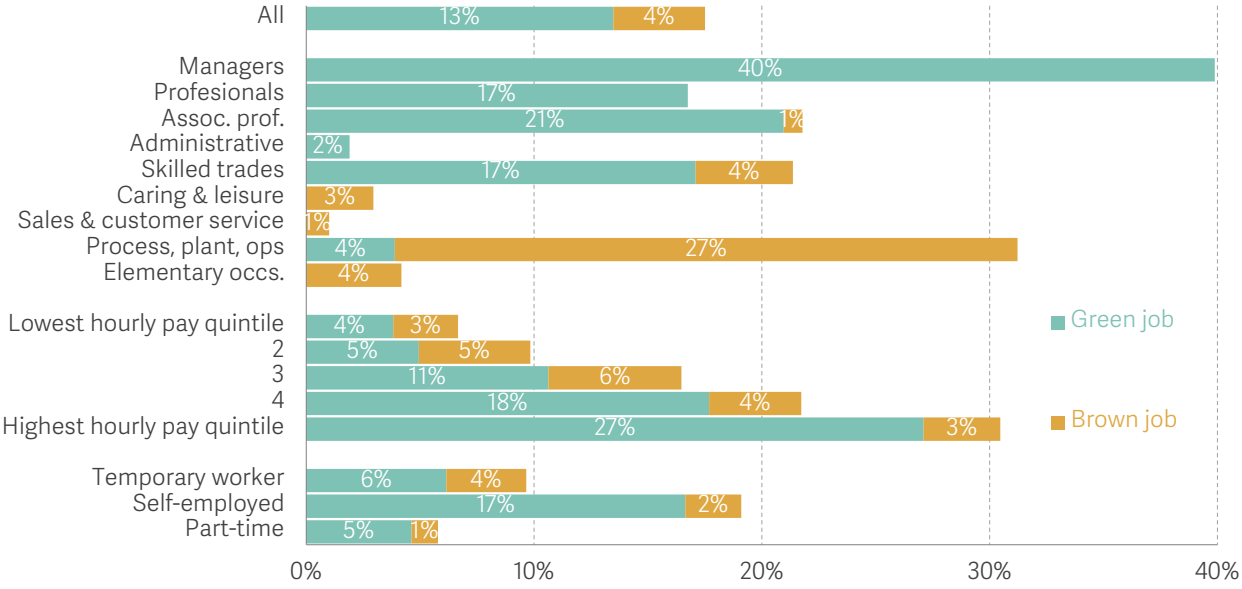
Figure 3 shows how the shares of green and brown jobs vary across occupational characteristics. Green workers tend to be most prevalent in the highest-paid occupations: including managerial (40 per cent of workers), professional (17 per cent of workers) and associate professional (21 per cent of workers). Brown jobs, however, are most concentrated in process, plant and machine operative occupations (27 per cent of workers). These findings are unsurprising when we consider the four-digit occupational classifications that define green and brown jobs, but they also help explain why more than a quarter of the highest-paid workers are in green jobs, with brown jobs tending to be concentrated in the middle of the pay distribution.

There is also some suggestion that green jobs tend to offer better conditions: Figure 3 shows that they comprise 13 per cent of overall employment but just 6 per cent of temporary contract work (by contrast, brown jobs comprise 4 per cent of overall employment and 4 per cent of workers on temporary contracts). Compared to the average worker, those in green jobs are more likely to be self-employed and those in

brown jobs are less likely to be so: 17 per cent of self-employed workers are located in a green job, but only 2 per cent are in a brown job.

FIGURE 3: **More than one-quarter of the highest-paid workers are in green jobs**

Proportion of workers aged 16-69 in green or brown jobs, by worker characteristics: UK, 2019



NOTES: Inverting the brown and green job figures shows that 33 per cent of all employment in green jobs is in managerial occupations, followed by professional occupations (26 per cent), associate professional and technical occupations (23 percent) and skilled trades occupations (14 per cent). 44 per cent of all employment in brown jobs is in process operative occupations, followed by professional occupations (21 per cent), and skilled trades and elementary occupations (11 per cent each). Green jobs refer to 'core green task' jobs (based on a mapping of occupations from O*NET, see Box 1) and brown jobs refer to 'brown changer' jobs (occupations particularly prevalent in emissions-intense sectors, see Box 2).
SOURCE: Analysis of ONS, Labour Force Survey

To further investigate the relationship between personal and job-level characteristics and the likelihood of working in either a green or brown job we run a series of binary logistic regressions (see Annex 2). Overall, the results we observe above still hold. Indeed, we also find that there is a pay premium of around 8 per cent, on average, to working in a green job having controlled for other worker characteristics such as education and experience; this confirms previous research that used a slightly different measure of green jobs.[21] Moreover, the pay premium is particularly high for those in green jobs within lower skilled occupational groups.

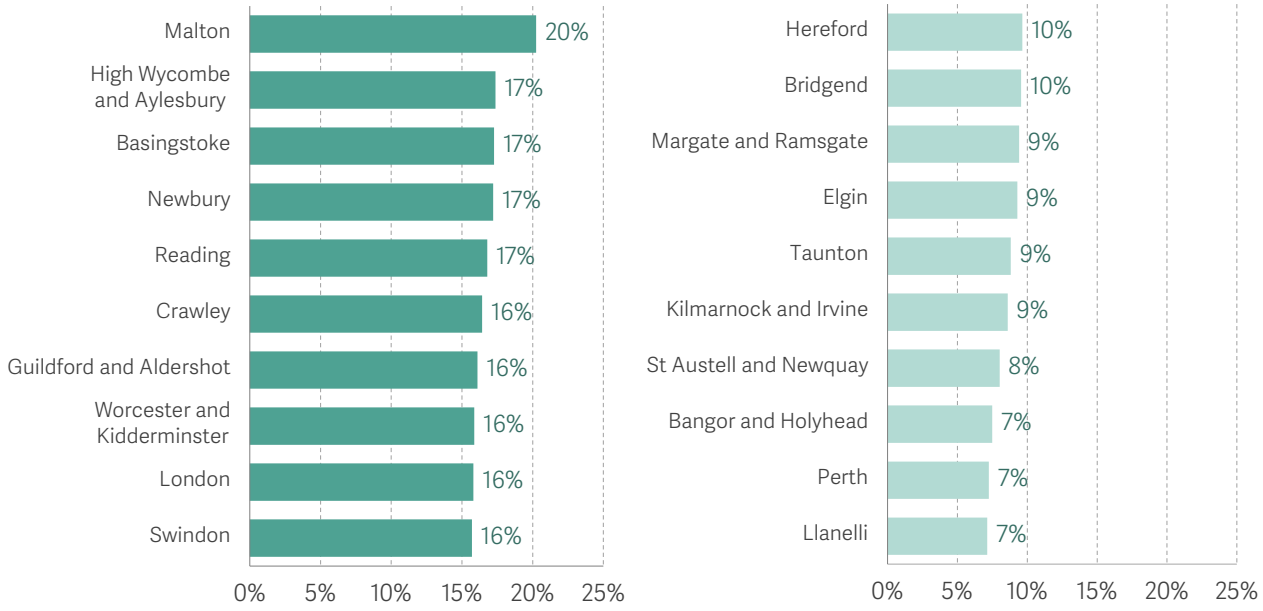
21 A Valero et. al., Are 'green' jobs good jobs?, Centre for Economic Performance, London School of Economics, October 2021.

Green jobs are, mostly, concentrated in London and the South East whereas areas in Wales, Scotland and Northern England see a greater concentration of brown jobs

Figure 4 shows that green jobs are particularly concentrated in Malton, a market town in North Yorkshire (where 20 per cent of workers are in a green job), as well as travel to work areas (TTWA) in the South East that have a high share of employment in information and communication technology, professional, and business service sectors. For example, Virgin Media and Microsoft are both headquartered in Reading.

FIGURE 4: **Green jobs are, mostly, concentrated in London and the wider South East**

Ten travel to work areas (TTWAs) with the highest share of employment in green jobs (left-hand panel), ten travel to work areas (TTWAs) with the lowest share of employment in green jobs (right-hand panel): UK, 2017-19

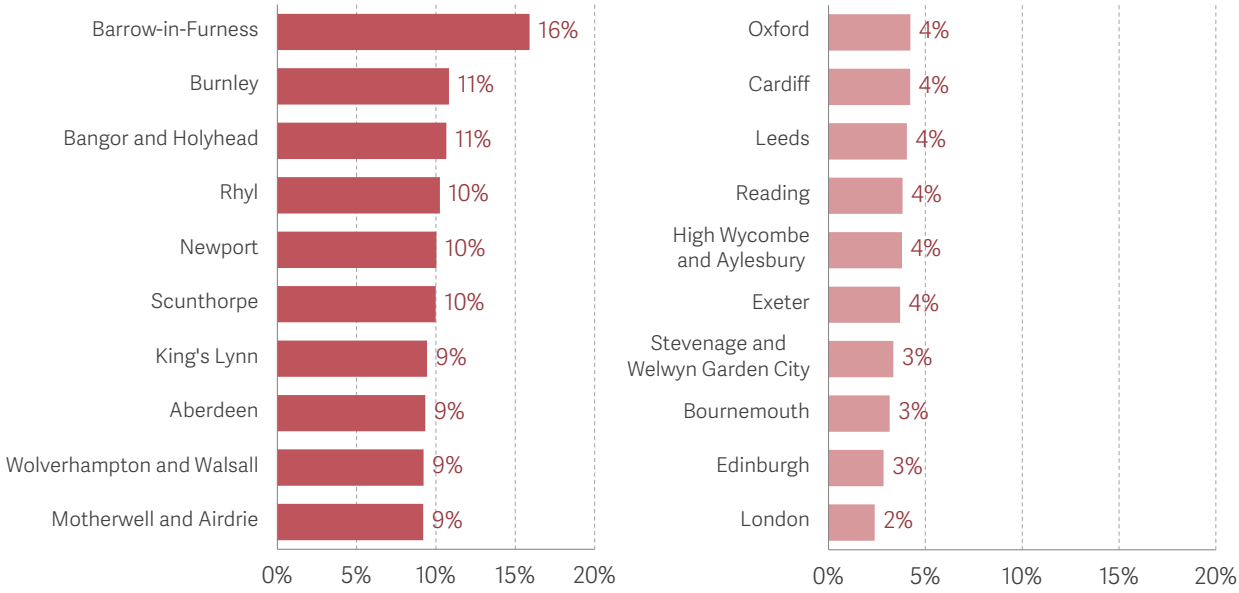


NOTES: 68 of the 219 TTWAs were dropped as a result of small sample sizes. Green jobs refer to 'core green task' jobs (based on a mapping of occupations from O*NET, see Box 1).
SOURCE: Analysis of ONS, Labour Force Survey.

Barrow-in-Furness has the highest share of brown jobs among all TTWAs at 16 per cent (Figure 5). The area has strong historic links to coal-fired energy generation, manufacturing and port activities. A number of TTWAs in Wales also have a high share of brown jobs such as Bangor and Holyhead, Rhyl, and Newport. Again, these areas can be characterised as having a large share of jobs in port activities and manufacturing. Cities tend to have a lower share of brown jobs perhaps reflecting the limited capacity for these areas to accommodate the land use requirements of emissions-intense industries.

FIGURE 5: **Areas in Wales, Scotland and Northern England see a greater concentration of brown jobs**

Ten travel to work areas (TTWAs) with the highest share of employment in brown jobs (left-hand panel), ten travel to work areas (TTWAs) with the lowest share of employment in brown jobs (right-hand panel): UK, 2017-19



NOTES: 123 of the 219 TTWAs were dropped as a result of small sample sizes. Green jobs refer to 'core green task' jobs (based on a mapping of occupations from O*NET, see Box 1) and brown jobs refer to 'brown changer' jobs (occupations particularly prevalent in emissions-intense sectors, see Box 2).
SOURCE: Analysis of ONS, Labour Force Survey.

Green and brown jobs look quite different in terms of their task content

Finally, we consider how green and brown jobs compare in terms of the type of tasks workers typically perform.[22] Figure 6 plots the relative importance of different types of tasks for green, brown and 'other' occupations. It shows, for example, that in green occupations, non-routine analytical and personal tasks (which tend to be associated with occupations requiring higher levels of education, like managerial, professional and technical roles) play a relatively important role. By contrast, routine and physical tasks (which tend to be associated with occupations requiring lower levels of education, like elementary or operational roles) are less relevant.[23] Importantly, brown occupations appear remarkably different from both green and 'other' occupations: performing routine, and especially non-routine, manual tasks is much more important in brown occupations than in non-brown occupations, and non-routine personal tasks are less common. These

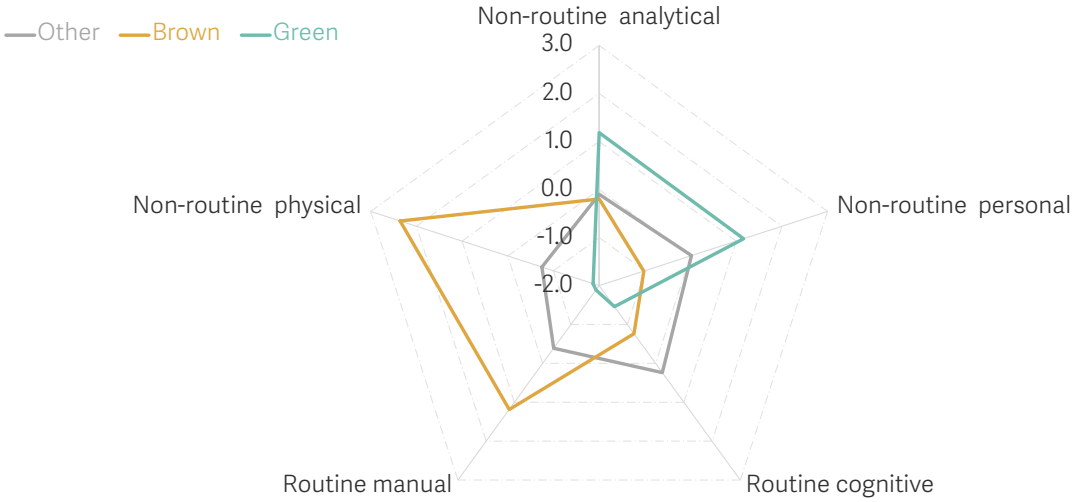
22 The characterisation of occupations in terms of the importance of five types of tasks (non-routine analytical, non-routine personal, non-routine physical, routine cognitive and routine manual tasks) follows the methodology adopted by D. Acemoglu & D. Autor, Skills, Tasks and Technologies: Implications for Employment and Earnings, Handbook of Labor Economics, 2011. For more details, see Box 1 in N Cominetti et al., Changing jobs? Change in the UK labour market and the role of worker mobility, Resolution Foundation, January 2022.

23 For further discussion of task content and its links to different occupational groupings, see Box 1 in N Cominetti et al., Changing jobs? Change in the UK labour market and the role of worker mobility, Resolution Foundation, January 2022.

findings are consistent with more granular analyses based on US occupations that have found that directly green jobs tend to require more education and involve more non-routine analytical tasks compared to non-green jobs.[24]

FIGURE 6: **Brown and green jobs look very different based on the type of tasks workers perform**

Relative intensity of different types of tasks across types of occupations: UK, 2019



NOTES: The measures of task intensity are standardised across all SOC 2010 four-digit level occupations. Green jobs refer to 'core green task' jobs (based on a mapping of occupations from O*NET, see Box 1) and brown jobs refer to 'brown changer' jobs (occupations particularly prevalent in emissions-intense sectors, see Box 2).
SOURCE: Analysis of O*NET and ONS, Labour Force Survey.

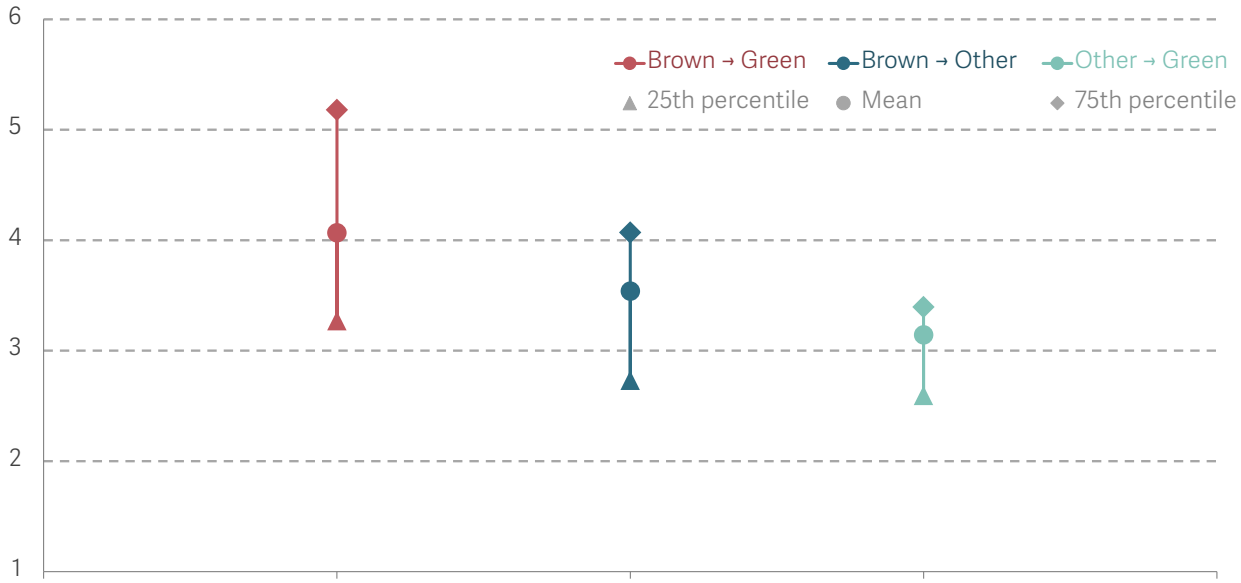
The differences in tasks across these groups of occupations can be better summarised using the concept of 'task distance'. For each pair of occupations, the task distance tells us how different the two occupations are, based on the relative importance of their underlying tasks, with occupations that are 'further away' requiring more change from workers when they move occupation.[25] Figure 7 shows the distribution of task distance between specific groups of occupations. On the left, we show the distribution (25th percentile, mean and 75th percentile) of the average distances between each brown and green occupation. With an average distance of just above 4, the tasks in brown and green occupations are more different than if we compare brown and 'other' (average distance of 3.5) or 'other' and green (average distance of just over 3).

24 For example, in work considering core green jobs (GNE and GES), green occupations have found to require more non-routine analytical tasks, see D Consoli et al., Do green jobs differ from non-green jobs in terms of skills, human capital?, Research Policy 45 (5), 2016; and A Bowen et al., Characterising green employment: The impacts of 'greening' on workforce composition, Energy Economics 72, 2018. Other work considers also green general skills, the types of general skills that are associated with greener occupations (based on their share of green tasks), highlighting the importance of engineering and managerial skills. This same paper compares green and brown jobs ***within broad occupational groupings***, finding that general skill requirements are generally closer than those in other jobs, see F Vona et al., Environmental Regulation, Green Skills: An Empirical Exploration, Journal of the Association of Environmental and Resource Economists 5(4), 2018.

25 Task distance is obtained by taking squared root of the sum of the squared differences across each of the five task components. This approached is based on C Robinson, Occupational Mobility, Occupational Distance and Specific Human Capital, The Journal of Human Resources, Spring 2018.

FIGURE 7: **Brown occupations are further away from both 'other' and especially green occupations**

Distribution of average task-distance measures between jobs belonging to different groups of occupations: UK, 2019



NOTES: Task distance measures are derived by combining differences in task intensity measures between four-digit occupations (see footnote). For each brown or 'other' occupation observed in the data, we compute the average task distance to all occupations in the relevant group (green or 'other'). We then compute the average, 25th and 75th percentiles across all jobs in the group. Green jobs refer to 'core green task' jobs (based on a mapping of occupations from O*NET, see Box 1) and brown jobs refer to 'brown changer' jobs (occupations particularly prevalent in emissions-intense sectors, see Box 2).
SOURCE: Analysis of O*NET and ONS, Labour Force Survey.

This analysis suggests that moving from a brown job to a green job might be particularly challenging: 25 per cent of workers in brown occupations in 2019 were employed in jobs with an average distance to green occupations of more than 5.[26] Figure 25 (in Annex 3) considers specifically the distribution of average distances between brown and green jobs within each hourly pay quintile. It shows that workers in the low-middle part of the pay distribution seem to be employed in brown occupations that are further away from green jobs in terms of task content. Therefore, they may have fewer chances to move into green occupations compared to workers in the upper part of the pay distribution, or to workers in the bottom part.

26 Box 4, later in this note, sets out how common occupational moves covering equivalent task distances to the ones shown in Figure 7 are in the UK labour market, and shows that only 14 per cent of occupation moves cover the task distance that would be required to move from the average brown job to the average green job.

At this stage, it is important to emphasise that although measuring the difference between brown and green jobs can give a sense of the challenges that workers moving between brown and green occupations might face, this is only one aspect of the change expected over the coming decade. As previously discussed, not all brown job workers would be expected to move to a non-brown job since not all currently brown jobs are likely to disappear under net zero targets. In particular, our classification of brown occupations contains some 'crossover' occupations (i.e. jobs that are disproportionately found in higher emissions sectors, but that already contain some green tasks anticipating the fact that they could become compatible with the net zero economy). This implies that workers' ability to adapt to new occupational content within these brown occupations might be another key challenge. Nevertheless, for workers who struggle to acquire the skills needed to perform 'greener' tasks and for those employed in sectors that are at risk of more extensive disruption, moving from a brown to a non-brown occupation could remain a relevant and attractive prospect. For this reason, it is important to see what lessons we can learn about those who have made similar job transitions in the past, and this is the topic of the following section.

Over the past decade, green – and especially brown – sectors haven't experienced much change, but job moves that have occurred provide lessons for this next decade

To understand both the forthcoming impact of the net zero transition on workers, and the UK labour market's ability to meet demand for workers in green jobs, it's important to take stock of the scale and the nature of change that brown and green jobs have experienced in the recent past. Here, we first focus on how brown and green jobs have changed as a share of employment, before going on to look at what we can learn from the transitions made by individual workers moving in and out of these jobs, and particularly between brown and green jobs.

Some green jobs have grown rapidly in recent years, whereas brown jobs have changed little as a share of employment

Figure 8 plots the share of workers in green or brown jobs, by gender, from 2011 to 2019. Green jobs have grown from 12.2 per cent to 13.5 per cent of employment. Interestingly, although green jobs are dominated by men (see Figure 2), 1 percentage point of the 1.3 percentage point rise has come from women. Part of this will likely reflect that the overall labour force has become more feminised over time, but it is still striking that women have driven the increase in green employment over the past decade.[27]

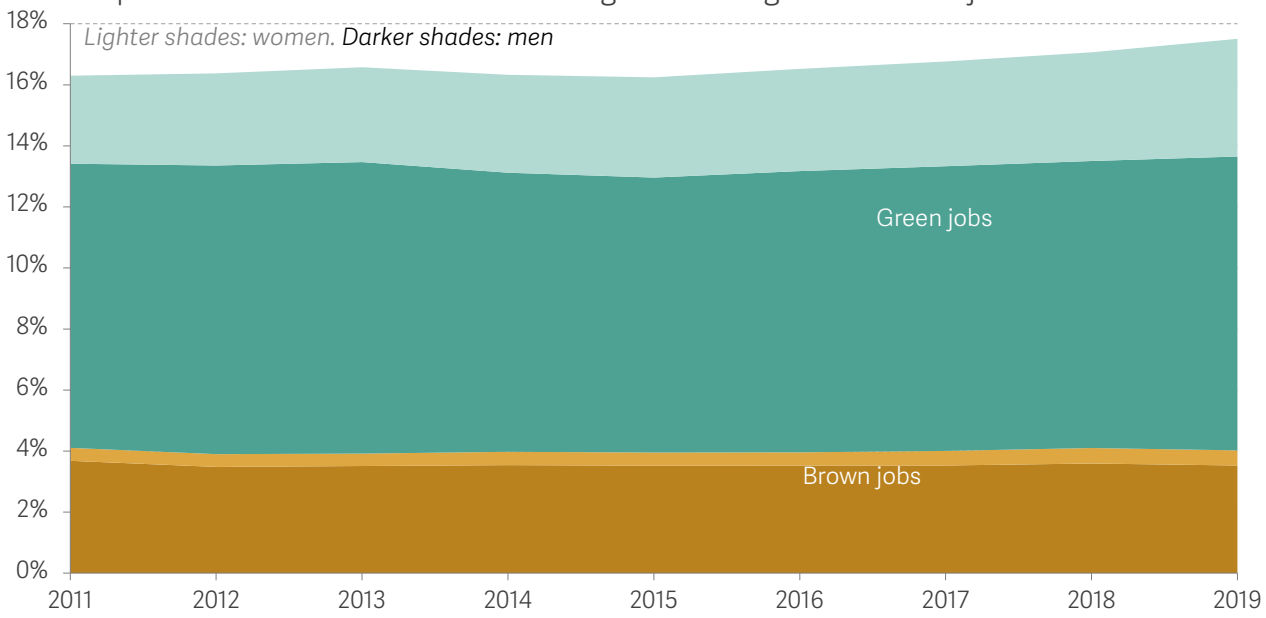
27 T Bell & L Gardiner, Feel poor, work more: Explaining the UK's record employment, Resolution Foundation, November 2019.

We note, however, that given our method of classifying green jobs (as set out in Box 1), our analysis will not pick up occupations that might have got greener over time, or those that might have emerged in more recent years, and it is likely that this is a conservative view of the overall growth in green employment.

The overall proportion of workers in jobs that we have classified as brown has changed even less since 2011 than those classified as green, remaining at around 4 per cent, with little change in the share of either men or women employed in these jobs.

FIGURE 8: **Green jobs have increased slightly as a share of employment since 2011**

Proportion of male and female workers aged 16-69 in green or brown jobs: UK



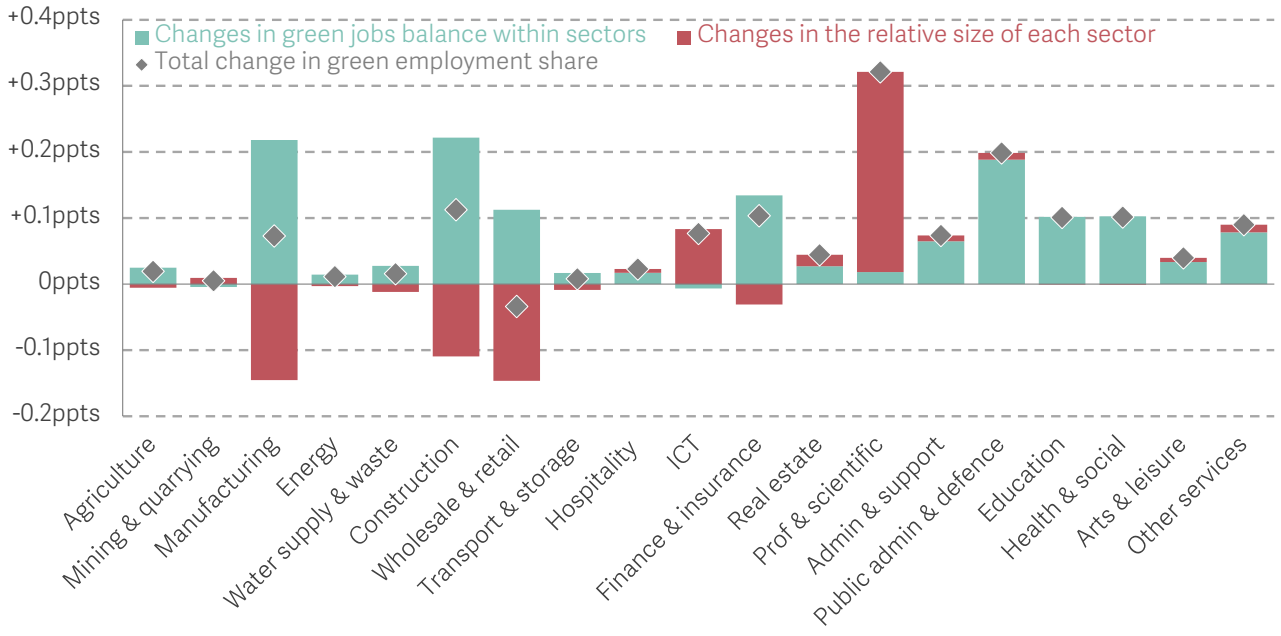
NOTES: Green jobs refer to 'core green task' jobs (based on a mapping of occupations from O*NET, see Box 1) and brown jobs refer to 'brown changer' jobs (occupations particularly prevalent in emissions-intense sectors, see Box 2).
SOURCE: Analysis of ONS, Labour Force Survey.

A key question, however, is how much of the increase in the share of employment composed of green jobs is driven by sectors increasing their share of green workers, or increases in the size of sectors with a larger share of green jobs. Figure 9 presents the results of a shift-share analysis that allows us to unpick these two contributions. Manufacturing and construction are the two sectors that have contributed the most to the overall growth in the share of workers that are in green jobs and, within both industries, the increase in green jobs is down to the sectors having a rising share of green occupations (offsetting the relative decline of these sectors as a share of all jobs in the UK).

If, for example, green jobs within manufacturing had followed the national sectoral trajectory they would have fallen by 0.15 percentage points (as a share of manufacturing employment). In fact, the share of manufacturing jobs that are green has increased by 0.07 percentage points, which means that the growth in the greenness of manufacturing jobs since 2011 has outweighed the national decline in this sector. The reverse is true for the professional and scientific sector, where the growth in green employment is primarily being driven by growth in the size of this sector. The implication is that the 'greening' of employment is ongoing, but that process is moving at different speeds across sectors.

FIGURE 9: **Although manufacturing and construction have shrunk, they contribute more green jobs now than in 2011**

Change in the national share of green jobs that is explained by changes in the size of the sector and changes in the green jobs balance within sectors: UK, 2011-2019

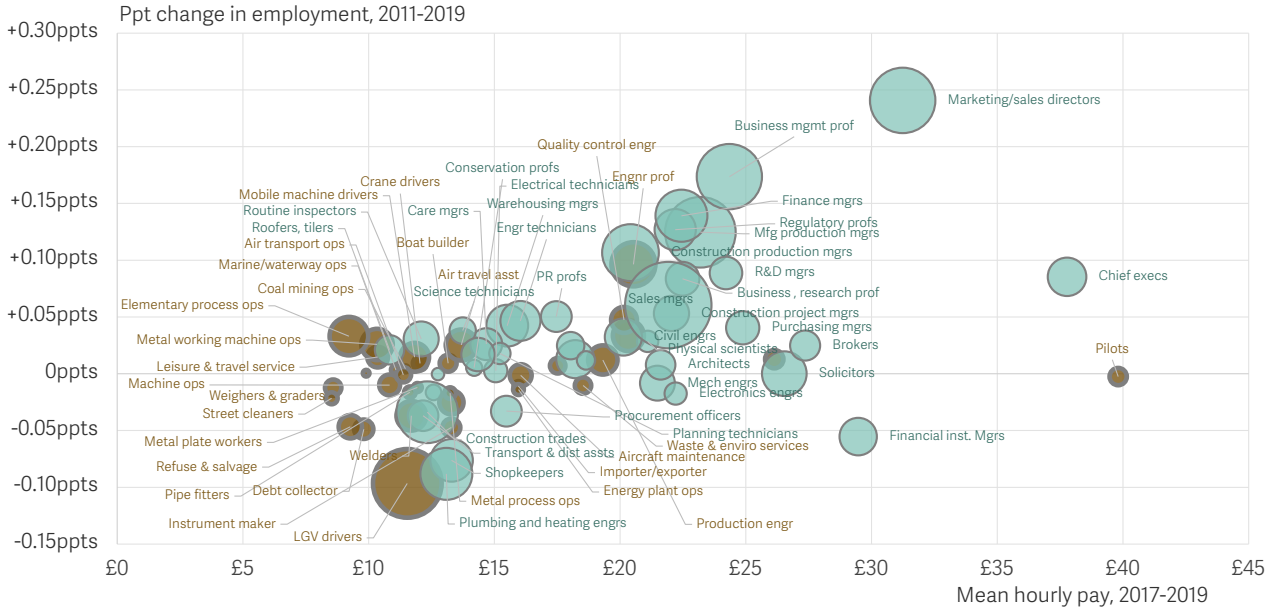


NOTES: The chart shows the results from a shift-share decomposition of the change in the national share of green jobs. Green jobs refer to 'core green task' jobs (based on a mapping of occupations from O*NET, see Box 1).
SOURCE: Analysis of ONS, Labour Force Survey.

Figure 10 disaggregates these changes by displaying brown and green occupations according to their share of employment in 2019 (bubble size), their average hourly pay in 2019 (horizontal axis) and the extent to which they have grown – or shrunk – as a share of employment since 2011 (vertical axis). Within green jobs, some relatively higher-paid green occupations, like marketing and sales directors, and business management professionals, have expanded, while others, mostly low paid, have contracted slightly – such as welders and metal workers. The occupations classified as brown, though, have remained more static as a share of employment.

FIGURE 10: **Most brown occupations tend to be static or declining as a share of employment**

Percentage point change in share of 16-69-year-old employment from 2011 to 2019 (vertical axis), mean hourly pay in 2019 (horizontal axis): UK



NOTES: Bubble size indicates occupation's share of employment in 2019. Green jobs refer to 'core green task' jobs (based on a mapping of occupations from O*NET, see Box 1) and brown jobs refer to 'brown changer' jobs (occupations particularly prevalent in emissions-intense sectors, see Box 2).
SOURCE: Analysis of ONS, Labour Force Survey.

The rates at which workers leave or enter brown jobs have been relatively constant in recent years, but an increasing share of brown job leavers are now moving into green jobs

So far, we have shown changes in the share of workers in green and brown jobs both overall, and across sectors. However, in order to anticipate how easily workers could move from brown and other occupations to green occupations as the demand for green jobs rises will require a better understanding of the characteristics of workers that have made such transitions in the recent past.

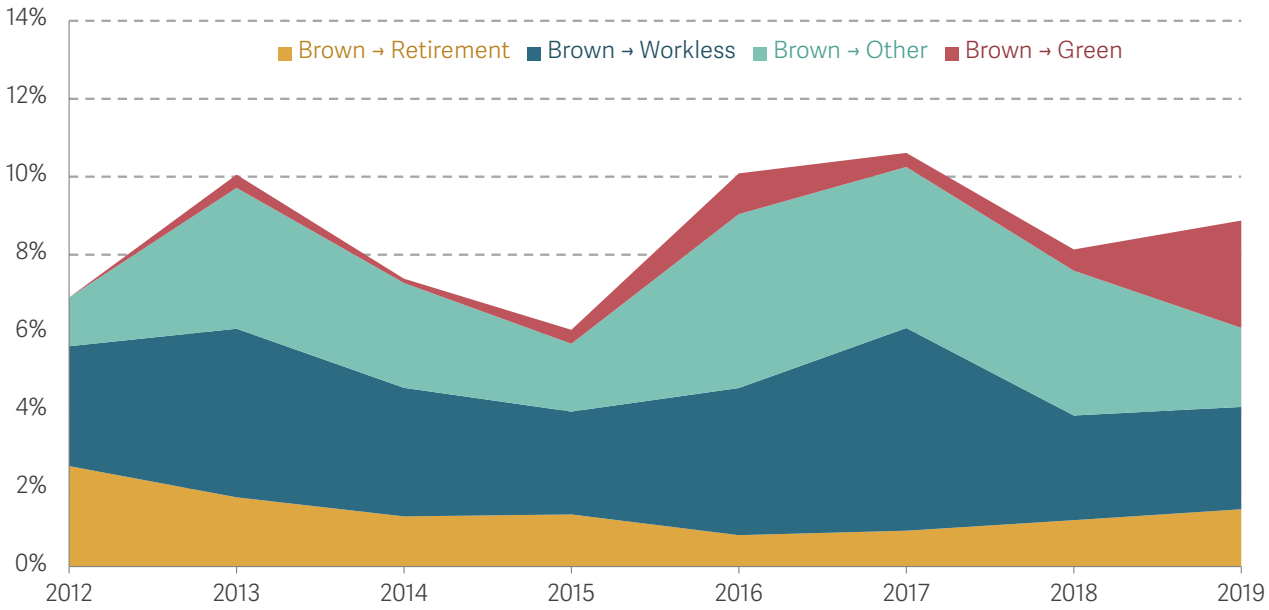
As we saw in Figure 10, the overall share of the workforce employed in brown occupations has been stable over recent years, with visible decline only occurring across some occupations (for example, LGV drivers – an occupation beset by labour shortages[28]). A similar overall picture emerges from Figure 11, which looks at the trend in the proportion of workers leaving brown jobs. We can see there was not much change in the overall exit rate from brown jobs between 2012 and 2019. Tracking workers up to one year later, we can see that among those who did move out of a brown occupation, an increasing proportion has moved into non-brown employment, as opposed to retiring or

28 See, for example: UK government action to reduce the HGV driver shortage.

becoming unemployed or inactive. Interestingly, among those who moved from a brown to a non-brown occupation, an increasing proportion moved into green occupations: from only 8.5 per cent in 2013 to over 50 per cent in 2019.[29]

FIGURE 11: **Workers leaving brown jobs have increasingly found employment in other non-brown and even green occupations**

Percentage of workers who left brown jobs (as a proportion of brown employment in previous year) by their destination one year later: UK, 2012-2019



NOTES: These measures pertain to workers who are observed employed in a brown occupation in year T-1 and who are subsequently observed one year later (T) as retired, workless (including unemployed or inactive, but excluding retirement), or having changed job to be employed in a green or 'other' occupation. Green jobs refer to 'core green task' jobs (based on a mapping of occupations from O*NET, see Box 1) and brown jobs refer to 'brown changer' jobs (occupations particularly prevalent in emissions-intense sectors, see Box 2).
SOURCE: Analysis of ONS, Five-quarter longitudinal Labour Force Survey.

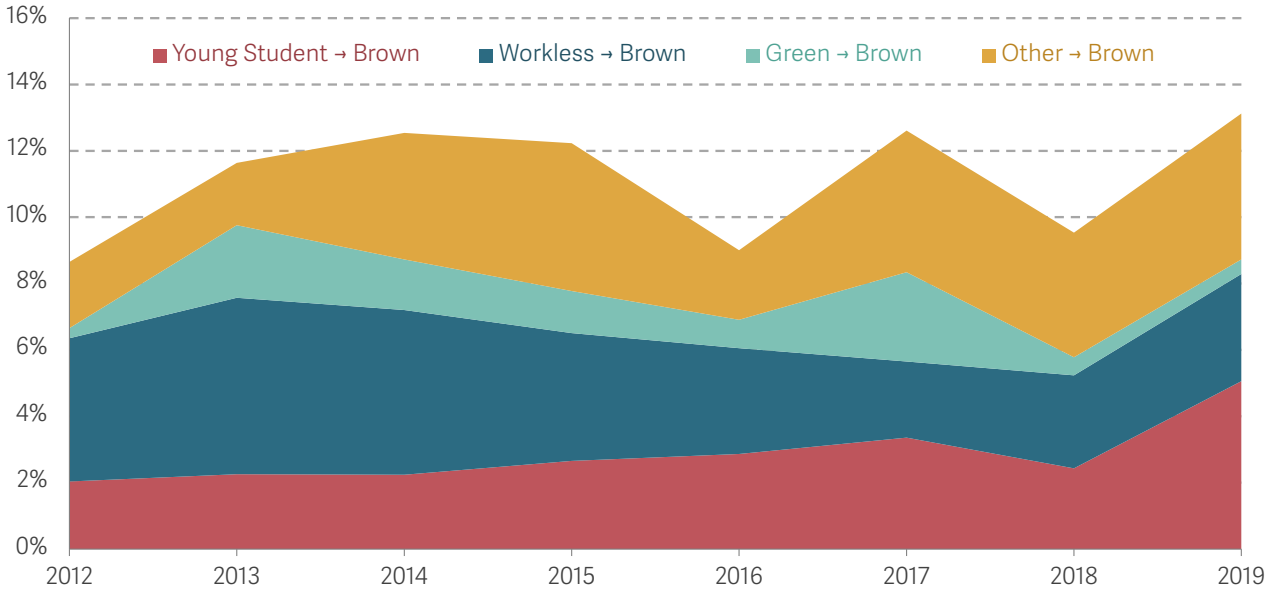
Consistent with the fact that we observed no change in the share of brown jobs employment, Figure 12 shows that the overall entry rate into brown occupations has been roughly steady over the same time period, but with an increase in the proportion of people moving into brown jobs from full-time education or from other non-brown occupations. This may suggest that, despite potential concerns on their long-term sustainability or degree of expected change, our group of brown jobs have remained somehow attractive over the recent years, including to young people just starting their careers.

29 This, however, remains a very small fraction of workers. In the analysis that follows we attempt to characterise these workers and their occupational moves but, given the small sample size, these results should be interpreted with caution.

As mentioned previously, some of these jobs include green tasks and might have therefore started to experience some within-occupation change in order to reduce emissions. So far, this potential change does not seem to have driven up long-term unemployment among incumbent workers in the sector: the proportion of people leaving brown jobs to be workless one year later have remained stable at around 3.5 per cent. However, it may explain why brown occupations have remained, and may remain, attractive destinations for both young workers fresh out of their studies and workers previously employed in non-brown (and to a lesser extent green) occupations, as these workers may possess the 'greener' skills needed to modernise brown sectors.

FIGURE 12: **An increasing proportion of new brown job starts come from workers moving jobs or young people entering the labour market**

Percentage of workers moving into brown jobs (as a proportion of brown employment in previous year) by their origin: UK, 2012-2019



NOTES: These measures pertain to workers who are observed employed in a brown occupation in year T and that, one year prior to that (T-1), were observed as workless (including unemployed or inactive, but not in education), studying (defined here as being less than 25 years old and enrolled in some course) or as being employed in a different job in a green or 'other' occupation. Green jobs refer to 'core green task' jobs (based on a mapping of occupations from O*NET, see Box 1) and brown jobs refer to 'brown changer' jobs (occupations particularly prevalent in emissions-intense sectors, see Box 2).
SOURCE: Analysis of ONS, Five-quarter longitudinal Labour Force Survey.

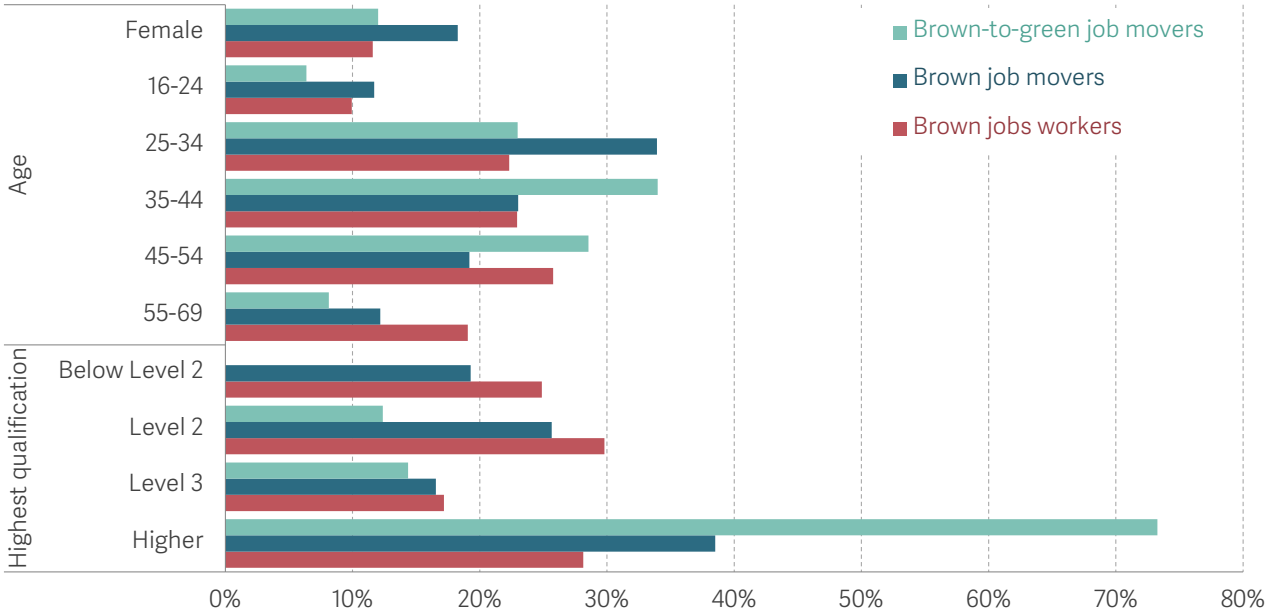
Workers moving from brown to green jobs tend to be of prime working age and more highly educated than the typical workers in brown jobs, and tend to move to green jobs with quite similar task content

Next, we focus on job to job moves, considering the average characteristics of workers who move from brown to non-brown occupations, and to green occupations specifically.

Figure 13 shows that workers who move from brown to non-brown occupations are more likely to be female and young (which is not surprising as younger workers are typically more mobile in the first place[30]). They are also generally more educated, with a larger share having a higher-level qualification or having at least a qualification at level 2 (GCSE-equivalent). Those who move directly from brown to green jobs, however, tend to be of prime working age (35 to 54). Importantly, workers making this type of transition appear to be much better educated than both typical brown job workers and brown job leavers overall.

FIGURE 13: **Workers moving from brown to green jobs tend to be of prime working age, and more highly educated**

Proportion of workers with given characteristics: UK, 2012-2019



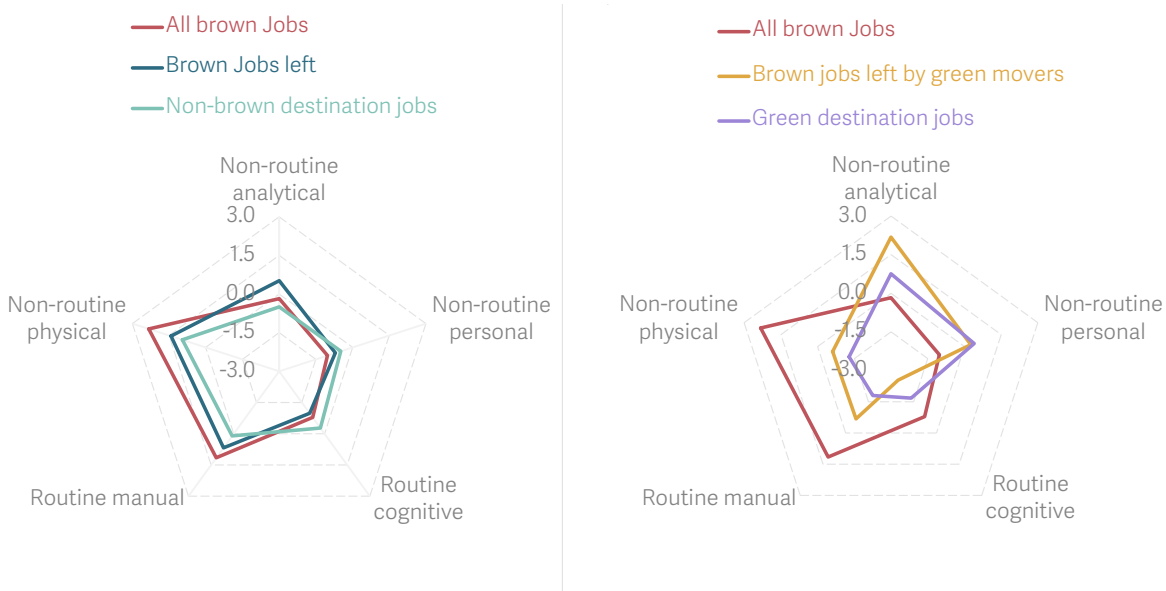
NOTES: These characteristics pertain to workers who were observed employed in a brown job at time T regardless of their status one year later (all brown workers); those who are observed in a non-brown job one year later (brown job leavers) and those who are specifically observed in a green job one year later (brown-to-green job movers). Green jobs refer to 'core green task' jobs (based on a mapping of occupations from O*NET, see Box 1) and brown jobs refer to 'brown changer' jobs (occupations particularly prevalent in emissions-intense sectors, see Box 2).
SOURCE: Analysis of ONS, Five-quarter longitudinal Labour Force Survey.

30 As documented in N Cominetti et al., Changing jobs? Change in the UK labour market and the role of worker mobility, Resolution Foundation, January 2022.

Next, we explore how the brown jobs that people move away from compare with typical brown jobs and with the destination non-brown jobs they move into. In line with the analysis presented in Figure 6, Figure 14 shows the average intensity of different types of tasks for different sets of occupations. On the left of the figure, we can see that, on average, the brown jobs that workers leave look quite similar to average brown jobs, except that physical tasks tend to be less important, and analytical and personal tasks play a slightly bigger role. We can also see that the non-brown occupations that brown job workers move into look relatively similar to the occupations in which the workers were originally employed: the average task distance associated to these moves is 2.9, much less than the average distance spanning between brown and 'other' or green occupations (see Figure 7). To illustrate, this task distance is one that would correspond to an LGV driver (a brown occupation) changing job to become a carpenter (a non-brown occupation).

FIGURE 14: **Brown job leavers moving into green jobs tend to come from brown jobs which are more similar to green jobs than the average brown job**

Relative intensity of different types of tasks across different groups of occupations workers employed in brown occupations moved from and into: UK, 2012-2019



NOTES: Task intensity measures set out in the upper part of the chart pertain to all occupations brown job workers are employed in (all brown jobs), the specific occupations brown job workers leave when they move to a non-brown occupation at time T+1 (brown jobs left) and the non-brown occupations these brown job leavers have moved into at time T+1. The lower part of the chart additionally shows task intensity measures of the brown occupations workers moving from brown to green jobs were employed in at time T as well as of the green occupations they move into at time T+1. The measures of task intensity are standardised across all SOC 2010 four-digit level occupations. Green jobs refer to 'core green task' jobs (based on a mapping of occupations from O*NET, see Box 1) and brown jobs refer to 'brown changer' jobs (occupations particularly prevalent in emissions-intense sectors, see Box 2). Note that these categories are not mutually exclusive.
SOURCE: Analysis of O*NET and Five-quarter longitudinal Labour Force Survey.

At the same time, it is worth noting how the workers who leave brown jobs tend to move to occupations with less emphasis on physical and analytical tasks, and instead concentrate more on performing routine cognitive tasks. On the right, we focus on workers moving specifically from brown to green jobs. Based on the relative importance of the tasks performed in these occupations, we can see that brown occupations which workers are moving away from are closer to the green occupations they are moving into than the average brown and green occupations. In particular, workers moving from brown to green occupations cover an average task distance of 3.6, less than the average distance between brown and green occupations of 4.1 shown in Figure 7. An illustrative example of an occupational move from a brown to a green job spanning a distance close to 3.6 is the one involving an electrical engineer (an occupation that requires a considerable amount of analytical skills) changing job to become a director in construction.

BOX 3: **Task distance and workers' occupational mobility in the UK**

Previous work in the Economy 2030 Inquiry considered the ability and propensity of workers in the UK to move across occupations, describing the distribution of the task distances (where 'task distance' is a shorthand for 'the distance between the tasks required in jobs') associated with workers' actual occupational moves.[31]

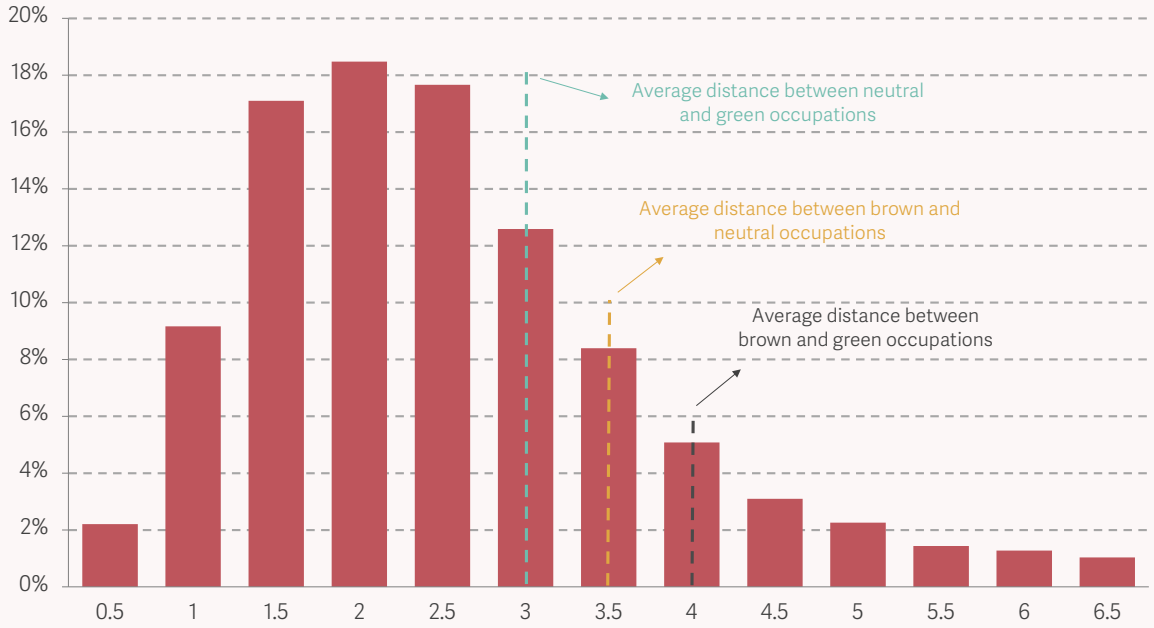
Drawing on that work, Figure 15 shows how the average task distances spanned by various moves into or out of brown or green jobs (as reported in Figure 7) compare with the distribution of task distances from all occupational moves in the recent past (2002-2020).

Based on this, we can see that, although job moves from 'other' to green occupations involve more task adaption than typical occupational changes (whose median task distance is 2.5), moves covering the equivalent task distance of at least 3 are not uncommon (34 per cent of occupational moves). Moves covering the distance spanned by average brown-to-other occupations are rarer, with 26 per cent involving an equivalent distance of 3.5 or higher. Only around 14 per cent of occupational transitions observed in the recent past covered a task distance of 4, which is equivalent to the average distance spanning across brown and green occupations.

31 N Cominetti et al., Changing jobs? Change in the UK labour market and the role of worker mobility, Resolution Foundation, January 2022.

FIGURE 15: **Occupational moves covering the average task distance spanned by brown-green occupations are quite rare in the labour market**

Distribution of task distances involved in workers' occupational moves: UK, 2002-2020



NOTES: The chart plots the relative frequency of occupational moves performed by British workers covering different task-distances. The vertical bars mark the average task distances associated to occupational moves between 'other' and green occupations, brown and 'other' occupations and between brown and green occupations. Green jobs refer to 'core green task' jobs (based on a mapping of occupations from O*NET, see Box 1) and brown jobs refer to 'brown changer' jobs (occupations particularly prevalent in emissions-intense sectors, see Box 2).
SOURCE: Analysis of O*NET and Five-quarter longitudinal Labour Force Survey.

This analysis suggests that, as far as we focus on this task-distance metric, we should expect occupational transitions between brown and green occupations to be relatively rare, although not impossible.

Overall, looking at how workers have moved across different types of jobs in the past tells us that workers' transitions from brown to green jobs are quite infrequent (as shown in Figure 11). This is unsurprising, given that only a small share of job moves in the economy require a change in the tasks performed of the extent that would be involved in switching from an average brown job to an average green job (see discussion in Box 3). Furthermore, those who do make such a move appear to be higher-skilled workers who were employed in those brown occupations with task content that was more similar to green occupations to start with (and thus requiring less change).

This means that, even though the proportion of workers moving from brown to green occupations has ticked up in the most recent years, we are unlikely to see a complete reallocation of workers from brown to green jobs in the coming decade. However, it

is not the case that all workers in jobs we identify as brown will need to find different occupations. In some brown occupations, green tasks will become more prominent, requiring incumbent workers to adapt to low carbon technologies and processes. While this is likely to vary across industries and occupations, the amount of adaptation required will probably be less challenging and more gradual than changing occupation altogether. For example, an LGV driver having to switch from internal combustion engine vehicles to electric vehicles would require less adaptation than if an LGV driver moved to an entirely different occupation.

However, some workers may still face disruptions, particularly those employed in brown occupations which face a drastic reduction in their demand under net zero commitments (with little scope for repurposing them towards green activities). For most of these workers, particularly the lower-educated ones, moving into non-green jobs that are more similar in terms of task profile may represent a more realistic alternative than moving to green jobs. Of course, there is still an important role to be played by policy interventions aiming at retraining targeted groups of workers, which we discuss later in this note.

Overall entry into green jobs has slowed down, although there has been a small increase in the proportion of green jobs started by workers moving from other types of occupations

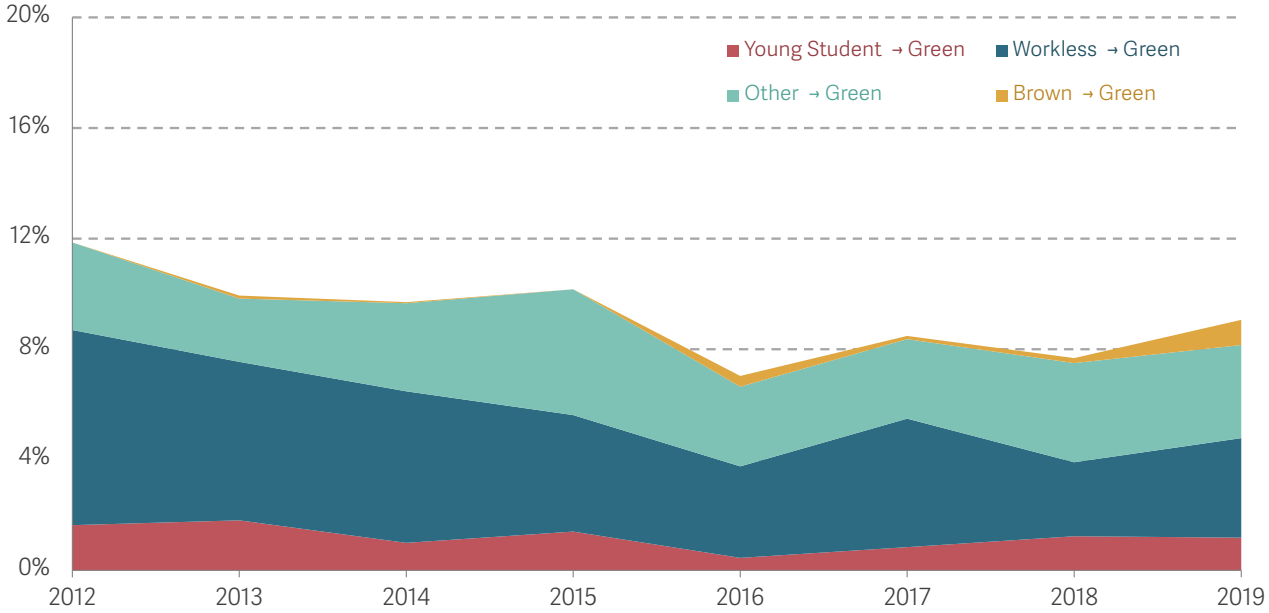
We now switch our attention to green jobs. We find that despite moderate employment growth between 2011 and 2019 (see Figure 8), the entry rate into green jobs has in fact slowed down over this period. Figure 16 plots the trend in the percentage of workers moving into a green job as a proportion of total green employment, which has declined from almost 12 per cent at the beginning of the period to about 8 per cent in 2019. At the same time, workers moving from non-green, and to a lesser extent brown occupations, have represented a growing proportion of those starting green jobs. Overall, occupational moves have been the main driver in the so-far limited expansion of the green workforce (Figure 26 in the Annex 3).

This need not be bad news: if green jobs are accessible and attractive to non-green workers, despite their different task content, we might expect that over the coming years, the existing workforce will be able to fill in gaps in the demand for green workers more rapidly than new cohorts of young people can do (as they represent a bigger pool). At the same time, stagnating job mobility,[32] an ageing workforce and potential skill gaps among current workers may stifle the growth of green sectors and hamper their future productivity, meaning that firms in green sectors may need to do more to attract younger workers just leaving education and/or to train their existing workforce.

32 N Cominetti et al., Changing jobs? Change in the UK labour market and the role of worker mobility, Resolution Foundation, January 2022.

FIGURE 16: **Green jobs have been increasingly started by workers changing occupations rather than those entering from non-employment or full-time education**

Percentage of workers moving into green jobs (as a proportion of green employment in previous year) by their origin: UK, 2012-2019



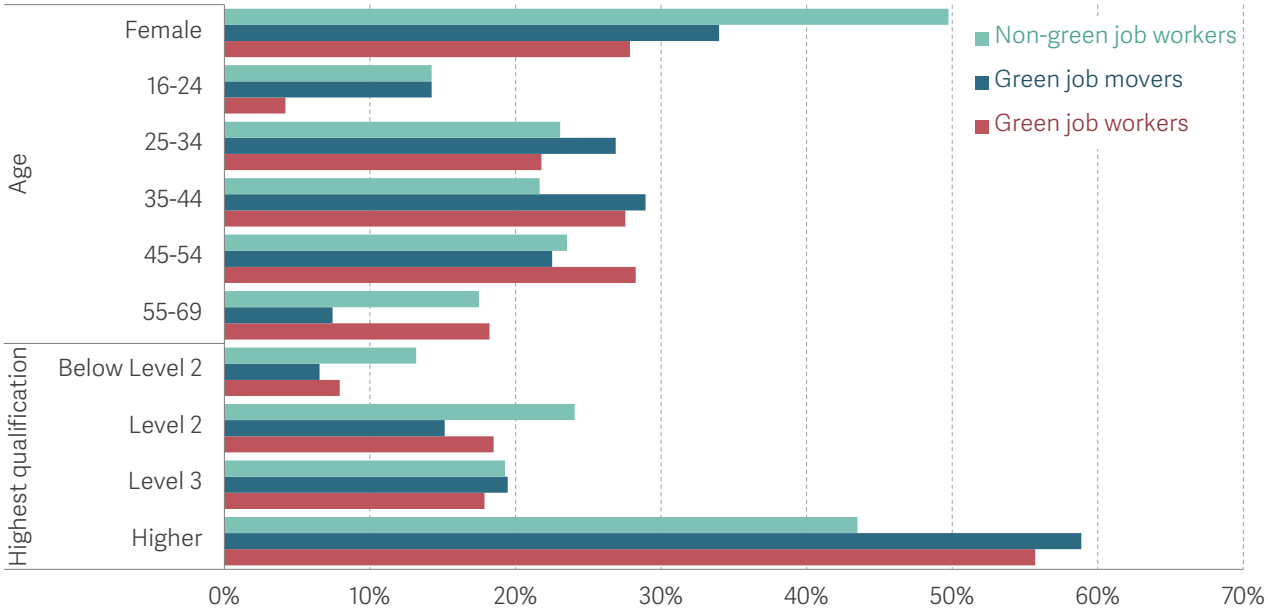
NOTES: These measures pertain to workers who are observed employed in a green occupation in year T and that, one year prior to that (T-1), were observed as workless (including unemployed or inactive, but not in education), studying (defined here as being less than 25 years old and enrolled in some course) or as being employed in a different job in a brown or 'other' occupation. Green jobs refer to 'core green task' jobs (based on a mapping of occupations from O*NET, see Box 1) and brown jobs refer to 'brown changer' jobs (occupations particularly prevalent in emissions-intense sectors, see Box 2).
SOURCE: Analysis of ONS, Five-quarter longitudinal Labour Force Survey.

Workers moving from non-green to green jobs tend to be younger and more educated than average green job workers

Anticipating how easily workers could move from non-green to green occupations as the demand for green jobs rises requires a better understanding of the characteristics of workers that have made such transitions in the recent past. Figure 17 plots the average characteristics of workers who moved from non-green to green jobs, comparing them to the broader groups of green and non-green job workers. It shows that movers to green jobs are more likely to be female than the typical green job worker, and tend to be younger, and more highly educated, than both green and non-green job workers.

FIGURE 17: **Workers moving from non-green to green jobs are much more highly educated than non-green job workers on average**

Average characteristics of workers: UK, 2012-2019



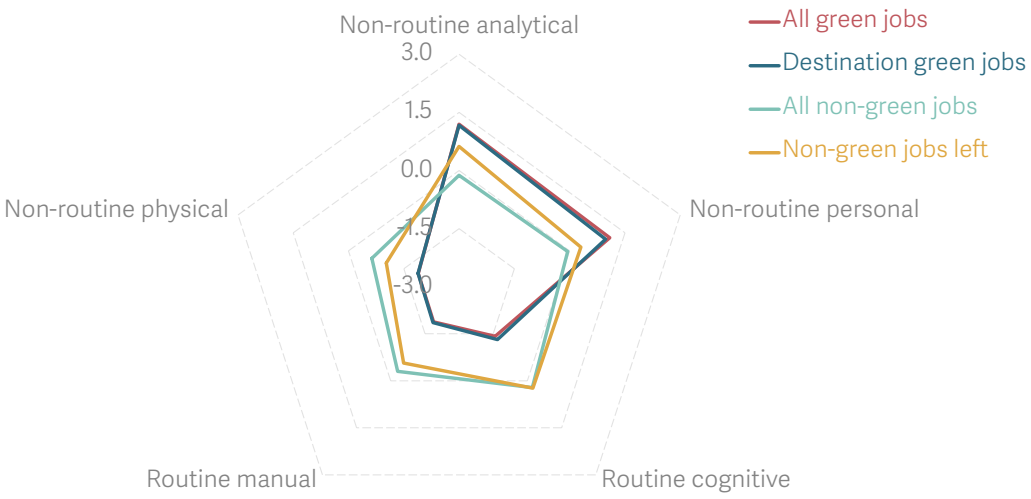
NOTES: These characteristics pertain to workers who were observed employed in a green job at time T regardless of their status one year earlier (green job workers); those who were employed in a non-green job and moved into a green one (green job movers) and those who are employed in a non-green job (non-green job workers). Green jobs refer to 'core green task' jobs (based on a mapping of occupations from O*NET, see Box 1).
SOURCE: Analysis of ONS, Five-quarter longitudinal Labour Force Survey.

Next, in Figure 18 we characterise the occupations that 'green movers' move from and into in terms of their task content. Something that stands out from this chart is that the green jobs that workers have moved into (starting from a non-green job) look just like the average green job (the red and dark blue lines are on top of each other in the chart). This suggests that a wide range of green occupations are accessible to workers who were previously employed in non-green occupations.[33] However, workers making these transitions were previously employed in non-green occupations that were slightly closer to green jobs than typical non-green occupations are. In particular, these workers were likely to be more used to performing non-routine analytical (or personal) tasks than typical non-green workers.

33 This is backed by the fact that of the 41 occupations we consider as "core green task", 38 are observed as being the destination of job-to-job transitions from non-green occupations.

FIGURE 18: **Workers moving from non-green to green jobs come from occupations whose content is more similar to typical green occupations**

Relative intensity of different types of tasks across different groups of jobs: UK, 2012-2019



NOTES: Task intensity measures set out in the chart pertain to all occupations green job workers are employed in (all green jobs), the specific occupations workers moving into green jobs from non-green jobs move into at time T+1 (destination green jobs) and the non-green occupations green job movers were employed at time T. The measures of task intensity are standardised across all SOC 2010 four-digit level occupations. Green jobs refer to 'core green task' jobs (based on a mapping of occupations from O*NET, see Box 1). Note that these categories are not mutually exclusive.
SOURCE: Analysis of O*NET and Five-quarter longitudinal Labour Force Survey.

Leaving a brown job and joining a green job are both associated with an increase in hourly wages

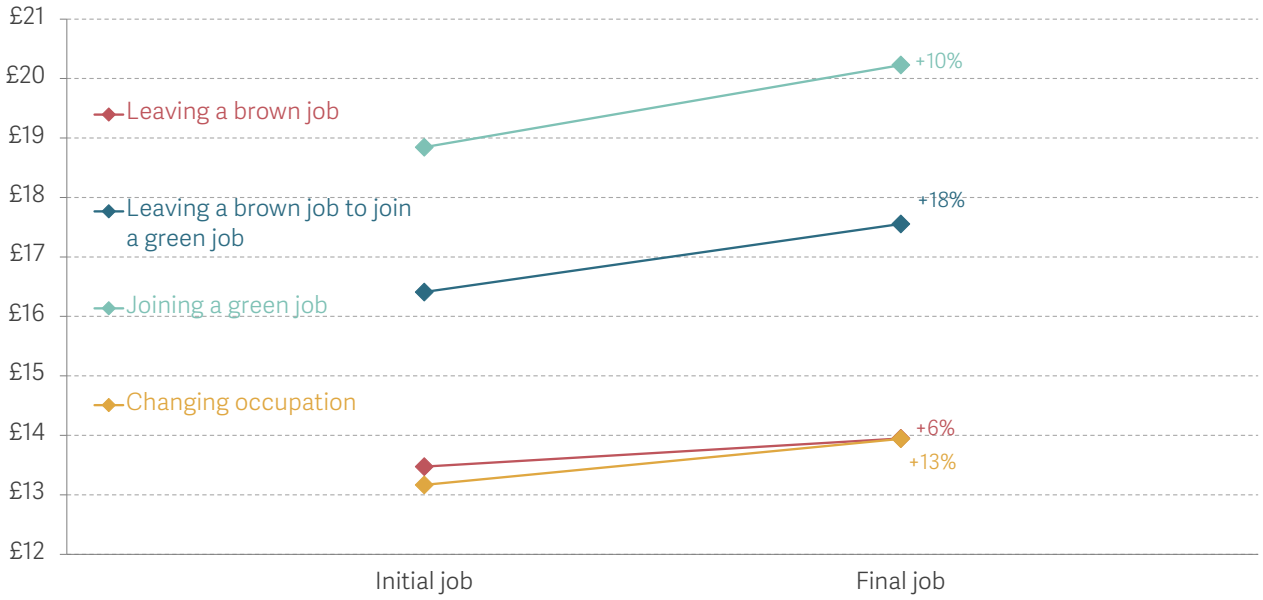
Finally, we consider the implications of workers' transitions between brown and green jobs for hourly wages. Our previous cross-sectional analysis of wages suggested that green jobs enjoy a wage premium, even after controlling for other observable characteristics of workers such as education and experience. However, it could be that unobserved factors lead certain individuals to be more likely to choose greener jobs and able to command higher wages. Examining the change in wages for movers effectively controls for such individual specific factors to the extent they are constant over time.

Figure 19 plots average hourly wages in the initial and final job for workers who experience relevant occupational yearly transitions. This shows several things. First, occupational changes (regardless of the type of worker involved) are generally associated with a wage increase. Second, this also holds true for workers leaving a brown occupation (to join any non-brown occupation), workers joining a green occupation (from any non-green occupation), and on workers moving from brown to green occupations

specifically.[34] Leaving a brown occupation is associated with the smallest improvement in hourly wages, both in absolute and relative terms, with an average increase of around 6 per cent. On average, moving from a non-green to a green job is associated with a wage boost of around £1.40 an hour, much larger, in absolute terms, than the one experienced by occupational changers overall. The few workers who move from a brown to a green job experience the largest wage increase in relative terms (18 per cent on average). Interestingly, in line with the analysis above (see Figure 13 and Figure 17) showing that these workers are typically more highly educated and are employed in occupations with more emphasis on non-routine analytical and personal tasks, Figure 19 shows that their starting hourly wages were considerably higher than the wages received by an average brown job worker. We can also see that, despite experiencing a substantial wage increase, brown-to-green movers still earn less than the average worker joining a green job.

FIGURE 19: **Moving into green jobs is associated with an increase in wages**

Average hourly wage (in GBP) in workers' initial and final jobs when they change jobs: UK, 2012-2020



NOTES: The chart shows the average hourly wage (in GBP) earned by workers changing occupation in their job in year T and in year T+1 by the type of occupation they move from and into. The percentages refer to the average percentage change in hourly pay across workers experiencing these occupational transitions. Green jobs refer to 'core green task' jobs (based on a mapping of occupations from O*NET, see Box 1) and brown jobs refer to 'brown changer' jobs (occupations particularly prevalent in emissions-intense sectors, see Box 2). Note that these categories are not mutually exclusive.
SOURCE: Analysis of ONS, Five-quarter longitudinal Labour Force Survey.

34 It is important to stress again that this group is particularly small in the LFS, so these changes in hourly wages should be interpreted with caution.

Looking at occupational transitions across green and brown jobs from the recent past can provide some insights on how the UK labour market could contribute and adjust to the expansion of the green economy and the transformation of emissions-intense sectors over the coming decade. Our work has shown that the occupational content and the skills required across green and brown occupations are quite different, potentially making job transitions between brown and green jobs difficult for workers. Notwithstanding these differences, over the last decade, a small but increasing proportion of workers leaving brown jobs found employment in green occupations. However, these job transitions typically involved workers who are more educated than average and who were previously employed in brown occupations that had more in common with green occupations than typical brown jobs do. This raises the question of whether brown-green transitions will be feasible for the rest of the brown job workforce. Moving into jobs that are neither brown nor green may be easier for these workers, and this has been more common in the past (although this type of move has been associated with smaller payoffs). It is also important to keep in mind that the availability of these more accessible jobs will depend on their future demand, with some of these jobs exposed to the risk of automation or other change too.

Considering transitions into green jobs, our analysis has also shown that workers' mobility from non-green to green occupations has been a key contributor to the (so far rather limited) growth in green employment.[35] Despite featuring more non-routine tasks (including more analytical tasks) and thus being more suitable for more highly educated workers, green jobs to date have turned out to be relatively accessible to workers previously employed in non-green occupations. Importantly, the green jobs these workers have moved into look just like typical green occupations, although these moves were made by workers who were more educated than average and employed in more analytical jobs. Furthermore, despite coming from jobs with relatively high pay, workers joining green occupations experienced a pay uplift. The question is whether existing incentives will be enough to attract the right profile of workers into new green jobs. Given that overall job mobility has slightly declined over time in Britain[36] (and the existing workforce is ageing[37]), part of the solution will have to include attracting younger workers by establishing better connections between the education system and industrial needs. Greening occupations from within, via the acquisition of new skills and green tasks, will also play a key role in this next decade, which requires economy wide change for net zero.

35 Which, as discussed previously, is likely to be an underestimate since new green jobs that have emerged over the past decade, particularly in the UK, are not necessarily captured in our classification method (set out in Box 1).
36 N Cominetti et al., Changing jobs? Change in the UK labour market and the role of worker mobility, Resolution Foundation, January 2022.
37 M Broome, Big welcomes and long goodbyes: the impact of demographic change in the 2020s, The Economy 2030 Inquiry, June 2022.

Enhanced policy commitments mean that this decade is likely to require more change: 'greening' some existing roles, and shifting workers to essential, newer green roles

Our analysis of job changes in the 2010s has highlighted jobs that are most likely to experience change in the transition to net zero, and groups for whom successful transitions and new opportunities might be harder to access

The previous sections have shown that there are differences between what we might consider to be greener and browner jobs – both in terms of the workers that tend to be employed in them, and the types of tasks and skills involved. In particular, green jobs in general tend to be higher skill, and higher paid, even after controlling for other factors such as education and experience.

We have also seen that those workers who in the past have made transitions from brown into green jobs tend to be those that already had closer skills profiles. This suggests that special attention will be required to support transitions for those in currently brown roles that might see reduced demand in the future, or which will require significant changes in tasks or skills as part of within-occupation change, and associated policy requirements are likely to vary across places, sectors and demographic groups. The following sections consider what lessons can be learned from the experiences of regions transitioning out of high-carbon activity, summarises the findings of forward-looking analyses of job and skills needs in the UK's net zero transition, and assesses what this all means for policy.

Key lessons can be learned from previous episodes of change that were particularly acute in some sectors and some areas

The overall evidence on the impacts of environmental policies and regulations on employment to date has been mixed. Studies have generally found small negative overall impacts on employment in the short-run in pollution- and energy-intensive industries, but also that such policies tend to increase innovation in clean technologies, which can be expected to generate opportunities for growth and new jobs over time (below, we discuss work for the Economy 2030 Inquiry that has sought to identify such opportunities for innovation-led growth in the UK).[38]

Of course, there have been episodes of large-scale labour market disruption in specific places in the past resulting from the phasing out of emissions-intense sectors, most notably coal. Where the net zero transition leads to acute issues in particular sectors or places, lessons can be learned from areas that have achieved successful transitions in the past. For example, the relative success in transitioning the Ruhr region away from

38 For discussion of the relevant literature, see A Dechezleprêtre & M Sato, The Impacts of Environmental Regulations on Competitiveness, Review of Environmental Economics and Policy, 11(2), 2017.

coal and towards technology and education, as compared to the experience in the Welsh valleys (summarised in Box 4), appears to be explained by better coordination between national, regional and local policy and actions, and effective coordination on skills supply and demand, with investments in skills and complementary assets and a focus on the provision of good jobs in services and environmental activities.

BOX 4: **Managing transitions out of coal mining in Germany's Ruhr vs. the Welsh valleys**

The transition to net zero will bring great change to workers and communities in which certain brown jobs are located. An IRRC report which was prepared with the objective of informing Australia's transition away from coal-fired power generation, uses case studies to investigate how successfully different regions with a heavy dependence on the coal power industry managed to implement policies and programmes to manage structural economic change.[39] The report provides important information on the types of policies and programmes that the UK could adopt to protect jobs and ensure a smooth transition to net zero for places that are likely to face disruption. This box focusses specifically on the cases of Germany's Ruhr region and the valleys in Wales.

In 1957, nearly half a million workers were employed in the Ruhr's coalmining industry (around 40 per cent of total employment), but by 2007, following the first phase of the Ruhr coal mine closures, this had declined to 24,000 (less than 2 per cent of total employment). During this time, there was substantial state-level public investment into mitigating the impact of job losses on workers. This included the establishment of new universities and technical colleges and environmental clean-up schemes. Policy-making shifted in the late 1980s to a new bottom-up approach. While state-level guidance retained a major role in long-term planning for specific projects, the design and implementation moved to the local level, and to local actors. Through this bottom-up approach, economic diversification was delivered through investment in new service sector growth and re-industrialisation support policies focused on environmental technologies. These were considered successful in slowing the pace of job losses and preventing mass outward migration and long-term economic decline.

39 P Sheldon, R Junankar, & A De Rosa Pontello; The Ruhr or Appalachia? Deciding the future of Australia's coal power workers and communities, Industrial Relations Research Centre, October 2018.

The second, much shorter, phase began with a federal government decision to phase out all subsidies for coal mining by 2018. To ensure "socially acceptable staff reduction" a comprehensive package of measures was implemented including: the re-location of about 10,600 employees within and to still-producing coalfields, a generous early-retirement scheme, opportunities for workers to transfer jobs within the company, qualification/requalification through training and on-the-job certification, and external transition into the services sector where appropriate.

By contrast with the successful structural adjustment programmes that significantly improved the Ruhr's economic resilience, a lack of a unified regional strategy and funding hampered the ability of the Welsh valleys to respond to structural economic change. In 1921, the Welsh valleys' coal mines directly employed about 270,000 people, more than 20 per cent of total UK coal mining employment. However, the gradual decline and ultimate collapse of the region's coal mining over the following seven decades brought entrenched high unemployment, poverty and net worker outmigration.[40]

Between 1934 and 1976, various governments implemented initiatives to foster economic development and employment transition including: retraining and relocation allowances for retrenched miners; state-funded housing; infrastructure and industrial development projects; and tax incentives and subsides to attract new inbound business investment. However, these initiatives failed to achieve sufficient industrial diversification, and the rapid closure of the valleys' remaining mines by the government in the 1980s triggered mass unemployment.

Although these closures were accompanied by generous redundancy payments for the early retirement of older miners and for the retraining of younger, laid-off, workers, these were not coupled with policies that generated sufficient demand for skilled labour. The top-down approaches adopted by the government in Westminster failed to adequately provide a long-term development strategy to build a more sustainable and successful regional economy for the valleys.

By focusing on both labour supply and labour demand, the Ruhr's regional strategy on structural adjustment resulted in considerably different outcomes for the labour market when compared with the valleys. Policies and programmes that made the Ruhr's transition more successful than that

40 This draws on: T Merrill & L Kitson, The End of Coal Mining in South Wales: Lessons learned from industrial transformation, International Institute for Sustainable Development, 2017.

seen in the valleys included: regional pooling of workers among remaining plants and mines to minimise workers time spent without work; assisting workers to find alternative work in fields that required similar skills; funding labour intensive regional projects (such as remediation and environmental clean-up schemes) to act as a bridge to other employment opportunities; and the provision of training and short-term placements in alternative fields of work to preventing unemployment and long-term unemployment.

The authors of the IRRC report argue strongly for having complementary top-down and bottom-up approaches. It is thought that successful cases have brought together a long-term agreed overarching framework, strong top-down leadership, and sufficient funding along with extensive local consultation and bottom-up initiatives. The examples of the Ruhr and the valleys provide important lessons on the types of interventions that might be required to ensure a successful transition to net zero for areas that might face particular disruption given pre-existing industrial specialisation.

But the next phase of net zero will involve more rapid change and new jobs across the economy, and ensuring (local) skills needs are met will be key to delivering net zero, realising new opportunities and managing transitions well

An increasing number of studies have sought to estimate the job creation potential in net zero aligned investments in the UK; these generally take sectoral or technology-based approaches. A previous review of ex ante studies which focused on net-zero aligned investments that could be made quickly found that investments in areas such as electric vehicles production and charging infrastructure, hydrogen and carbon capture usage and storage (CCUS) for industry, renewable power generation and distribution and housing energy efficiency were each estimated to have the potential to generate tens of thousands of new jobs this decade (and more beyond that).[41] Typically, shorter-run job creation relates to construction and installation activities, whereas medium-to-longer run opportunities relate to maintenance, production and R&D related to these technologies.

More recently, the Government's Green Jobs Taskforce[42] set out estimates of employment and skills needs across three groups of sectors relevant for the transition to net zero, differentiating three categories of sectors: those that are well-established and will experience significant growth (e.g. offshore wind, electricity networks or smart grids); sectors that are predicted to grow ahead of the transition (e.g. hydrogen and

41 S Unsworth et al., Jobs for a strong and sustainable recovery from Covid-19, Centre for Economic Performance, October 2020.
42 BEIS, The Green Jobs Taskforce report, July 2021.

carbon capture usage and storage - CCUS); and sectors that are experiencing significant transformation and perhaps decline in some areas (e.g. automotive, heating and cooling, oil and gas and waste management) (see Box 5 for a summary). While noting specific skills requirements across these areas, the Taskforce also highlighted the importance of various types of general skills for the transition, including the ability to work between and across disciplines. A key example is in whole-house retrofitting: net zero homes will require multiple technologies such as solar panels, EV chargepoints, heat pumps, batteries and smart systems to control and enable technologies to work together. Other key areas, such as general STEM skills, together with digital, project and change management, and leadership skills are also emphasised.

BOX 5: **Net zero and demand for skills in the UK across specific sectors**

The Green Jobs Taskforce report set out how the net zero transition will impact the demand for skills in three broad categories of sectors, and we summarise key points here. First, it set out the well-established sectors which will experience significant growth:

- **Offshore wind**: This sector could employ around 70,000 people, compared to around 26,000 in 2021,[43] and, while demand is expected to be strongest for engineers and technicians, a broad range of skills will be required and there is a high degree of transferability from workers currently employed in oil and gas.
- **Electricity:** The National Grid estimates there is a need to recruit for an additional 260,000 energy jobs between now and 2050 to get to net zero.[44] Such jobs will require skills in both smart and traditional networks engineering.
- **Smart systems technologies**: By 2050, the domestic market for smart systems and flexibility solutions could support as many as 10,000 jobs,[45] with additional jobs if exporting opportunities are realised.
- **Buildings retrofit**: It is estimated that retrofitting will require recruiting and training an additional 230,000 people by the end of the decade to improve building fabric energy efficiency.[46]

43 This is according to the Offshore Wind Industry Council (OWIC), Offshore Wind Skills Intelligence Model Report, 2021. In the most recent report, current jobs are estimated at over 31,000, with a forecast of nearly 100,000 employed by 2030, see OWIC, Offshore Wind Skills Intelligence Report, May 2022.
44 National Grid, Building the Net Zero Energy Workforce, January 2020.
45 BEIS, Energy Innovation Needs Assessment, November 2019.
46 Construction Industry Training Board [CITB] (2021), Building skills for net zero, March 2021.

Sectors that are predicted to grow during the transition to net zero include new low carbon technologies and emerging sectors such as hydrogen and CCUS which are particularly relevant for heavy industry, and where the required skills are closely related to those held by the current energy workforce. It is also expected that there will be more service jobs linked to low-carbon industries, in areas like carbon markets and climate finance and consultancy services,[47] together with a growing need for building climate resilience across housing, construction, water, infrastructure, among other areas.

Finally, the Green Jobs Taskforce suggest that a number of sectors will undergo significant transformation in the transition to net zero:

- **Automotive**: Assuming the UK retains its global market share, the overall workforce of the automotive and EV battery ecosystem could grow by 29 per cent from 170,000 to 220,000 employees by 2040.[48] There are gaps in the workforce that would need to be overcome with retraining, upskilling and new recruitment.
- **Heating and cooling**: Around 60,000 workers will be needed for heat pump installation in domestic and non-domestic buildings over the next seven years.[49]
- **Circular economy**: The growth of circular economy sectors, including repair, re-manufacture, refill and servitisation, could create between 54,000 to 102,000 jobs by 2030.[50] Shifting towards repairs has the potential to reduce imports and require more skilled workers.
- **Oil and gas:** These sectors will undergo significant transformation, and potentially, see a decline in employment over the coming decades. Between 2014 and 2017, the UK oil and gas sector lost over 70,000 direct jobs, as well as additional losses in the supply chain. Another 80,000 workers are likely to leave the sector between 2018 and 2035 due to natural attrition.[51] It has been estimated that 90 per cent of the UK's oil and gas workforce have medium to high skills transferability with respect to other energy sectors.[52]

47 Committee on Climate Change, Independent Assessment of UK Climate Risk, June 2021.
48 The Faraday Institution, Faraday report - March 2020. Annual gigafactory study: UK electric vehicle and battery production potential to 2040, 2020.
49 Construction Industry Training Board [CITB], Building skills for net zero, March 2021.
50 WRAP/Green Alliance, Employment in the circular economy, January 2015.
51 OPITO, UKCS Workforce Dynamics 2018–2035: Shaping the skills of tomorrow, 2018.
52 Energy Transition Institute, UK Offshore energy workforce transferability review, 2021.

The potential for the creation of new jobs must be considered in the context of the currently high employment rates in the UK and the need to improve the quality of work for many of those in the labour force.[53] In such a context, new net zero investments can create only limited additional net employment benefits, and instead we should focus on the impacts on real wages, job quality and the mix of jobs, ensuring that new cohorts of job seekers and workers that have been displaced (because of net zero or the other shocks and transitions this decade) can access good jobs in areas that are growing. Our previous analysis has shown that this might be harder for some groups, warranting a focus on accessibility and facilitation of transitions in such cases.

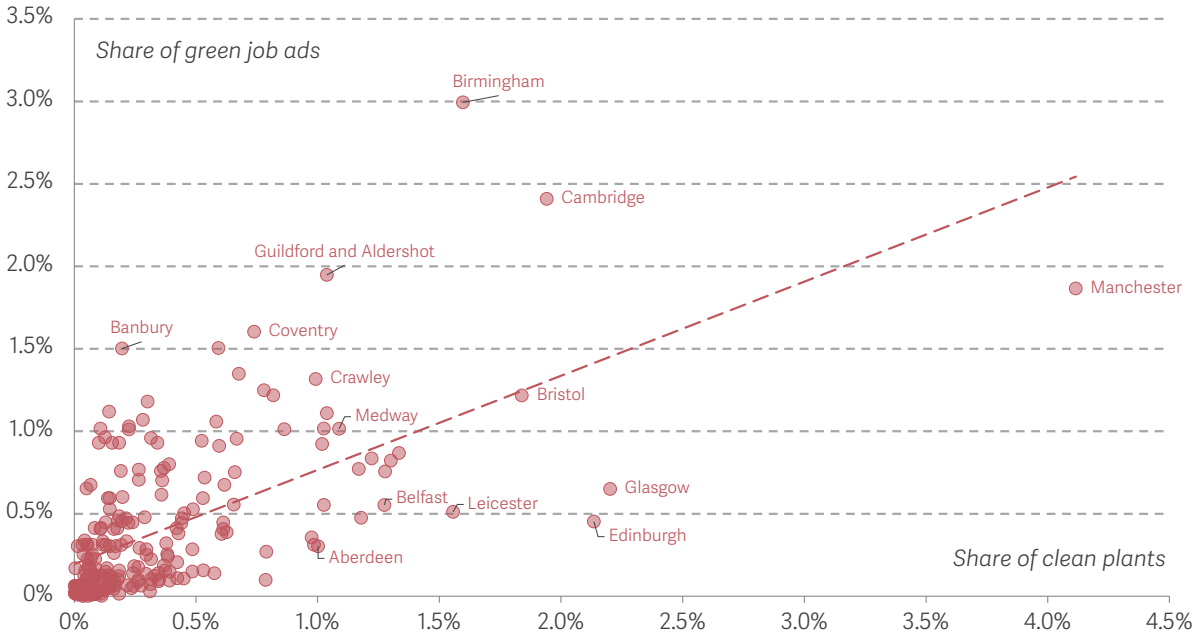
Place will matter, both in terms of the nature of the investments and change which will vary based on pre-existing sectoral make-up and endowments of different areas, and in determining the extent to which local workers are able to benefit in terms of accessing new job opportunities. Previous work in the Economy 2030 Inquiry has analysed the potential growth opportunities that the net zero transition brings to the UK, based on current capabilities in clean innovation, products and services across the country.[54] Analysis of different datasets suggests that doubling down on net zero capabilities as part of a coordinated growth strategy could be consistent with addressing regional disparities in economic activity, since less productive regions appear to be more specialised in such technologies, goods and services. An obvious example is carbon capture usage and storage (CCUS), which is being developed within the UK's industrial heartlands and which can also benefit from the UK's transferrable expertise in oil and gas and relevant infrastructure.[55]

However, when considering outcomes for people and places, the extent to which innovative activity and the presence of firms translates into new local job opportunities matters. To explore this, we rely on previous work where we assigned online job advertisements to green jobs categories.[56] Figure 20 plots the regional share of total UK 'core green task' job vacancies[57] against the regional share of clean firm plants, showing that there is a positive correlation between these two measures.[58] This suggests that there is some link between the location of clean firms and the places where new green jobs are emerging.

53 For discussion on low pay and insecurity in the UK labour market, see N Cominetti et al., Low Pay Britain 2022: Low pay and insecurity in the UK labour market, Resolution Foundation, May 2022.
54 B Curran et al. Growing Clean: Identifying and investing in sustainable growth opportunities across the UK, Resolution Foundation, May 2022.
55 E Serin et al., Seizing sustainable growth opportunities from carbon capture usage and storage in the UK, GRI & CEP, September 2021. Two industrial clusters have been selected to lead UK deployment of CCUS: the East Coast cluster in Teeside and the Humber, and Hynet in the North West and North Wales (BEIS, October 2021 update: Track-1 clusters confirmed, November 2021).
56 A Valero et al., Are 'green' jobs good jobs?, CEP Paper Number CEPSP39, October 2021.
57 As before, this is based on the core green task indicator, but the pattern looks the same if the overall greenness index is used instead.
58 We note that we exclude the "London, Slough and Heathrow" outlier for visual purposes - it accounts for over 11 per cent of the UK's directly green jobs adds and 21 per cent of its clean firms. The equivalent analysis using firm registered address rather than business sites (plants) looks similar.

FIGURE 20: **Areas with a higher share of 'clean' firms also account for a higher share of new green jobs**

Regional share of green job ads (2019) and share of clean firm plants (2021): UK



NOTES: Travel to Work Area (TTWA) level share of total UK 'clean' firm plants (as at 2021) and TTWA share of total core green jobs (as at 2019, to avoid differences in hiring activity during the early stages of the pandemic in 2020). Outlier TTWA "London, Slough and Heathrow" is excluded. Green job ads refer to 'core green task' (based on a mapping of occupations from O*NET, see Box 1).
SOURCE: Estimates based on The Data City and Burning Glass Technologies, drawing on B Curran et al. (2022) and A Valero et al. (2021).

Policy makers will need to help firms, and the workforce, meet demand for new green roles and adjust to changing technology and task requirements in pre-existing jobs

As we've already set out, investments required to meet the UK's net zero targets will generate a significant amount of new green jobs related to activities that are already growing (e.g. zero carbon heat in buildings) or in emerging sectors that are expected to grow given government and industry commitment (e.g. CCUS). And as this report has frequently highlighted, it will also require some jobs to undergo changes in both the tasks they require and the skills they deploy.

Indeed, the availability of the appropriate skills will be fundamental to the delivery of net zero projects, and the extent to which local workers and firms are able to access related growth opportunities. A recent example of skills constraints being a barrier to net zero investments is the Green Homes Grant, announced in 2020, which aimed to deliver 600,000 energy efficiency upgrades in a six-month period. In fact, 47,500 homes were upgraded, and only one-fifth of the original £1.5 billion budget was spent; it appears that this was due to a lack of accredited tradespeople, as well as an onerous application

process.[59] Even when there are clear potential benefits to retraining in areas that are set to grow in importance, there are a number of barriers faced by firms and individuals which can prevent investments in new skills.[60]

For example, as set out in Box 6, home heat workers will require new skills in order to install heat pumps. While current installers reported a positive attitude to retraining when surveyed in 2019, barriers to investing in it relate to uncertainty over consumer demand and the financial costs of training (particularly for those who are self-employed). There is an important role for Government here to stimulate both the demand and supply side for these types of skills, and others needed in the transition to net zero. Heat pumps is an area where the Government is creating more certainty on the demand side, combining regulations on new homes, grants for voluntary heat pump upgrades in existing properties, and a 2035 backstop after which no more gas boilers will be installed in UK homes. But there is less clarity on energy efficiency, which is important in its own right for reducing emissions (and alleviating the current energy crisis), and as a complement to heat pumps. [61]

More generally, such issues occur against the background of persistent gaps in technical skills,[62] UK employers' comparatively poor performance in providing effective training (wherein UK workers are significantly less likely than those in other European countries to report that their training improved the way they work), and the fact that employers' investments in training have been declining over time.[63] While our analysis on the previous decade has shown that on average green jobs have tended to be more prevalent amongst graduates, it is likely that many of the new skills required can also be delivered via on-the-job training and via the further education system. Addressing underinvestment in skills in the UK, particularly in some groups or areas, will be crucial for allowing firms to adjust to new technologies and tasks that arise as a result of the net zero transition, and improving productivity and living standards.

59 See: Green Homes Grant Voucher Scheme, House of Commons Committee of Public Accounts, November 2021.
60 For firms, underinvestment in training tends to occur due to the fact that workers can be 'poached'n and due to the presence of human capital externalities which mean that firms cannot internalise all the benefits of their training. Financial constraints can also play a role, given that training is a discretionary expenditure. At the individual level, financial (costs of training and foregone income) and information constraints (which skills to invest in) can prevent investments in new skills. Generally, where there is uncertainty over future demand and the shape of markets, this can also prevent investments in new skills. For more discussion, see: See: J Li et al., Trends in job-related training and polices for building future skills into the recovery, Centre for Vocational Educational Research Discussion paper 033, December 2020.
61 A Corlett & J Marshall, Shrinking footprints: the impacts of the net zero transition on households and consumption, The Economy 2030 Inquiry, March 2022.
62 J Oliveira-Cunha et al., Business Time: How ready are UK firms for this decisive decade?, The Economy 2030 Inquiry, November 2021.
63 J Li et al., Trends in job-related training and polices for building future skills into the recovery, Centre for Vocational Educational Research Discussion paper 033, December 2020.

BOX 6: **Home heat workers' perceived barriers to retraining**

The Government has set a target to deploy at least 600,000 heat pumps per year by 2028 in order to achieve its net zero ambitions: this will require a significant acceleration given current installation rates of around 35,000 heat pumps a year.[64]

The Heat Pump Association estimates that 50,200 fully trained heat pump installers will be required to fit 1 million heat pumps a year by 2030. Installing a heat pump requires different skills than those involved in fitting and maintaining a gas boiler. As a result, meeting the Government's targets will require a significant programme of retraining among existing home heat workers.

Research by the Social Market Foundation (SMF) finds that there are currently 147,800 plumbing, heating and ventilation engineers in the UK, 130,000 of which are Gas Safe registered, indicating that the vast majority of the workforce works on gas heating systems.[65] A large proportion of the workforce is self-employed: 51 per cent of plumbing, heating and ventilation engineers, rising to 77 per cent among the gas industry specifically. The installer base is also thought to be relatively old compared to the average UK worker. A Heat Pump Association survey from 2019 found that 58 per cent of respondents were over 51 years of age.

By conducting interviews with home heat workers, the SMF found that installers generally had a positive attitude towards phasing out fossil-fuel heating and retraining to install heat pumps. For some installers, the motivation for retraining stems from environmental concern. However, for the majority, retraining was seen as a business opportunity within an emerging market, while others believe it is important for job stability and future security.

Despite their positive attitude, interviewees identified a number of significant barriers to retraining. Firstly, the low consumer demand for low-carbon heating systems, especially heat pumps, provided little incentive to retrain, with many individuals believing that will be enough demand for gas work to sustain their livelihoods until retirement (these interviews took place in 2019). Secondly, interviewees saw the financial cost of retraining as a barrier. This was particularly acute among self-employed individuals, who reported that the loss of earnings from attending training courses as an even greater

64 See A Corlett & J Marshall, Shrinking footprints: The impacts of the net zero transition on households and consumption, Resolution Foundation, March 2022.
65 Social Market Foundation, Installing for time?, February 2020.

barrier than the direct cost of training courses.

Based on the findings, the SMF suggested a number of interventions to incentivise retraining, including: programmes to stimulate greater consumer demand for heat pumps; expanding vocational tax credits to compensate the loss of earnings from the time required to retrain; introducing an official training standard and accreditation badge to instil greater confidence for both installers and consumers; and developing an engaging recruitment campaign to draw in applications.

The transition to net zero will occur alongside other drivers of change in labour markets, and associated challenges and opportunities cannot be viewed in isolation

The analysis in this briefing note has shown that there might be particular challenges for certain workers where new tasks or skills are far from those that they already possess. This implies that targeted workforce training programmes will be required to facilitate the adoption of new technologies and practices for net zero within occupations, and transition displaced workers into new occupations or areas where demand is growing. There will be a key role for policy at the national and local levels in terms of helping businesses and workers to adapt, and addressing frictions that create mismatches between skills supply and demand. Our analysis suggests that there might also be challenges ensuring that new opportunities for good quality green jobs are accessible to groups that have so far been under-represented including women, those from ethnic minority backgrounds and younger workers.

But the training needs of the net zero workforce need to be considered in the context of other shocks and transitions this decade, including change following Covid-19, Brexit and the impacts of broader technological trends such as automation. In particular, lifelong learning, reskilling and upskilling are important mechanisms to ensure that workers are able to adapt to technological change including the rise of AI and robotics. Previous analysis suggested that greener jobs were perhaps at less risk of automation (even after controlling for occupation-level measures of human capital), and therefore more resilient to broader trends.[66] Future work in the Economy 2030 Inquiry will consider the likely impacts of automation on labour markets, and what these transitions, as they combine, mean for policy.

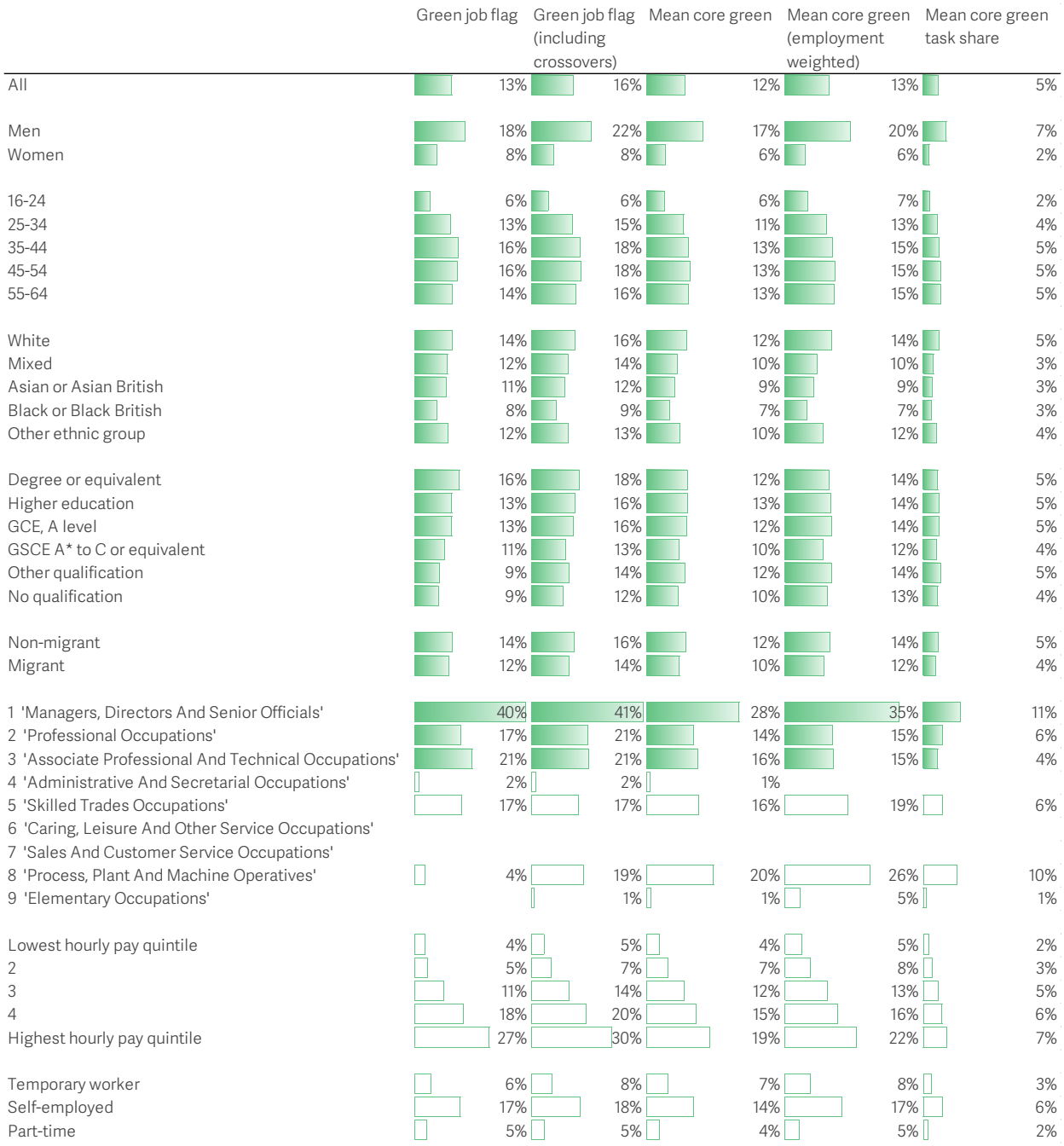
66 As previously noted, studies that have examined the task content of green jobs have noted that the work content in green jobs is on average less routinised (and hence less at risk of being automated) than that of non-green jobs. See, for example: D Consoli et al., Do green jobs differ from non-green jobs in terms of skills, human capital?, Research Policy 45 (5), 2016. In addition, previous work has found there to be a negative correlation between the overall greenness of jobs and ONS estimates of the occupational probability of automation, particularly for the directly green jobs that involve green tasks and skills, see: A Valero et al., Are 'green' jobs good jobs?, CEP Paper Number CEPSP39, October 2021.

Annex 1: headline comparisons of different measures of greenness

This annex contains the results of robustness checks, or the full results of some of the regression analysis.

FIGURE 21: **Different measures of greenness do not change the patterns we observe across worker characteristics**

Proportion of workers aged 16-69 in green jobs, using different definitions of greenness: UK, 2019



NOTES: Green jobs classifications based on a cross walk from O*NET into UK SOC2010, under various assumptions as set out in Box 1. Green job flag is our 'core green task' binary green variable used in this briefing note. Green job flag including crossovers includes the 10 occupations that are also brown, and considered brown for the purposes of this briefing note. Mean core green is the average overall greenness (GNE and GES) across jobs. Mean core green (employment weighted) is the average using US and UK employment weights in the crosswalk from O*NET into UK SOC 2010. Mean core green task share uses information from O*NET on the share of occupational tasks that are green.
SOURCE: Analysis of ONS, Labour Force Survey.

NOTES: Green jobs classifications based on a cross walk from O*NET into UK SOC2010, under various assumptions as set out in Box 1. Green job flag is our 'core green task' binary green variable used in this briefing note. Green job flag including crossovers includes the 10 occupations that are also brown, and considered brown for the purposes of this briefing note. Mean core green is the average overall greenness (GNE and GES) across jobs. Mean core green (employment weighted) is the average using US and UK employment weights in the crosswalk from O*NET into UK SOC 2010. Mean core green task share uses information from O*NET on the share of occupational tasks that are green.
SOURCE: Analysis of ONS, Labour Force Survey.

Annex 2: Additional regression results on the relationship between being in a green or brown job and various personal and worker characteristics

To test the relationship between key personal and work characteristics and the likelihood of working in brown and green jobs we have run a series of regressions, which are detailed below.

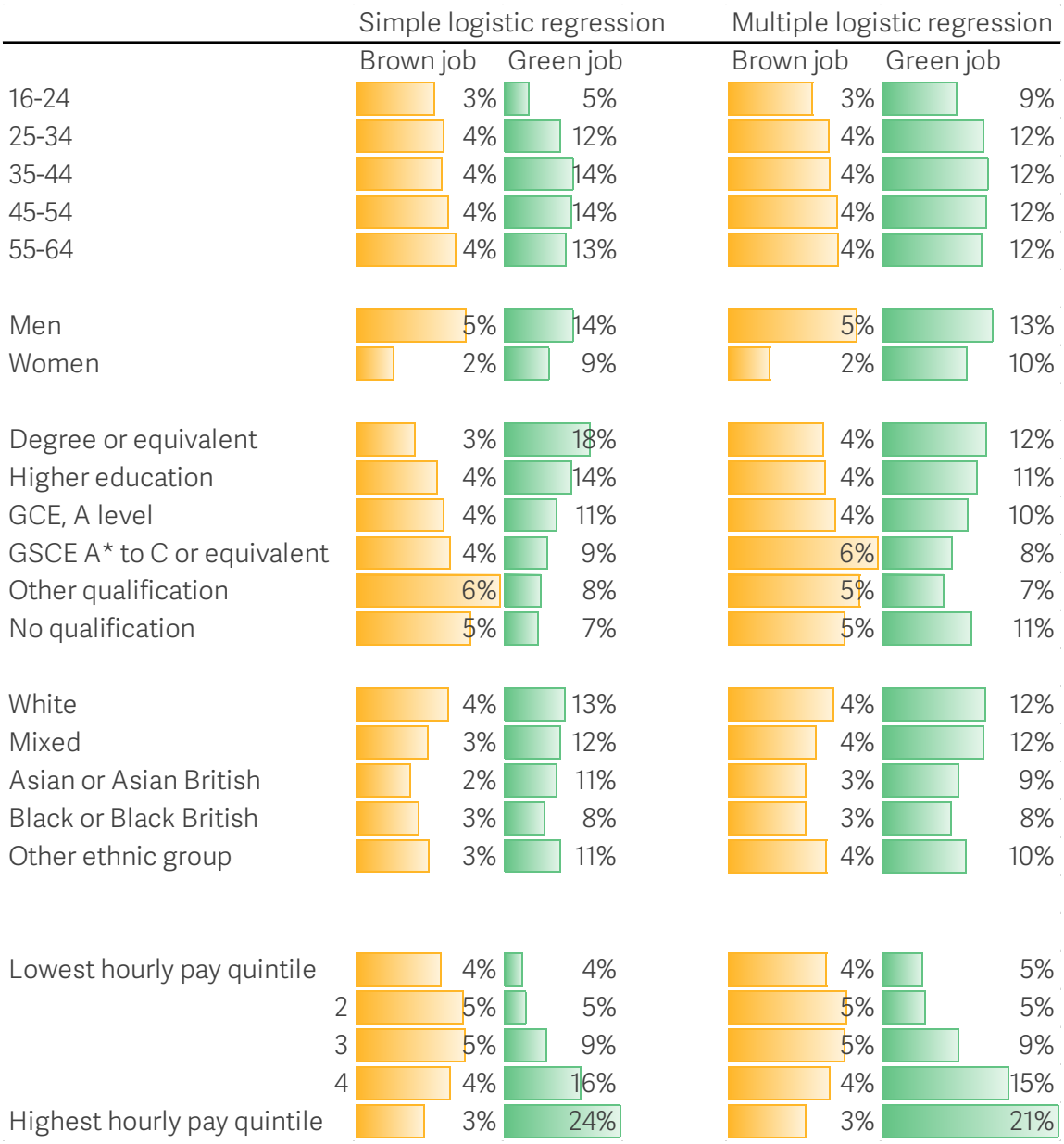
First, we ran separate simple logistic regressions looking at (i) whether a worker was in a green job and (ii) whether a worker was in a brown job, controlling for 3-digit industry, by age group, sex, qualification level, ethnicity and hourly pay quintile. The results of these regressions, as shown in Figure 22, confirm the same relationships that we observe in Figure 2 and Figure 3 suggesting that they are not explained by differences across sectors. After controlling for industry, binary logistic regressions show that the marginal prediction of being in a green job is 24 per cent for workers in the top earnings quintile to be employed in green job compared to just 4 per cent for workers in the bottom earnings quintile.

Second, we ran separate multiple logistic regressions looking at (i) whether a worker was in a green job and (ii) whether a worker was in a brown job, holding 3-digit industry, age group, sex, qualification level, ethnicity and hourly pay quintile constant, by age, sex, qualification, ethnicity, and pay. Including multiple right-hand-side variables somewhat dilutes the gender gap for those in green jobs but it does little to reduce difference between men and women working in brown jobs. With a range of personal and worker characteristics held constant, the relationship between pay and being in a green or brown job remains unchanged – green jobs are associated with being higher up the wage distribution whereas brown jobs are more likely to be middling on pay.

Third, we used Mincer wage regressions in order to investigate whether there is, in fact, a wage premium for green jobs. Mincer wage regressions allow us to investigate the relationship between being in a green job and having higher hourly pay, controlling for factors like education and years of experience. We find evidence of a green wage premium, which is smaller and less significant once we control for broad occupational groups (as illustrated in the third column in Figure 23). However, if we break broad occupational groupings into different skill levels we find that within some less skilled occupations green jobs tend to have an even higher premium. Overall then, we observe that workers in green jobs enjoy a wage premium even after controlling for a range of factors - though we should note unobservable characteristics that might influence both wages and the likelihood of workers being in green jobs cannot be controlled for here.

FIGURE 22: **After controlling for a range of factors, more-educated and higher-paid workers are more likely to work in green jobs**

Predicted share of green and brown jobs based on binary logistic regressions: UK, 2019



NOTES: Sample includes employed workers aged 16-69. Simple logistic regression just controls for industry (3-digit) fixed effects. Multiple logistic regressions control for industry (3-digit), age groups, quintiles of hourly pay, sex, ethnicity and qualification levels. Green jobs refer to 'core green task' jobs (based on a mapping of occupations from O*NET, see Box 1).
SOURCE: Analysis of ONS, Labour Force Survey.

FIGURE 23: **There is a wage premium for workers in green jobs**

Mincerian wage regressions: log wages and green jobs: UK, 2011-2019

Wages and the greenness of jobs in the UK			
	(1)	(2)	(3)
Green job	0.338***	0.248***	0.082**
	(0.043)	(0.034)	(0.035)
Female		-0.118***	-0.089***
		(0.011)	(0.007)
Degree		0.364***	0.203***
		(0.020)	(0.012)
Experience		0.027***	0.022***
		(0.002)	(0.002)
Experience squared		-0.000***	-0.000***
		(0.000)	(0.000)
N	362,758	362,330	362,330
Clusters	369	369	369
Industry	Yes	Yes	Yes
Occupation	No	No	Yes

NOTES: Sample includes employed workers aged 16-69. Labour Force Survey person income weights applied. All columns control for year, region (NUTS1) and industry (3-digit) fixed effects. Standard errors are clustered at the occupation level. *** denotes significance at the 1% level, ** 5% level and * 10% level. Green jobs refer to 'core green task' jobs (based on a mapping of occupations from O*NET, see Box 1).SOURCE: Analysis of ONS, Labour Force Survey.

FIGURE 24: **There is a wage premium for workers in green jobs in high skill and labour-intensive occupations**

Mincerian wage regressions: log wages and green jobs, by three broad occupational groups within which our binary green jobs indicator falls: UK, 2011-2019

Wages and the greenness of jobs in the UK, by occupation

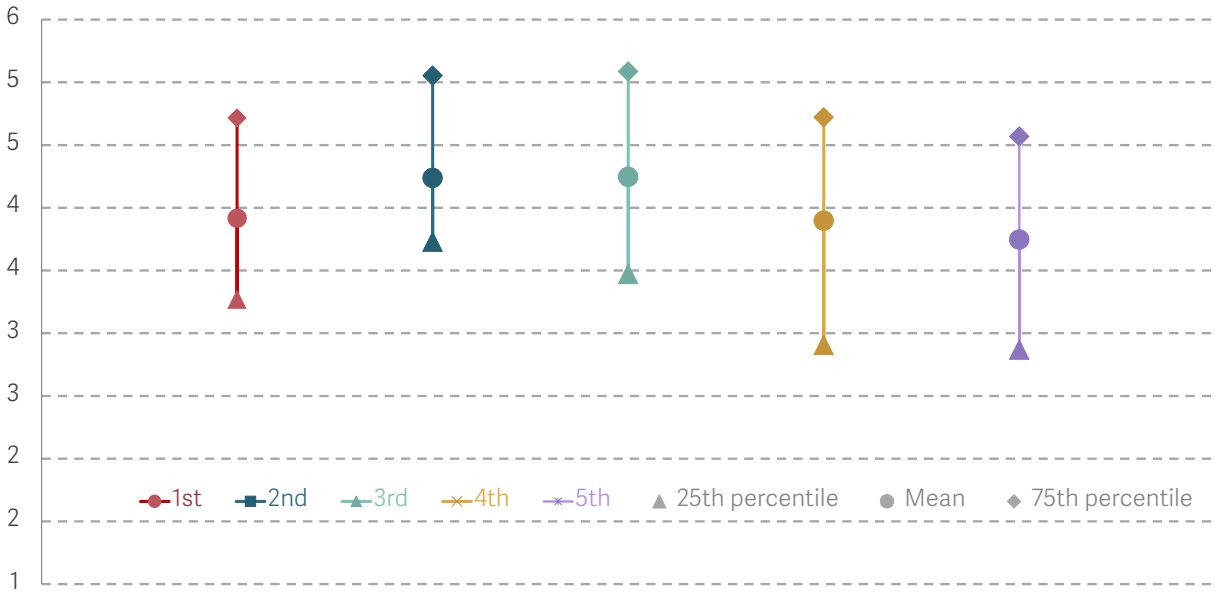
	(1)	(2)	(3)	(4)
	All	High skill	Middle skill	Labour-intensive
Green job	0.082**	0.087***	0.016	0.140***
	(0.035)	(0.030)	(0.025)	(0.013)
Female	-0.089***	-0.112***	-0.075***	-0.086***
	(0.007)	(0.011)	(0.014)	(0.012)
Degree	0.202***	0.287***	0.158***	0.065***
	(0.012)	(0.016)	(0.010)	(0.009)
Experience	0.022***	0.038***	0.027***	0.014***
	(0.002)	(0.001)	(0.001)	(0.001)
Experience squared	-0.000***	-0.001***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
N	365,095	165,562	71,116	61,672
Clusters	369	172	82	71

NOTES: Sample includes employed workers aged 16-69. Labour Force Survey person weights applied. High skill occupations consist of 1) managers, directors and senior officials, 2) professionals and 3) associate professional and technical occupations. Middle skill occupations are 4) administrative and secretarial and 5) skilled trades occupations. Labour-intensive occupations are 8) process, plant and machine operatives. All columns control for year, industry (3-digit) and region (NUTS1) fixed effects. Column (1) including occupation controls. Standard errors are clustered at the occupation level. *** denotes significance at the 1% level, ** 5% level and * 10% level. Green jobs refer to 'core green task' jobs (based on a mapping of occupations from O*NET, see Box 1).
SOURCE: Analysis of ONS, Labour Force Survey.

Annex 3: Additional figures

FIGURE 25: **Brown jobs in the middle pay quintiles are further away on average from green jobs**

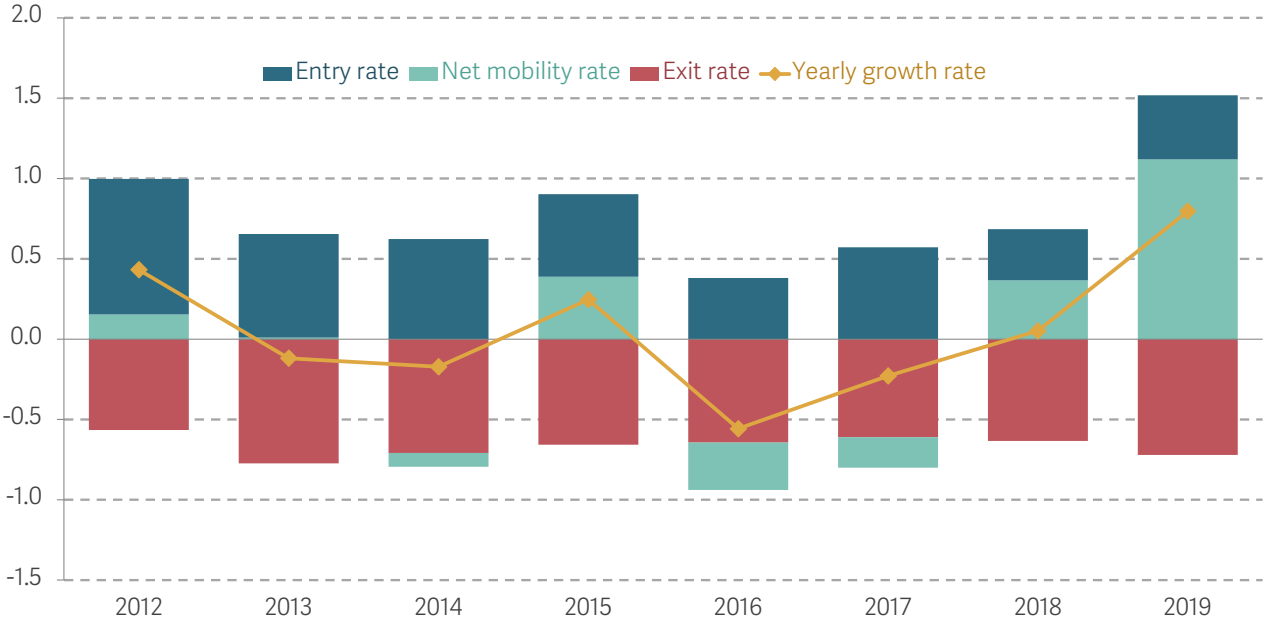
Distribution of average task-distance measures between brown and green jobs: UK, 2019



NOTES: Task distance measures are derived by combining differences in task intensity measures between four-digit occupations (see footnote). For each brown occupation observed in the data, we compute the average task-distance to all green occupations. We then compute the average, 25th and 75th percentiles across all brown jobs pertaining to workers in a given hourly pay quintile. Green jobs refer to 'core green task' jobs (based on a mapping of occupations from O*NET, see Box 1) and brown jobs refer to 'brown changer' jobs (occupations particularly prevalent in emissions-intense sectors, see Box 2).
SOURCE: Analysis of O*NET and Labour Force Survey.

FIGURE 26: **The limited growth in green employment has been driven by increases in workers moving from non-green to green jobs**

Contribution to annual change in share of green jobs made by workers entering or exiting employment and moving across green and non-green occupations (net mobility rate): UK, 2012-2019



NOTES: Green jobs refer to 'core green task' jobs (based on a mapping of occupations from O*NET, see Box 1).
SOURCE: Analysis of ONS, Five-quarter longitudinal Labour Force Survey.

THE ECONOMY 2030 INQUIRY

SHAPING A DECADE OF CHANGE

The UK is on the brink of a decade of huge economic change – from the Covid-19 recovery, to exiting the EU and transitioning towards a Net Zero future. The Economy 2030 Inquiry will examine this decisive decade for Britain, and set out a plan for how we can successfully navigate it.

The Inquiry is a collaboration between the Resolution Foundation and the Centre for Economic Performance at the London School of Economics. It is funded by the Nuffield Foundation.

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