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Briefing paper

Net-Zero Skills

Jobs, skills and training for the Net-Zero energy transition

UKERC
UK Energy Research Centre

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Acronyms & abbreviations

AEB	Adult Education Budget
BEIS	Department for Business, Energy and Industrial Strategy
CCC	Climate Change Committee
CCUS	Carbon Capture, Utilisation and Storage
DESNZ	Department for Energy Security and Net Zero
FE	Further Education
HEY LEP	Humber and East Yorkshire Local Economic Partnership
LCREE	Low Carbon Renewable Energy Economy survey
LEP	Local Economic Partnership
LSIP	Local Skills Improvement Plan
MCA	Mayoral Combined Authority
NRH	National Retrofit Hub
NSF	National Skills Fund
OWIC	Offshore Wind Industry Council
SIC	Standard Industrial Classification
SOC	Standard Occupational Classification
STEM	Science, Technology, Engineering and Mathematics
TVET	Technical and Vocational Education and Training
WMCA	West Midlands Combined Authority

Executive Summary

This briefing paper investigates the evidence for low-carbon jobs, training and skills requirements in the UK's energy system, with a deeper focus on Net-Zero skills in England. Through an extensive literature review and 10 interviews with experts and practitioners, it analyses how the skills landscape is adapting to support the growth of low-carbon energy sectors, including both energy supply and end-use. The paper identifies ongoing barriers and opportunities for expanding low-carbon job competencies, culminating in a set of policy recommendations to create clear, inclusive training pathways into low-carbon energy jobs.

The size of the low-carbon skills gap

The CCC has reviewed literature on Net-Zero impacts and estimates that between 135,000 and 725,000 net new jobs could be created in the UK by 2030 directly in low-carbon sectors (CCC, 2023). This wide range highlights uncertainties in estimates about the number of workers required to support the transition to Net-Zero. Nevertheless, the potential for low-carbon energy job creation is significant and even accounting for jobs displaced, is generally expected to be modestly net positive overall (Hanna, Heptonstall & Gross, 2024). A key issue is therefore ensuring that this job growth is achieved in a socially just and geographically balanced way.

Many sectors expected to contribute significantly to the 'greening' of the economy are already facing considerable skills gaps. Specifically, in renewable energy, building energy efficiency and manufacturing, skills have been recognised as a major bottleneck (Cedefop, 2018; Green Alliance, 2022; Reay, 2023). There is currently no national strategy in place to address these gaps and secure the hundreds of thousands of workers needed to transition to a Net-Zero energy system.

The **building energy retrofit** sector is experiencing a significant shortage of skilled workers (Reay, 2023). Research by Green Alliance highlights gaps in installers of heat pumps and energy efficiency measures, retrofit coordinators (responsible for ensuring compliance with procurement, specification, and delivery of measures in retrofit projects) and digital professionals (Green Alliance, 2022). Although an estimated 120,000–230,000 new jobs could be added to the sector by 2030 (CCC, 2023), attracting workers poses a challenge. Inconsistent, stop-start policies and funding streams have disincentivised private investment in skills and training (Hargraves, Karpathy & Griffin, 2022) and formal training for construction jobs continues to focus on skills for new builds and fossil fuel technologies (Energy Systems Catapult, 2021).

The **offshore wind** sector is forecast to employ at least 100,000 workers in 2030 but also faces various skills gaps (Aura, 2018; Green Jobs Taskforce, 2021; OWIC, 2023). The Offshore Wind Industry Council reports a need for electrical, digital, consenting (navigating regulatory and legal processes for obtaining project approval) and marine and port skills (OWIC, 2023). Given that the lead time for new entrants to reach competency through apprenticeships can be up to six years, the offshore wind sector will also need to rely on recruiting experienced workers, and those with transferable skills from other industries, such as oil and gas, to fill these gaps and avoid future shortages (HEY LEP, 2023).

Not all industrial decarbonisation can be achieved through direct electrification, and particularly across hard-to-abate industries, decarbonisation will depend on the development of **hydrogen and CCUS** sectors. Growth of these sectors is considered highly conditional, subject to the competitiveness of international markets, the availability of skilled labour, and levels of investment (CCC, 2023). Potential skills gaps have therefore not been identified. Reflecting these uncertainties, the CCC estimates that these industries could create between 1,500 and 97,000 new jobs by 2030 (CCC, 2023). The current offshore oil and gas workforce is expected to provide a large number of skills required in these sectors (Green Jobs Taskforce, 2021).

The Green Jobs Taskforce estimates that the **low-carbon transport** sector could create 78,000 new jobs by 2040, including 24,500 in battery manufacturing, 43,500 in the battery supply chain, and 10,000 in EV manufacturing (Green Jobs Taskforce, 2021). Many of these jobs will be contingent on the development of gigafactories, without which there could be job losses in vehicle manufacturing (CCC, 2023). Within the sector, the main skills gaps are in charging point installers and operators, vehicle scrappage and recycling experts, battery manufacturers and operators, and electrification engineers (Green Alliance, 2022).

Addressing the low-carbon skills gap

1. Taking stock of potential barriers

Skills transferability barriers. It has been estimated that 100,000 jobs in the UK's offshore energy sector will be filled by workers transferring from oil and gas into offshore renewable roles, and by new entrants from outside the sector (Robert Gordon University, 2021). There is debate, however, about how transferable skills across high- and low-carbon sectors actually are, and whether a

'topping up' of skills or more rigorous retraining will be required for those transitioning (Sato et al., 2023; Bowen, Kuralbayeva & Tipoe, 2018).

Monitoring and data barriers. Several studies on green jobs have highlighted data limitations when it comes to analysing green jobs and skills in the UK (Bowen, Kuralbayeva & Tipoe, 2018; Cardenas-Rubio et al., 2022; Sato et al., 2023; Strachan, Greig & Jones, 2022; Vona et al., 2018). For instance, Cardenas-Rubio et al. suggest that the Standard Industry Classification (SIC) and Standard Occupational Classifications (SOC) in the UK are too coarse in terms of providing detailed information on the exact tasks, skills and knowledge of any occupation (Cardenas-Rubio et al., 2022). A lack of sensitivity in SIC codes means that it is also difficult to understand what businesses do in terms of green and non-green economic activity (ibid).

Mobility barriers. Whether or not workers are able to take low-carbon jobs will depend on where and when existing jobs are being lost and new jobs become available. It will also depend on the supply of and demand for relevant training, which is likely to be unevenly distributed in terms of quantity and quality (Bray, Mejía Montero & Ford, 2022). If green jobs or re-skilling opportunities do not appear in areas where jobs have been phased out, workers will either have to lose out on opportunities, seek employment in other high-carbon sectors, or relocate, which risks reinforcing existing regional inequalities (Botta, 2018; Lim, Aklin & Frank, 2023; Sato et al., 2023).

Diversity barriers. The current energy sector is predominantly represented by white male workers (CCC, 2023). For instance, whilst there is limited data on ethnic diversity within the UK's energy sector, available statistics suggest that only 5% of the workforce comes from Black, Asian, and Minority Ethnic (BAME) backgrounds (Energy and Utility Skills, 2021). Unless active measures are taken to support underrepresented groups joining the Net-Zero energy workforce, occupational gender and ethnicity gaps are likely to persist (ILO, 2018).

Regional barriers. UK regions with a higher concentration of energy-intensive industries, such as the North East, Yorkshire and the Humber, and the West Midlands, stand a higher chance of being negatively affected by the transition. These regions are often also those whose economies have seen the least growth in recent decades (Aldersgate, 2020). As far as skills are concerned, they are also likely to have less capacity and resources to be able to provide adequate re-skilling support for workers who will need to transition into new jobs, or to provide training opportunities encouraging new people into low-carbon sectors.

2. Policy recommendations

Based on the discussion above, we set out a range of recommended actions that should be prioritised between now and 2050.

- To tackle the green skills gap, we need a coordinated national strategy. It is recommended that a new, independent statutory body be established to monitor, research and advise on the development of skills for Net-Zero. While accounting for similar or parallel initiatives in Scotland, Wales and Northern Ireland, this national 'Net-Zero Skills Commission' would:

  - develop a national Net-Zero skills strategy, accounting for now until 2050, with actionable, long-term plans for transforming the skills system to meet Net-Zero requirements. This would additionally include producing sectoral national skills plans, such as a National Retrofit Skills Strategy. A range of stakeholders would need to be included in this process, namely representatives from government, industry (including SMEs), local authorities, citizen groups, trade unions, education and training providers. This strategy should consider different regional, local and sectoral needs, and take into account how the skills aspect of the transition can be made socially inclusive.

  - review existing occupational standards for Net-Zero jobs, analyse and identify ongoing and emerging skills gaps, and provide expert advice on improving training and education pathways. This could include being mandated to release yearly progress reports against Net-Zero targets, providing recommendations for the Government to respond to.

  - review and update occupational metrics to include distinct classifications for low-carbon jobs and skills. This should involve developing detailed lists of associated skills and activities for defined occupational roles, and introducing new roles specific to green industries within existing data and classifications, such as the ONS LCREE survey, SIC and SOC.

- Private sector training organisations and collaborations have an important role to play in developing Net-Zero skills and providing training, and these can include innovative delivery models such as shared apprenticeship schemes and renewable energy community benefit funds. Clearer, more consistent and long-term policy support is needed to create conditions where employers are incentivised to commit to longer-

term training initiatives, thereby increasing the likelihood of prospective workers taking on training where they have higher confidence that employer demand exists.

- Current public financing mechanisms for skills, including the Apprenticeship Levy, the National Skills Fund, and the Adult Education Budget, should be reviewed to see how funding can be better directed towards the development of training for green jobs. Additional public funding should also be leveraged to support long-term development of skills for Net-Zero, specifically for FE colleges and training providers to be able to develop new, high-quality green courses and overcome low participation rates. There is also a case for targeted funding for SMEs who cannot afford to send staff to be trained or take on apprentices.

- To ensure that the skills being taught are flexible enough to respond to evolving industry needs, a 'greening' of the curricula will need to take place across the skills system. This means that FE college training courses for traditional, non-green jobs should consider how or which green skills may be relevant to both current and future roles and integrate these within teaching where possible. It also means that the current number of low-carbon FE courses will need to be significantly increased.

- Increased public investment in the development of regional centres of excellence is recommended. These centres can act as focal points for training, research, and development related to Net-Zero jobs and skills, and help to ensure that opportunities for scaling up the low-carbon workforce are more evenly geographically distributed.

- Training and education providers will need to consider possible labour mobility and accessibility limitations faced by individuals aspiring to join the Net-Zero workforce. Ensuring there are locally present, flexible opportunities to learn will help to address these challenges. More specifically, this could include developing more training courses which include hybrid in-person or online teaching methods and are delivered at flexible times, as well as introducing more modular courses or micro-credentials for those who only need a topping up of existing skills.

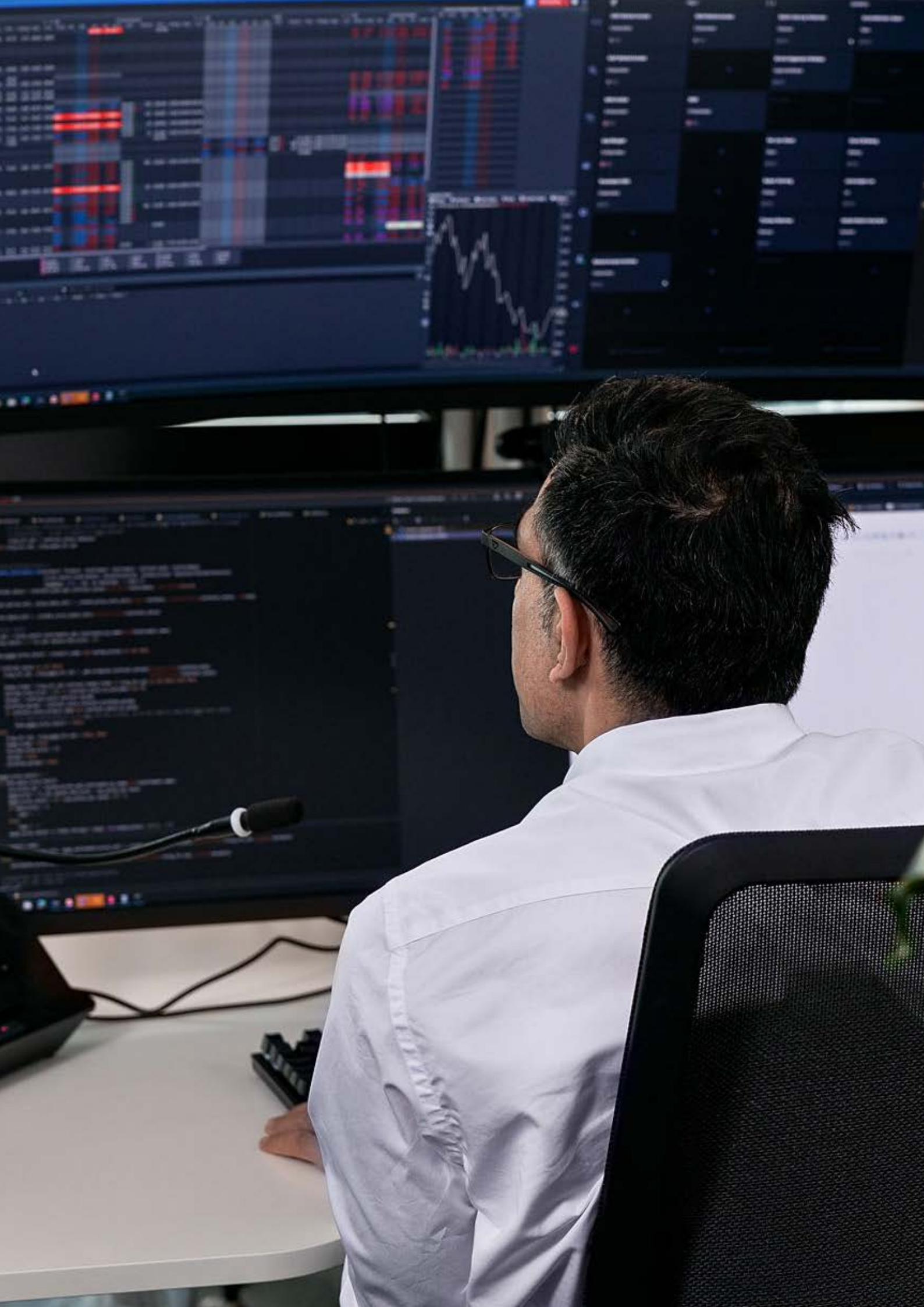
- For people working in industries which will need to be phased down, ready access to high-quality re-skilling programmes will be important. Closer links between sectors expected to be displaced, such as oil and gas, and sectors expected to grow, will help to create clear and direct routes into new jobs. Additional financial support should be made available for overcoming barriers to re-skilling, such as paid time off for taking on training, sabbaticals, and skills vouchers.

In cases where employment termination is inevitable, just termination packages, early dismissal notices, and early access to re-skilling opportunities should be provided. It is also recommended that workers who stand to be affected are involved in the transition planning process.

■ To increase public awareness of green job opportunities and career pathways, engagement with local and regional community groups and schools (e.g. through media campaigns, workshops and talks) is recommended. This could help to demystify what is meant by 'green jobs', and stimulate more public interest in joining local, low-carbon industries.

■ To attract a wider pool of talent, green sectors should be inclusive and respectful places to work, where underrepresented groups are not liable to be discriminated against. The Green Jobs Taskforce report presents possible avenues for improving recruitment practices, including through diverse representation in recruitment panels, introducing anonymous application forms, creating a culture of inclusivity within organisations, and providing diversity and inclusion training for leaders and recruitment teams (Green Jobs Taskforce, 2021).

■ Systematically creating a more diverse workforce will also require more detailed labour market information and data collection. Metrics related to gender, ethnicity, and social background should be included, published, and regularly updated within industry and government surveys. This would provide a clearer understanding of where targeted interventions for diversifying the workforce could be implemented across different sectors, at varying levels of governance, including local, regional and national, as well as training providers and industry.



Section 1. Introduction

The UK has set goals to reach Net-Zero emissions by 2050, including an interim target of reducing greenhouse gas emissions by 78% from 1990 levels by 2035 (BEIS, 2020b; UK Parliament, 2019), and a national mission to achieve zero carbon electricity by 2030 (DESNZ, 2024d). Decarbonising the economy at the magnitude and pace required to meet these targets will require a transformation of the energy system, including a restructuring of energy infrastructure and labour market dynamics (Briggs et al., 2022; Fragkos & Paroussos, 2018). For low-carbon energy sectors such as renewables, energy-efficient buildings, and low-carbon transport, the transition to Net-Zero is generally considered an opportunity to generate moderate net growth in employment (Hanna, Heptonstall & Gross, 2024; CCC, 2023); overall, the CCC estimates that between 135,000 and 725,000 green jobs could be created in the UK (CCC, 2023). The transition could also help to overcome regional inequalities across the country by providing opportunities for economic growth in historically disadvantaged areas (Aldersgate, 2020; Green Jobs Taskforce, 2021; Sato et al., 2023).

Internationally, addressing insufficient skills and knowledge in the labour force is a key priority for action to deliver a low-carbon transition to Net-Zero energy systems (IET, 2023). Responding to this challenge, the US Inflation Reduction Act (IRA) and the EU Green Deal include large-scale investment programmes, legislation and policies to develop low-carbon energy supply chains and skills, and support a just transition to quality jobs (Bustamante & Peck, 2024; Williams et al., 2022; European Commission 2023a & b). Growth of the Net-Zero energy workforce is, however, not a given. Above all, a transition that is 'fast but fair' can only take place if the labour market is primed to adapt accordingly (Briggs et al., 2022). The actual rate at which the workforce is able to develop will therefore depend on additional factors, including labour market flexibility and labour market mobility (which relate to the size and skills profile of the workforce, as well as how easily workers are able to move or relocate to access new jobs), and the availability of training and skills (García-García, Carpintero & Buendía, 2020; Fragkos & Paroussos, 2018). Despite analyses which anticipate net employment growth, reaching the point where there are enough skilled people working in the industries needed to sustain a Net-Zero energy system will not be straightforward (Bray, Mejía Montero & Ford, 2022). Many of the sectors which are expected to significantly contribute to the 'greening' of the economy are already experiencing considerable skills gaps (Christie-Miller & Luke, 2021; Green Jobs Taskforce, 2021; Green Alliance, 2022; Reay, 2023). Specifically, in renewable energy, buildings, energy efficiency, and manufacturing, skills are recognised as a major bottleneck (Cedefop, 2018). This may lead to critical delays in technology development and deployment, increasing the likelihood of projects being scrapped and targets being pushed back.

Skills also emerge as a central feature of a just Net-Zero transition (Balata et al., 2023). In the UK, the transition will not be experienced evenly, and a key determinant of the social, environmental and financial costs will be the ability to meet new skills requirements (Mattos, 2018). In regions with high-carbon industrial clusters, for instance, whole swathes of existing roles will disappear as industries are phased-down, and, if workers are not provided with tailored support and re-skilling opportunities, they risk being severely disadvantaged (Diski, Chapman & Kumar, 2021). Similarly, if training programmes for low-carbon jobs are not developed and promoted with a focus on inclusivity, the emerging and future low-carbon workforce is at risk of replicating the same low levels of gender and racial diversity found in traditional energy sectors (ILO, 2018).

The availability of clear training pathways, providing individuals from all backgrounds, but particularly those in transition-vulnerable jobs, with the skills to access just, green jobs, will be key to ensuring a transition which is both effective and inclusive. Where these are created in time, the transition could become a catalyst for raising living standards for regions and communities, and for generating new sustainable employment opportunities across the country (Green Jobs Taskforce, 2021). Additionally, it could allow the UK to benefit earlier from the productivity gains associated with a low-carbon economy (Green Alliance, 2022).

Aims and approach

It is documented that the transition to Net-Zero could provide a moderate net growth in green jobs (Hanna, Heptonstall & Gross, 2024), but the skills requirements associated with this potential growth are comparatively under-researched. The aim of this briefing paper is therefore to investigate the evidence for low-carbon jobs and skills requirements in the UK's energy system, based on a review of existing literature and findings from expert interviews. It first provides an overview of key sectors involved in the energy transition, assessing their current workforce and skills status. It follows by providing an overview of the skills and training landscape with a focus on England, discussing relevant policies and highlighting approaches currently taken at national and regional levels to promote green skills. Using three illustrative sectoral case studies, it then investigates challenges and opportunities for improving the supply of, and demand for skills and training for low-carbon energy careers. Findings are then discussed in further depth, and a range of policy recommendations are provided.

The following questions were developed to guide this research:

Theme	Guiding Question
Skills and training for the low-carbon energy workforce	What approaches are currently being used (nationally, regionally and locally) to develop skills and competencies?
	What are the key current and emerging skills gaps?
	What are the main barriers to developing effective training?
	What might a national Net-Zero skills strategy look like?
Investment	What are the considerations around cost-effective investments for low-carbon training and skills?
Data	What are the data requirements for evaluating and monitoring progress related to low-carbon jobs and skills?

Relevant evidence was gathered using a Rapid Evidence Assessment (REA) methodology, which involves a 'short but systematic assessment on a constrained topic' (Speirs, Gross & Heptonstall, 2015). Academic literature was drawn from Web of Science, Science Direct, and Google Scholar. UK Government websites and Google were consulted to find grey literature[1] . Ten semi-structured interviews with UK-based industry professionals and academics were used to gain additional insight where there was an identified gap in the literature[2]. This briefing paper is divided into five sections:

Section 2 provides an overview of sectors involved in the transition to a Net-Zero energy system in the UK, including those related to energy supply and energy end-use. For each sector, it highlights ongoing Net-Zero policy targets and regulations in place and compares the current size of the workforce to estimates about future workforce needs.

Section 3 discusses the skills and education policy landscape in the UK with a deeper focus on England, first providing an overview of the skills system, then highlighting key weaknesses in how skills-related responsibilities are currently delegated. Following this, it presents examples of

[1] See Appendix 1 for the table of keywords used during the REA search.

[2] See Appendix 2 for the list of interviewees.

approaches being taken at national, regional and local scales to provide training and skills for low-carbon energy jobs.

Section 4 considers ongoing and emerging barriers to developing a skilled, low-carbon energy workforce. It also spotlights the negative socio-economic impacts the transition may have if these barriers are not addressed in time.

Section 5 presents three sectoral case studies. This includes one case study on building retrofit, which is assessed through a national lens, and two regionally focused case studies, including one on electric vehicle manufacturing in the West Midlands, and one on offshore wind in Yorkshire and the Humber. Each highlights sector-specific challenges to growing the workforce and concludes with a series of recommendations for improving training and skills provision with a series of recommendations for improving training and skills provision.

Section 6 summarises overall findings and discusses a range of opportunities which could help to create clear, inclusive training pathways into low-carbon energy jobs. It concludes with a series of recommendations.

Box 1. What is a green job?

Whilst there is no universal definition for green jobs, a range of studies have sought to define them according to different levels of granularity. The Green Jobs Taskforce sets out that a green job is employment in activity which directly or indirectly supports the attainment of Net-Zero and other environmental objectives, including nature restoration and mitigating against climate risks (Green Jobs Taskforce, 2021). The Paris Agreement (UNFCCC 2015) recommended that the low-carbon transition should ensure a just transition by creating 'decent work' and quality jobs. Accordingly, the International Labour Organisation contended that green jobs should be just employment, i.e. extending beyond the scope of 'green' in a purely environmental sense to include considerations about job safety, job security, wages, and worker rights (ILO, 2018). Since only a small portion of jobs may in practice comprise entirely green tasks, it is more correct to consider any employment based on the extent to which it is green, known as 'greenness'. Therefore, it is possible to measure the greenness of industries, occupational categories, and specific tasks, amongst other aspects (Bowen, Kuralbayeva & Tipoe, 2018; Sofroniou & Anderson, 2021; Stanef-Puică et al., 2022; Valero et al., 2021; Saussay et al., 2022; Curtis & Marinescu, 2022).

Section 2. UK energy sectors and workforce needs

The Net-Zero transition will fundamentally transform how buildings are heated, how electricity is generated, and how transport is fuelled. The CCC has reviewed literature on Net-Zero impacts and estimates that between 135,000 and 725,000 net new jobs could be created in the UK by 2030 directly in low-carbon sectors[3] (CCC, 2023). This section provides an overview of workforce requirements across the low-carbon energy landscape in the UK. This includes a look at key low- and high-carbon sectors supporting the current energy system.

The 'energy system' — adopting a comprehensive scope

The IPPC suggests that a broader view of the 'energy system', which considers the influence of societal and institutional factors and includes both energy supply and end-use sectors, is essential for developing mitigation strategies and progressing towards Net-Zero energy systems (IPCC, 2023). Whilst there is no fixed definition of a 'Net-Zero energy system', the IPCC lists the following as common characteristics (ibid):

- an electricity system that either produces no net CO_2 or removes CO_2 from the atmosphere
- electrification of end-uses
- substantially lower use of fossil fuels
- use of alternative energy carriers such as hydrogen, bioenergy, or ammonia to substitute for fossil fuels in sectors less amenable to electrification
- more efficient use of energy than at the present day
- greater energy system integration across regions and components of the energy system
- use of CO_2 removal to offset any residual emissions

Whilst this briefing paper does not attempt to draw a specific boundary around all the sectors which interact with the current energy system and which may play a role in a future Net-Zero energy system, it follows the IPCC's suggestion of adopting a broad definitional scope. Therefore, herein, both the UK's energy supply sectors (encompassing primary energy, conversion, and transmission

[3] This wide range highlights uncertainties in estimates about the number of workers required to support the transition to Net-Zero.

processes) and the energy end-use sectors (including transport, buildings, and industry) are included as part of the energy system.

In particular, this briefing paper focuses its attention on sectors which will undergo transformation in the transition to Net-Zero. This includes low-carbon sectors which will require large-scale workforce and infrastructural growth, and high-carbon sectors which will need to be phased down and/or significantly transformed. This includes the following sectors:

- low-carbon energy supply sectors, including wind, solar PV, nuclear, CCUS (carbon, capture, utilisation and storage) and hydrogen, and energy storage and demand response
- low-carbon heat and energy efficiency sectors, including building retrofit, heat pumps and heat networks
- low-carbon transport sectors, including electric vehicle (EV) and battery manufacturing, and electric railway networks; high-carbon energy sectors, including oil and gas, and energy-intensive manufacturing

These low- and high-carbon sectors are analysed in further detail below. For each, a discussion of ongoing Net-Zero policies and targets, considerations related to growth (e.g. how conditional growth is), current workforce numbers, and future workforce estimates are provided. Evidence on ongoing skills gaps or future skills requirements is also included where it has been identified in the literature.

Table 1 provides an overview of current and future workforce estimates for various energy sectors. Estimates about current and future workforce requirements in low-carbon sectors are wide-ranging, and often show discrepancies depending on methodologies and definitions used. Therefore, this table is provided to give a sense of the scale and pace at which different sectors may need to grow on the pathway to achieving Net-Zero.

Table 1: Current and future workforce estimates for sectors in the UK low-carbon energy system (see Appendix 3 for data sources).

Sector	Current workforce (2022/2023)		Forecast future workforce (Total jobs unless specified)[2]				
	Total	Direct and/or indirect jobs?[1]	2030	2043	2043	2050	Direct and/or indirect jobs?[1]
Offshore wind	32,000	17,400 direct and 14,850 indirect	100,000 – 120,000				56,300 direct and 48,100 indirect
Onshore wind	6,600	direct	27,000 (new jobs)				27,000 directly in construction and installation; 30,000 during wind farm operation (i.e. beyond 2030).
Solar PV	9,000	direct				12,400	Unspecified
Nuclear[3]	23,100 - 44,850	direct and indirect (higher estimate includes supply chain)			33,200 - 48,600		direct and indirect: includes supply chain
Hydrogen[4]	1,600	direct	12,000				direct: includes domestic and export markets
Carbon capture (utilisation) and storage (CCS / CCUS)[5]	800	direct (CCS)		10,000			direct (CCUS): domestic market only
Energy storage, smart systems and flexibility[6]	5,600	direct (energy storage)					direct: 10,000 in domestic market, 14,000 in export opportunities
Energy efficiency and low-carbon heating[7]	154,200	Direct	120,000 — 230,000 (new jobs)				Direct
Low-emission vehicles and supporting infrastructure[8]	34,800	direct	80,000 — 100,000 (new jobs)				direct: electric vehicle and battery manufacturing
Oil and gas (energy supply and refining)	120,500	26,000 direct and 94,500 indirect	15,000 (displaced jobs)				Unspecified

Notes to Table 1

[1]Direct employment refers to jobs that arise directly as a result of an investment, whilst indirect employment commonly refers to jobs created within the supply chain supporting a specific project (Hanna, Heptonstall & Gross, 2024).

[2] Future workforce estimates are shown for years where this information was available in the literature reviewed.

[3]Nuclear current workforce is for civil nuclear only, based on ONS (2024) and Nuclear Skills Delivery Group (2023). Lower range excludes decommissioning and waste processing; upper range includes ongoing decommissioning.

[4]Hydrogen current workforce includes alternative fuels for low carbon and renewable energy, excluding bioenergy, compressed natural gas and liquefied petroleum gas.

[5]CCS / CCUS: 2040 figure is for domestic business opportunities. Export markets are projected to contribute an additional 62,700 jobs in 2040, significantly higher than domestic CCUS jobs.

[6]Current workforce for energy storage includes energy storage systems, batteries and fuel cells. Future workforce includes electricity storage, vehicle to grid and smart vehicle chargers.

[7]"Energy efficiency" includes energy efficient lighting, energy efficient products and energy monitoring, saving or control systems. "Low-carbon heating" includes renewable heat and renewable combined heat and power.

[8]"Low-emission vehicles and supporting infrastructure" includes design and manufacture of hybrid vehicles, electric vehicles, fuel cell vehicles, and installation of supporting infrastructure. Excludes fuel-efficient, conventional vehicles.

2.1 Low-carbon energy supply

A rapid increase in renewable energy production will be needed to achieve the UK's clean power by 2030 target (DESNZ, 2024d), and meet competing demands for electrification of heating, transport, and industry. In the UK, the renewable energy mix is made up of four main sources: wind, solar PV, hydroelectricity and bioenergy. In 2022, 40% of the UK's electricity supply came from renewables—a five-fold increase compared to 2010 (Staffell & Jansen, 2023). The latest Office for National Statistics (ONS) data from the Low Carbon and Renewable Energy Economy Survey (LCREE) suggests that 272,400 people were employed in the sector in 2022, with a turnover of £69.4 billion (ONS, 2023). The CCC estimates that renewables and nuclear power could create between 2,500 and 95,000 direct jobs by 2030 (CCC, 2023).

2.1.1 Wind power

Offshore wind

The UK is a global leader in offshore wind energy, with almost 15GW of capacity installed (DESNZ, 2024e; UKRI, 2024). In 2022, the British Energy Security Strategy introduced a new target of 50 GW of offshore wind capacity by 2030 (BEIS, 2022a), subsequently raised to 60GW by the incoming government (Scott, 2024). Expanding offshore wind capacity to at least 50GW would have a significant impact on demands for equipment and services required to develop, construct, and operate offshore wind farms (OWIC, 2023). The offshore wind power sector employed around 32,000 workers in 2022, and it has been estimated that this workforce would need to expand to around 100,000 - 120,000 by 2030 to reach 50 to 60GW (OWIC, 2023).

Several reports have highlighted ongoing skills needs in the sector (Aura, 2018; Green Jobs Taskforce, 2021; HEY LEP, 2023; OWIC, 2023). The Green Jobs Taskforce report highlights an increased need for workers across all stages of the project lifecycle, including design, manufacturing, construction, installation, operations and maintenance (Green Jobs Taskforce, 2021).

[4] The CCC's wide range is driven by assumptions about technology mix and deployment levels, with the lower boundary representing jobs from investment into 35GW of onshore wind and the upper boundary representing investment into 130GW.

The Offshore Wind Industry Council (OWIC) draws attention to several ongoing skills gaps (OWIC, 2023):

- high-level electrical skills
- digital skills e.g., data analysts, scientists and engineers with an understanding of data analysis and presentation
- consenting skills (navigating regulatory and legal processes for obtaining project approval) particularly amongst Statutory Nature Conservation Bodies (SNCBs) and regulators
- marine and port-oriented skills.

Onshore wind

Onshore wind in the UK has a total installed capacity of 15.5 GW, an increase in over 10GW since 2010 (Rankl, 2024). The rate of its growth has slowed dramatically in recent years, however, due to changes in planning policy for onshore wind projects introduced in 2015. While only two onshore wind projects were built in 2022 (Renewable UK, 2023), the Government has recently reversed previous planning constraints and committed to doubling onshore wind by 2030, equivalent to a total capacity of 30GW (MHCLG, 2024).

ONS LCREE data suggests that the onshore wind sector directly employs a total of 6,600 people (ONS, 2023). Renewable UK estimates that, to reach 30GW of onshore wind by 2030, 27,000 full-time jobs would need to be created in construction and installation, with a further 30,000 long-term jobs created throughout the operation of the wind farms (Renewable UK, 2021). Research into requirements for meeting Scotland's ambitions for 20 GW of onshore wind by 2030 suggests that the workforce will need to reach 20,500 workers in 2027 (Morrison et al., 2024).

There is scant literature on skills gaps within the UK's onshore wind sector. Morrison et al. identify a current shortage of skilled planners and specialist environmental consultants in Scotland, and estimate that in the future there may be a significant shortage of workers in technical roles, particularly high-voltage engineers and wind turbine technicians (Morrison et al., 2024).

2.1.2 Solar PV

Solar PV is one of the cheapest sources of new-build power generation and, following the CCC's balanced pathway, could provide 10–15% of total power generation in the UK by 2050 (CCC, 2020a). Currently, the UK has 15 GW of solar PV installed capacity (DESNZ, 2024), with a target to increase capacity nearly fivefold, to 70 GW, by 2035. This target has been supported by the Solar Taskforce, including through development of a strategic roadmap for increased solar PV deployment (DESNZ, 2023c). The ONS LCREE survey estimates that there are 9,000 workers in the industry (ONS, 2023). Industry forecasts from the Renewable Energy Association suggest that by 2050, the UK's solar PV industry could support 12,400 jobs (Renewable Energy Association, 2023).

2.1.3 Nuclear

The recent release of the Civil Nuclear Roadmap to 2050 sets out the Government's ambitions to quadruple the current nuclear energy capacity to 24 GW by 2050 (DESNZ, 2024a; Moustafa et.al., 2024). The Nuclear Skills Delivery Group reports that the civil nuclear workforce is currently made up of almost 45,000 employees including the supply chain (Nuclear Skills Delivery Group, 2023). It is estimated that up until 2043 the civil nuclear workforce will remain relatively stable, growing modestly to 48,600 employees (ibid).

Skills considered 'fragile' on the basis of possible shortages include civil engineers, pipe welders, pipe fitters, mechanical fitters, electricians, and project planners amongst others (Nuclear Skills Strategy Group, 2021).

2.1.4 CCUS and Hydrogen

CCUS

There are not yet any commercial applications of CCUS in the UK, although it is expected to play a central role in decarbonising hard-to-abate sectors, producing low-carbon electricity and hydrogen, and removing existing CO_2 from the atmosphere (Serin et al., 2021). To this end, the Government has invested £1 billion in the establishment of two CCUS clusters by the mid-2020s and two more clusters by 2030 (DESNZ, 2024f). The Government has previously estimated that such investment could support 10,000 jobs domestically by 2040 (BEIS, 2019a).

Hydrogen

The UK government estimates that reaching its ambition for up to 10 GW of low-carbon hydrogen capacity by 2030 could generate 12,000 jobs in production, transport and storage, including domestic and export markets (DESNZ, 2024f). Interim targets for hydrogen include reaching 1 GW of CCUS-enabled, and up to 1 GW of electrolytic hydrogen capacity by 2025. The pipeline for electrolytic hydrogen includes 11 new commercial scale projects (DESNZ, 2024b).

Growth of hydrogen and CCUS industries in the UK is highly conditional (CCC, 2023). Although the UK's continental shelf accounts for approximately a quarter of Europe's CO_2 storage potential, how well these industries are able to develop will depend on the competitiveness of international markets, the availability of skilled labour, and levels of investment. Reflecting these uncertainties, the CCC therefore estimates that the development of a CCUS and hydrogen economy in the UK could create between 1,500 and 97,000 new jobs by 2030 (CCC, 2023).

Since both CCUS and hydrogen are still considered emerging sectors, the gaps in existing and new skills needed are undocumented. Subject to re-skilling options, the current offshore oil and gas industry is expected to provide a large number of competencies required in these sectors (Green Jobs Taskforce, 2021).

2.1.5 Energy storage and demand response

Energy storage and demand response improve energy system flexibility by increasing alignment between renewable energy generation and demand. To this end, the Government estimates that to support 40 GW of wind in the system by 2030, 30 GW of low-carbon flexible assets (including storage, demand response and interconnection) will be needed to ensure energy security (BEIS, 2021d). It has also been estimated that flexibility from technologies including electricity storage, vehicle to grid and smart vehicle chargers could support 24,000 jobs by 2050, across domestic and export markets (BEIS, 2019b).

2.2 Low-carbon heat and energy efficiency

2.2.1 Building energy retrofit

The Government has committed to ensuring as many homes as possible are rated EPC Band C standard and above by 2035 (BEIS, 2017). It has also pledged to reduce energy consumption from buildings and industry by 15% by 2030 (BEIS, 2022b). This latter target was initially led by the Energy Efficiency Taskforce, which was disbanded in late 2023 (DESNZ, 2023d), six months after forming, underlining continuing uncertainty in national policies for building energy renovation.

In 2023, the Great British Insulation Scheme (GBIS) was also introduced. This £1 billion government scheme aims to help 300,000 households across the country with the cost of installing new home insulation until 2026 (DESNZ, 2024c). It has been estimated that the installation of energy efficiency measures and low-carbon heating systems could support between 120,000 and 230,000 new, direct jobs in the building energy retrofit sector by 2030 (CCC, 2023). According to the Construction Industry Training Board (CITB), reaching Net-Zero targets for the building sector would have required 12,000 workers a year to be trained from 2021 to 2024, and then 30,000 a year from 2025 to 2030 (CITB, 2021).

The building energy retrofit sector is experiencing a significant shortage of skilled workers (Reay, 2023). Literature highlights various gaps, including installers of heat pumps and other energy

efficiency measures, retrofit coordinators (responsible for ensuring compliance with procurement, specification, and delivery of measures in retrofit projects), and digital professionals (Green Alliance, 2022). A skills forecast project by the Energy Systems Catapult identified the following four priority gaps (Energy Systems Catapult, 2021):

- property assessment
- advice and customer care
- low-carbon heating installation
- technology integration

2.2.2 Heat pumps

The Government's Ten Point Plan for a Green Industrial Revolution announced a target of 600,000 heat pumps to be installed per year by 2028 (BEIS, 2020a). This target is still in place, although the Government has since pushed back the phase-out date for oil and LPG boilers from 2026 to 2035 (GOV UK, 2023).

The Heat Pump Association (HPA) suggests that around 50,000 heat pump installers will be needed by 2030 to install one million heat pumps per year (Heat Pump Association, 2020), i.e. one for every 20 heat pumps fitted. According to figures from the Microgeneration Certification Scheme (MCS) database, in 2023, there were 4,000-5,000 MCS-certified heat pump installers (MCS, 2023). There are signs that this number is accelerating at pace, with the latest industry data from HPA suggesting that there are an additional 11,000 individuals in the UK now qualified to install heat pumps (Heat Pump Association, 2023).

The Green Jobs Taskforce report describes a potential mismatch between skills for installing conventional heating systems and skills for installing heat pumps, explaining that heat pump installation also requires knowledge in heat loss calculations, hydraulic balancing, flow temperature calculations and heating system sizing (Green Jobs Taskforce, 2021).

2.2.3 Heat networks

Heat networks are set to play a growing role in the supply of low-carbon heat to homes, non-domestic buildings and the public sector. Following the CCC's Balanced Net-Zero Pathway, 20% of heat could be distributed through heat networks by 2050 (CCC, 2020b). According to the Heat Network Industry Council, this would require £60–£80 billion in investment and could create 30,000 jobs across the UK (Heat Network Industry Council, n.d).

2.3 Low-carbon transport

Transport accounted for 34% of CO_2 emissions produced in the UK in 2022 (DESNZ, 2023a). The switch to a low-carbon transport system will therefore be one of the most important actions to enable the transition to Net-Zero.

2.3.1 Electric vehicle and battery manufacturing

The previous government delayed the phase-out date for internal combustion engine (ICE) vehicle sales from 2030 to 2035, risking an adverse impact on the volume of new electric car sales in the UK (CCC, 2023). It decided to proceed with the Zero Emission Vehicles mandate, first introduced in the 2021 Net Zero Strategy. This mandate sets annual targets for vehicle manufacturers, who will now have to ensure that 80% of new car and van sales are zero emission by 2030 (DfT, 2024).

Despite inconsistent national policies governing the industry, it has been estimated that there could be 78,000 new jobs in low-carbon transport by 2040, although this would depend on the UK's automotive sector being able to keep pace with global trends (Green Jobs Taskforce, 2021). An expected 24,500 of these jobs would be in battery manufacturing, 43,500 in the battery supply chain, and around 10,000 in EV manufacturing (ibid). The CCC presents a higher forecast of up to 100,000 new jobs by 2030 created directly in EV and battery production, estimating that nearly 20,000 of these jobs could come from the development of ten battery gigafactories in the UK (CCC, 2023). There could be job losses in the vehicle manufacturing industry if these gigafactories are not developed (ibid).

The exact skillsets which will be needed in the EV manufacturing sector are still unclear, partly due to a lack of granular data, and partly because these depend on the extent to which the manufacturing supply chain is able to remain within the UK. One report finds that in the transition to EV production, there will still be a demand for skilled workers in the operative production of vehicles and parts (Herrmann et al., 2020). However, 10–30% of these types of skilled jobs found in ICE vehicle production systems may disappear (ibid). Green Alliance suggests that the main skills gaps are in charging point installers and operators, vehicle scrappage and recycling experts, battery manufacturers and operators, and electrification engineers (Green Alliance, 2022).

Considering employment needs in a gigafactory, the Green Jobs Taskforce estimates that production operators and equipment technicians would account for 75% of the workforce, and the remaining 25% would need higher-level qualifications, such as graduate level skills (Green Jobs Taskforce, 2021).

2.3.2 Electric railway networks

The Government plans to remove all diesel-only trains, including passenger and freight, from the network by 2040 (DfT, 2021). The track is already 38% electrified, with the development of hydrogen-based electricity expected to accelerate this process (Office of Rail and Road, 2023). The Rail Delivery Group (RDG) estimates that decarbonising rail could support an average of 6,000 jobs per year between 2024 and 2050 through the roll out of electrification and assembly of rolling stock, as well as in the supply chain, through the manufacturing of components and procurement of renewable energy (Rail Delivery Group, 2021).

2.4 High-carbon energy

2.4.1 Fossil fuels

The UK's energy mix is set to become increasingly less dependent on fossil fuels. The UK fossil fuel sector is geographically concentrated, clustered primarily around the North Sea, and is already being phased down (CCC, 2023), with the planned closure of Grangemouth oil refinery recently confirmed (Geddes, 2024). There are currently 26,000 direct workers (almost 95,000 indirect employees) across the oil and gas industry, and 15,000 of these could see job losses by 2030 (CCC, 2023; Experian 2024).

The 2021 North Sea Transition Deal commits to supporting these workers to retain high-quality jobs across the supply chain, for instance, by providing re-skilling opportunities in the CCUS and hydrogen sectors (BEIS, 2021c). Specifically, roles such as pipe designers and fitters, leak test technicians, and offshore barge operators could move to CCUS (Green Jobs Taskforce, 2021). The Deal also notes, however, that there is a wide range of uncertainties which could impact the delivery of new jobs and re-skilling opportunities. These uncertainties may reflect 'unknowns' such as the rate and scale at which the CCU and hydrogen industries in the UK are able to develop (CCC, 2023).

Research by Robert Gordon University estimates that over 90% of the UK's oil and gas workforce have medium to high skills transferability and are well positioned to work in other energy sectors (Robert Gordon University, 2021). Specifically, they suggest high levels of transferability to decommissioning and subsea network projects, and medium transferability to offshore wind, CCUS, and blue hydrogen (ibid). The success of these job transitions will also be contingent on clear access points into new sectors.

2.4.2 Energy-intensive manufacturing

The energy-intensive manufacturing sector, which includes steel, cement, chemicals and petrochemicals, glass and other industries, is set to undergo substantive changes in the coming decades. These changes will involve switching fuels through direct electrification and the use of hydrogen, as well as the application of CCUS and other measures (Reay, 2023).

For workers in this sector, there are transferable skills that could be used in the industrial decarbonisation process. The CCC estimates that up to 9,500 new jobs could be created through opportunities associated with the decarbonisation of energy-intensive manufacturing in the UK (CCC, 2023). However, there is a risk that without subsidies, these changes could increase costs and impact the competitiveness of UK industry. This could ultimately lead to production being moved or outsourced abroad, resulting potentially in domestic job losses (ibid). In the recent case of Port Talbot steelworks in Wales, 2,800 jobs are expected to be lost after Tata Steel announced its plans to close two blast furnaces by September 2024 and rely instead upon its global operations and supply chain, in order to address financial losses and a need to transition to more sustainable production (Mavrokefalidis, 2024).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Section 3. A review of the UK skills and training landscape

Since the democratic devolution in the late 1990s, each nation in the UK has had the flexibility to develop its own approach to education and skills, creating a 'patchwork of policy' adapted to its respective needs (Gluck, 2024). This section provides an overview of the national skills, education and training system, with a focus on England. It first describes significant changes to the system in recent years, amongst them, the increased devolution of policy to regional actors, and the decreased investment in skills and education. It then highlights several approaches being taken at national, regional and local levels to develop and provide training for low-carbon energy jobs. Findings suggest that whilst progress has been made to tailor training and skills to Net-Zero requirements, the rate of change has so far been inadequate.

3.1 The UK skills system

The 'skills system' covers school education, further education (FE) colleges, universities, and the 'wider skills and learning system', including workplace training and independent education (Reay, 2023). Significant recent changes to skills policy include the reform of technical education (including the introduction of T levels), increased employer engagement in the education and skills system, increased regional devolution, and the expansion of lifelong learning (ibid). This last change includes the introduction of a lifetime skills guarantee, providing access to Skills Bootcamps as well as free qualifications for adults over 24 without A levels, an advanced technical diploma or equivalent.

Governance of the skills system involves multiple stakeholders, including several government departments, agencies, and sector bodies. In England, the Department for Education (DfE) currently leads on skills and education policy, and the Department for Work and Pensions (DWP) plays a role in supporting employment and skills initiatives. In July 2024, the Government launched Skills England which aims to assess current and future skills needs in the economy both nationally and regionally, while ensuring that training, qualifications and apprenticeships match skills gaps and are aligned with the new government's forthcoming Industrial Strategy (DfE, 2024). It is intended that

Skills England will work closely with devolved administrations and regional authorities, including combined authorities (ibid). In 2022, DfE established a new Unit for Future Skills, to improve the quality and granularity of skills, data, and anticipate future skills needs. This takes over the work of several institutional bodies from previous years (e.g. the UK Commission for Employment and Skills (UKCES), Sector Skills Councils, the Sector Skills Development Agency, and the Skills and Productivity Board) which served similar roles before being decommissioned and replaced. A critique of skills policy in England has targeted this chopping and changing of different institutions in line with government changes (Uyarra, Shapira & Harding, 2016). Cedefop (the European Centre for the Development of Vocational Training) also observes that the UK's institutional set up of skills forecasting for the green economy has become weaker and more fragmented since the dissolution of UKCES, which conducted regular skills anticipation and occupational forecasts until 2016 (Cedefop, 2018).

England's skills system is increasingly regionally devolved, with local skills improvement plans (LSIPs) and local enterprise partnerships (LEPs) providing the primary framework for skills' development across regions in recent years.

- LSIPs are developed by employer representative bodies (ERBs), in partnership with employers, technical education providers, and other stakeholders, setting out the key changes needed in a local area to make technical skills training more responsive to employers' needs. LSIPs are expected to continue until 2025, with the research from all 38 LSIPs collated into a report and specific roadmaps for stakeholders (Gluck, 2024). LSIPs are currently the only government initiative focused on developing local skills strategies (Balata et al., 2023), and are required to consider Net-Zero as part of their development (Reay, 2023).

- LEPs were introduced in 2010 to replace regional development agencies (RDAs) and bring industry and local government associations (LGAs) together to develop training plans based on local skills needs and requirements. LEPs play a central role in determining economic priorities and developing workforce skills (Bray, Mejía Montero & Ford, 2022), although they are, in some cases, beginning to be replaced by Mayoral Combined Authorities[5] (MCAs). The transition to LEPs has also coincided with a reduction in financial resources and decision-making powers allocated to regions, making it less clear how local skills plans will be achieved (Corradini, Morris & Vanino, 2023).

[5] See, for instance, the devolution of Humber and East Yorkshire LEP at the end of 2023 into a MCA (DLUHC, 2023).

This turn towards more devolved forms of decision-making on education policy means that training and skills development opportunities can be tailored to suit regional contexts and requirements, which is key given that local economies each host distinct forms of embedded skills (linked to the presence of specific industries), knowledge and technology (Froy et al., 2022; Hausmann & Neffke, 2019). However, simply creating space for regional and local decision-making on skills strategies for Net-Zero may not be sufficient to ensure alignment at a national level. Whilst it is important that regional actors are granted the autonomy to tailor LSIPs to local competencies, consideration should also be given to how these regional strategies can work together more collaboratively to meet targets, such as Net-Zero, which go far beyond a local scope. Currently, for instance, no specific national skills taxonomy or strategy exists in the UK (Strachan, Greig & Jones, 2022), and as a consequence, different classifications, definitions, and methodologies for skills and jobs, end up being used to shape LSIPs and other regional Net-Zero strategies. In the absence of a national direction for skills, dependency on employer-led and sector-led training to fill in skills gaps has also grown. This has led to the development of training and standards which, whilst directly tied to industry needs, can also be 'rather fragmented' (Cedefop, 2018), prone to prioritising short-term over long-term skills needs, and lacking coherence.

A number of national funding mechanisms, including the National Skills Fund, the Apprenticeship Levy, and the Adult Education Budget, are used to promote and finance skills development in the UK. While these funds support broad educational and training initiatives, there is uncertainty about their contributions specifically towards Net-Zero skills development. A brief overview of each is provided in Box 2.

Box 2. Overview of key funding mechanisms for skills

National Skills Fund. At the end of 2021, the Government announced the National Skills Fund, a £2.5 billion fund to finance programmes supporting post-pandemic economic recovery and help meet future skills needs. It currently funds the Government's Skills Bootcamps and 'free courses for jobs' offer for adult learners living in England (Bolton & Lewis, 2023). As with other funding schemes, it is hard to estimate how much of the fund has been channelled towards training and skills to support Net-Zero (Balata et al., 2023).

Apprenticeship Levy. The Apprenticeship Levy has operated since 2017 as a means of combining employer and public funding for apprenticeships. It requires employers with annual wage bills of over £3 million to pay a levy equivalent to 0.5% of payroll to finance apprenticeship training. This could play a central role in meeting Net-Zero skills needs for the whole of the UK, although its effectiveness has been questioned (Reay, 2023). For instance, apprenticeship uptake across the UK has still not recovered to pre-Apprenticeship Levy levels, and between May 2019 and March 2022, over £3 billion of the levy went unspent by employers (ibid).

Adult Education Budget. The Adult Education Budget (AEB) covers funding for adult education (excluding apprenticeships), community learning, and learner support in England. It is targeted at groups of learners with low skills, including young adults, unemployed individuals actively seeking work, and employed individuals in receipt of a low wage. The Education and Skills Funding Agency (ESFA) oversees the distribution of AEB funding to education providers, including FE colleges and training providers, although increasingly, the budget is devolved towards MCAs. The AEB has also been reduced since it was first introduced, standing at £1.3 billion in 2022-23 (Bolton & Lewis, 2023). It does not feature green or Net-Zero specific targets, and it is not known how much of the fund has supported training and skills for Net-Zero.

3.2 Approaches used to develop skills for the low-carbon workforce

Training for Net-Zero skills and jobs must be addressed by educational and training providers across the education and skills system. This section examines national and local approaches to developing green and low carbon skills in the energy sector, evaluating how effectively these approaches meet the scale of the challenge.

Skills England's first report states that it will be critical to collaborate closely with the Department for Energy Security and Net Zero (DESNZ), specifically the new Office for Clean Energy Jobs within DESNZ linked to the Government's clean power by 2030 mission (DfE, 2024). Whilst the UK does not have a national skills strategy, the Net Zero Strategy (2021), which sets out the Government's ambition to support 440,000 jobs across Net-Zero industries by 2030, includes a commitment to 'reform the skills system' (BEIS, 2021b). This includes, for instance, a commitment to publishing sector and supply chain development plans with a focus on green skills (ibid). New initiatives focusing on training for green skills also continue to emerge. For example, Skills Bootcamps, which are free courses of up to 16 weeks for adults aged 19+, are focused on green, technical and digital skills (Simmonds & Lally, 2024). There has also been a roll out of government-funded competitions, such as the Home Decarbonisation Skills Training Competition, covering the costs of training for workers in building retrofit, energy efficiency and low-carbon heating. Nevertheless, given the magnitude of skilled workers required to meet Net-Zero, government action on skills for Net-Zero has been subject to criticism (Balata et al., 2023; Bray, Mejía Montero & Ford, 2022; Reay, 2023; White et al., 2022). Low-carbon skills are still rarely a policy focus, and particular concerns have been expressed about the low extent to which these are integrated within apprenticeships and further education (White et al., 2022).

There has also been a lack of focus on how training opportunities provided at a national level can target those most in need of support, whether this refers to those needing to be re-skilled, those out of work, or those who are already systemically disadvantaged. Comparatively, in the devolved administrations, there have been attempts to provide targeted training opportunities for low-carbon skills. In Scotland, for example, the Oil and Gas Transition Training Fund was set up in 2016 with a view to supporting those most vulnerable to the impacts of the phase down of the oil and gas industry. Through this fund, the Scottish government has provided re-skilling programmes, with a focus on wind turbine engineering, welding and railway engineering, to 4,000 workers either

actively at risk of being made redundant, or who worked in the oil and gas sector or its supply chain and lost their job since 2015 (European Commission, 2020).

In place of government-led action, there are also collaborative projects being undertaken across industry, academia, and other organisations with a stake in the transition. Two examples discussed during the interviews for this briefing paper include the Electric Revolution Skills Hub and National Retrofit Hub, which will be described next.

The Electric Revolution Skills Hub (ERSH) aligns industry, skills providers, accrediting organisations and academic institutions to create a 'national skills resource' for stakeholders in electrification (specifically those working in power electronics, machines and drives). Its primary output is a multi-feature digital platform which aims to address fragmentation within the industry. The platform includes a collaboratively developed taxonomy of skills ('the PEMDBoK') required for electrification roles, with the aim of capturing 'the full scope of topic specialist areas' and establishing a common language for electrification skills across various industries (ERSH, 2024). The platform also features a self-assessment tool which allows a user to input their existing skillset and matches it with tailored job and training opportunities.

For the building retrofit sector, the National Retrofit Hub fills a similar role. In the absence of a government-endorsed national strategy for retrofit, the hub collaborates with stakeholders across the supply chain to make training and skills recommendations for the sector. This includes carrying out research to map skills pathways, identifying ongoing gaps in skills and training, and developing courses which more accurately address both current and future needs. Currently, given that retrofit is under-addressed in conventional construction courses, they are actively working on reforming the curriculum for retrofit.

Whilst the Net-Zero transition will require a change in curricula across the entire skills system, it is the FE sector which is 'at the heart of UK skills provision' for the transition to Net-Zero at local and regional levels (Reay, 2023). In particular, the FE sector will be particularly important to developing green career pathways into the built environment, energy and transport sectors (ibid). FE colleges are both enhancing existing courses and introducing new programmes specifically focused on Net-Zero jobs. Since 2017, offshore wind company Ørsted has partnered with the Grimsby Institute and Furness College to offer apprenticeships on the UK's east and west coasts, with apprentices who successfully completed the three-year programme becoming full-time employees (Ørsted, n.d).

In the nuclear sector, the National College for Nuclear is a partnership with industry employers, regulators, skills bodies, and training providers to align FE curricula with industry needs, including creating relevant low-carbon courses. Additionally, the UK's first Low Carbon Heating Technician apprenticeship, developed by the Microgeneration Certification Scheme (MCS) in collaboration with the Institute for Apprenticeships and Technical Education (IfATE), is set to welcome its first cohort of apprentices in September 2024 (MCS, 2023).

Although it is anticipated that FE colleges will continue to play a primary role creating and delivering courses needed to provide skills for Net-Zero, this is not reflected in current rates of investment. Specifically, the FE sector has experienced a prolonged period of reduced funding (Bolton & Lewis, 2023; Chapman, Kumar & Yunda, 2024) and Chapman et al. argue that a 'stagnation' in skills and productivity in the UK has largely been driven by a decline in state and private sector investment in skills (Chapman, Kumar & Yunda, 2024). This was similarly highlighted in 2018 by the House of Lords Economic Affairs Committee, which suggested the FE sector's position had been weakened by budget reductions and a complex funding architecture, ultimately leading to a 'collapse' in learner numbers (Economic Affairs Committee, 2018). Between 2022–2023, total public spending on adult skills was around £4.4 billion—a 30% drop from its peak of £6.3 billion in 2003–04 (Institute for Fiscal Studies, 2023). Ed Atkins, from the University of Bristol, emphasised how the skills system faces difficulties meeting educational demands:

> *"There's been a lot of talk about green apprenticeships and changing further education curricula to provide more green skills, for example, including stuff on heat pumps in plumbing or electrician courses and so on. That's great, but at the same time, [it's trying to do that] at a time when the education system is really struggling to fulfil what it's currently being asked for already."*

Finally, approaches to providing skills will vary depending on the maturity of different low-carbon sectors and whether they have the data to predict how skill requirements will evolve. More established sectors, such as offshore wind, have a clearer sense of the precise roles and skills which will be needed to support the future industry and have been able to accelerate the roll-out of apprenticeships to match these needs. The Offshore Wind Industry Council (OWIC), for instance, carries out a yearly intelligence survey, complete with diversity metrics, tracking how and where the UK's offshore wind workforce is evolving (OWIC, 2023). Conversely, sectors such as hydrogen and CCUS are still nascent, and it is less known what specific skills will be needed to support their growth.


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Section 4. Barriers to developing skills for the low-carbon workforce

This section considers ongoing and emerging barriers to developing a skilled, low-carbon energy workforce. These include data limitations and barriers related to training supply, access, and demand. It also highlights the negative impacts the transition may have if these barriers are not overcome in a regionally contextualised and socially inclusive manner.

4.1 Monitoring and data limitations

Understanding how skills requirements are changing, and where skills gaps are emerging, are prerequisites for developing training courses which are able to respond to the needs of the labour market. In the UK, one of the key barriers to understanding how the Net-Zero workforce is growing, and how skills requirements are changing, is the paucity of accurate, granular data. Several studies on green jobs have highlighted the data limitations when it comes to analysing green jobs and skills in the UK (Bowen, Kuralbayeva & Tipoe, 2018; Cardenas-Rubio et al., 2022; Sato et al., 2023; Strachan, Greig & Jones, 2022; Vona et al., 2018; Valero et al., 2021; Whittard et al., 2024).

For instance, Cardenas-Rubio et al. suggest that the Standard Industrial Classification (SIC) and the Standard Occupational Classification (SOC) in the UK are too coarse in terms of providing detailed information on the exact tasks, skills and knowledge of any occupation (Cardenas-Rubio et al., 2022). The SOC was updated in 2020, marking some progress in terms of detail, however it still falls short compared to international standards like the US O*NET classifications. The current SOC does not adequately address several occupations that are central to the Net-Zero transition. There is no distinction made, for instance, between construction and retrofit roles. A similar lack of sensitivity in SIC codes means that it is also difficult to understand what businesses do in terms of green and non-green economic activity (ibid). Misato Sato, from the Grantham Research Institute at LSE, highlighted how research into low-carbon jobs is affected by this lack of disaggregation at the occupation level:

"It's really hard to go beyond the occupation level. The occupation level in the US is quite granular, but here, the SOC code is so broad they just have 'engineers' or something – like even within chemical engineers there's green and brown, so it's really constraining to use the occupation definitions in the UK."

This lack of disaggregated data has led to a dependence in some industries on using sector-led data (e.g. RenewableUK for offshore wind) to analyse how skills across the energy system are changing. Due to the significant planning and resources required, this data can be limited in scope, and methodologies used can vary widely, leading to inconsistent estimates across sectors (Green Jobs Taskforce, 2021). Additionally, metrics which are central to enabling a just, inclusive transition are still infrequently included in government and industry surveys (ibid). The ONS LCREE survey, for instance, is not broken down by diversity characteristics.

These monitoring and data limitations hinder educational institutions and training providers from developing and implementing courses that accurately address both current and future job and skill requirements. Similarly, the lack of comprehensive data compromises policy effectiveness at regional and local levels, as policymakers cannot accurately track how well different sectors, and their workforces, are progressing towards Net-Zero targets.

4.2 Regional barriers

The transition to Net-Zero will not be experienced evenly, with certain regions under more pressure to decarbonise rapidly than others. In particular, UK regions with a higher concentration of energy-intensive industries stand a higher chance of being negatively affected by the transition, particularly if the phasing-down of these industries does not coincide with the arrival of new, alternative career opportunities. These regions are often also those whose economies have seen the least growth in recent decades. Between 1998 and 2016, for example, the regional economies of the North East, Yorkshire and the Humber and the West Midlands all grew at less than half the rate of London's (Aldersgate, 2020). As far as skills are concerned, these regions are therefore also likely to have less capacity and resources to be able to provide adequate re-skilling support for workers who will need to transition into new jobs, or to provide training opportunities encouraging new people into low-carbon sectors.

In many of these industrial clusters, moreover, memories of the 1970s and 1980s transition away from the coal and steel industry—which led to significant social disruption and left communities stranded—are still present. Diski, Chapman and Kumar suggest that this transition caused economic upheaval which has still not been addressed by the growth of the service sector or retraining programmes (Diski, Chapman & Kumar, 2021). In particular, criticism has been levelled at the abruptness of the transition, which saw the coal workforce shrink from 241,600 to 56,000 workers over the course of ten years, as well as the limited range of alternative career or re-skilling options that were made available at the time (CCC, 2023; Diski, Chapman & Kumar, 2021).

4.3 Skills-transferability barriers

It has been estimated that around 100,000 (50%) of the jobs in the UK offshore energy sector (including offshore wind, hydrogen, CCUS activities, and oil and gas) in 2030 are expected to be filled by workers transferring from oil and gas to offshore renewable roles, and by new entrants from outside the sector (Robert Gordon University, 2021). This is in part because many workers in these industries are considered to have skills which are transferable to low-carbon jobs (Bowen, Kuralbayeva & Tipoe, 2018; Louie & Pearce, 2016; Robert Gordon University, 2021). There is a debate within the literature, however, about how transferable high- and low-carbon skills in the energy sector are, and whether or not a simple 'topping up' or more rigorous retraining will be required in most cases. For instance, research by Sato et al. finds that across the US and UK, low-carbon job advertisements include greater requirements for technical, managerial, and social skills compared with other job adverts, suggesting low-carbon employment may be more skills-intensive overall (Sato et al., 2023). Possibly, therefore, the emerging skills gap resulting from the Net-Zero transition may actually be 'broader and larger' than previous analyses have predicted (ibid).

Uncertainties about the transferability of skills between high- and low-carbon energy roles may pose a key barrier to creating clear re-training pathways for workers. If skills transferability is overestimated, it is possible that workers entering the sector may not have the requisite skills to carry out the high-quality work needed, and if skills transferability is underestimated, workers may be obliged to undertake training (often self-funded) for skills they already possess.

4.4 Mobility barriers

Whether or not workers who have been displaced from their high-carbon jobs are able to transition into low-carbon jobs will depend on the levels of geographical congruence between where jobs are being lost and where they are appearing. It will also depend on the availability of training opportunities, which are likely to be unevenly distributed in terms of quantity and quality (Bray, Mejía Montero & Ford, 2022). If green jobs or re-skilling opportunities do not appear in areas where jobs have been phased out, workers will either have to lose out on opportunities, seek employment in other high-carbon sectors, or relocate, which risks reinforcing existing regional inequalities (Botta, 2018; Lim, Aklin & Frank, 2023; Sato et al., 2023). Sato et al. find that whilst high-carbon jobs in the UK are highly spatially concentrated on the coast by the North Sea, low-carbon jobs tend to be more dispersed (Sato et al., 2023). Additionally, this can reinforce the trend of skilled workers moving into urban areas and leaving more rural, less connected areas without the workforce to develop, manufacture or install innovative technologies and systems (Bray, Mejía Montero & Ford, 2022). Misato Sato noted the potential oversight of these spatial dynamics at policy-level:

> *"There might be some new jobs coming into these areas that are currently poor and dependent on fossil fuels, but maybe not a lot. I think politicians often overlook the spatial dimension."*

This issue is also not specific to those being retrained. For potential new entrants, such as school leavers, reduced access to low-carbon courses, such as FE college courses or apprenticeships, can be a key barrier. Sometimes, training opportunities for green careers are locally or regionally unavailable. For example, in Hull, it has previously been reported that there are no training providers within 50 miles of the city for 23 of 62 apprenticeship standards related to offshore wind (Aura, 2018).

Worker mobility is affected by additional factors including geographical access barriers, as outlined above, but also financial barriers, for individuals who are unable to afford taking time out to train or retrain, and timing barriers, for those who find that available training options are incompatible with their existing schedules. Ed Atkins, from the University of Bristol, highlighted the need to think about how training opportunities might address existing mobility and access limitations:

"We need to reflect on the fact that adult education and re-skilling is very different to how we understand education generally. [...] We need to have compartmentalised and quite localised education, we need to have night schools and adult education centres, we need to invest in further education colleges to provide courses which people can dip in and out of alongside their other responsibilities."

4.5 Diversity barriers

The current energy sector is predominantly represented by white male workers (CCC, 2023). Whilst there is limited data on ethnic diversity within the energy sector, available statistics suggest that only 5% of the workforce comes from Black, Asian, and Minority Ethnic (BAME) backgrounds (Energy and Utility Skills, 2021). Whittard et al. also report that ethnic groups appear dually disadvantaged in terms of both being underrepresented in green employment and facing a pay penalty compared to white workers (Whittard et al., 2024). Similarly, although there is some variation among sectors, the International Energy Agency (IEA) reports that women's participation in the energy sector is lower than in the broader economy (IEA, 2020). This is a long-standing issue, indeed Cedefop research dating back to 2013 indicated that education and training pathways into new green occupations were largely dominated by men (Cedefop, 2013).

The fact that the energy workforce is predominantly male has additional gendered implications. An International Labour Organisation (ILO) report suggests that the transition to a low-carbon economy will have the greatest impact on male-dominated, medium-skill occupations. This implies that male workers in high-carbon roles may require additional support re-skilling to avoid unemployment (Kapetaniou et al., 2020). The same ILO report also indicates that unless active measures are taken to encourage underrepresented groups to enter and be retained within the workforce, current occupational gender gaps are likely to persist (ILO, 2018).

Section 5. Case studies

This section presents one national and two regionally specific, sectoral case studies, focusing on skills-related challenges, needs, and opportunities. Each case study concludes with a series of recommendations for improving training and skills provision. The three case studies address the following:

1. Building energy renovation (UK national scale)
2. Electric vehicle (EV) manufacturing in the West Midlands
3. Offshore wind in Yorkshire and the Humber

The building retrofit case study addresses challenges that are common across the sector, offering recommendations primarily aimed at enhancing national-level coordination. In contrast, the offshore wind and electric vehicle manufacturing case studies focus on industries that are regionally clustered in Yorkshire and the Humber and the West Midlands, respectively.

The rationale for providing a mix of viewpoints—two regional and one national—is that a successful transition requires a nationally coordinated vision, combined with regionally tailored approaches. According to Benjamin Silverstone from Warwick Manufacturing Group (WMG)[7], green skills development strategies and training standards need to be "nationally conceived, regionally contextualised, locally delivered" such that national goals are tailored to the specific needs and strengths of different regions.

5.1 National case study: building energy renovation

The transition to Net-Zero will require a very substantial reduction in emissions from the UK's building stock, to be achieved primarily through low-carbon heating and energy efficiency retrofits delivered at scale (CCC, 2020b). Various estimates suggest that 120,000–230,000 new jobs could be added to the retrofit workforce by 2030, representing an increase of up to 11% in jobs in the sector relative to today (CCC, 2023). Given that an estimated 26 million homes across the UK will

[7] A department at the University of Warwick providing research and education in engineering, manufacturing, and technology, and working closely with the automotive industry.

need to be retrofitted between now and 2050, this sector should see geographically dispersed opportunities for new employment (ibid). However, it will be contingent on the strength of policy measures and regulations to support development of the supply chain, as well as the availability of skilled labour.

5.1.1 Training and skills for building energy renovation: challenges

Retrofit policy gap

UK building retrofit policies have to date been characterised by a stop-start approach to funding and an over-reliance on subsidies to drive the market (Brocklehurst et al., 2021; Hargraves, Karpathy & Griffin, 2022). A succession of short-term funding streams, such as the Community Energy Saving Programme (CESP) (2009–2012), the Green Deal (2013–2015), the Green Homes Grant (2020–2021), and the Energy Companies Obligation (ECO) (launched in 2013 and released in four different phases, with the fourth phase, ECO4 planned until 2026), have disincentivised SMEs along the retrofit supply chain from investing in skills and training (Energy Systems Catapult, 2021). This inconsistent demand affects the availability and accessibility of good quality training options, which are essential to meet the target for as many homes as possible to reach EPC band C by 2035.

Joe Kelly, Director at Baxter Kelly, an SME installing energy efficiency measures in homes (including insulation, heat pumps, and solar PV panels), spoke about his experience navigating ECO4:

> *"Most of our turnover is still through ECO obligation and from March 26th there is no obligation. We don't know when ECO5 is starting, there's currently chaos, contract values are all dropping at the moment because they're ahead of delivery, and so the policy behind it all is so up in the air continuously that it makes it really hard to invest in your own business."*

Inadequacy of current training for retrofit skills

Typical educational pathways into the construction sector do not prepare people to work in building energy renovation. Formal construction training, including FE courses and apprenticeships, continues to be predicated on teaching skills for new builds and fossil fuel technologies (Energy Systems Catapult, 2021). Similarly, whilst more training routes for jobs in retrofit are appearing (e.g. MCS heat pump installer courses (MCS, n.d.) these tend to be narrowly focused on technical skills, often limited to one or two technologies. Successful retrofit, however, requires knowledge of how different technologies and components of a whole home interact. Pippa Palmer, from the National Retrofit Hub, emphasised the need to adopt a 'whole-house[8]' approach to training:

> *"We can't just put green in as an afterthought. There has to be a real understanding of what happens if you change the thermal performance of a building. What happens to moisture control? What happens with ventilation? [...] You just can't tinker with one part of it. So the whole house thinking and building physics, which maybe don't come into a lot of jobs, are suddenly very, very important."*

Additionally, building retrofit requires increased communication between workers and residents, but soft, customer-facing competencies generally do not feature in formal skills training. Ian Heptonstall, from the Supply Chain Sustainability School, highlighted this missing component:

> *"If you're doing retrofit, you need to understand the customer really well. [...] Now, most people working in large-scale construction don't have those skills because they've never met the customer at all, so they need to have people skills they don't currently have."*

[8] A 'whole house' renovation typically includes a comprehensive list of energy efficiency measures (e.g. insulation, heat pump, solar panels) designed to complement each other. By considering the interactions between different measures, the 'whole house' approach aims to maximise energy efficiency and significantly reduce energy use in homes. This contrasts with 'single measures', which refer to individual energy efficiency upgrades or improvements made to a home, typically implemented one at a time rather than as part of a comprehensive or coordinated plan.

Low sector appeal

There is a shortage of skilled workers in the building retrofit sector (CITB, 2021) but rolling out more FE courses and apprenticeships should not be viewed as the one-size-fits-all solution to this problem. The lack of retrofit skills comes on top of a general lack of attractiveness in the buildings sector, a challenge that predates the demands of the energy transition. Currently, there is low appetite for jobs in retrofit, and even when courses are heavily subsidised or offered at no cost to participants (as in the case of the Green Homes Grant Skills Competition) providers still struggle to fill places (Hargraves, Karpathy & Griffin, 2022).

Reasons for this include lack of awareness and assurance about what a long-term career in retrofit could look like, as well as uncertainty about how long emerging roles will last. Additionally, jobs in construction are typically considered to have low prestige, with employment prospects not viewed as aspirational and therefore not encouraged in schools (Killip & Robson, 2024). This is one facet of the construction sector's 'low-skills equilibrium', where a market consistently characterised by low wages, poor job security and low prestige creates low demand for skills (Killip, 2020; Green, 2016).

Lack of established roles, skills and qualifications

There are no Standard Industrial Classification codes (SIC) specific to the building retrofit sector in the UK (DESNZ & BEIS, 2021). Without clearly outlined roles and associated skillsets for jobs in retrofit, it is a challenge to keep track of where the most critical skills gaps are appearing, as well as how the industry is developing. Furthermore, the UK labour market for construction and retrofit is unlicensed, which means there are no mandatory entry or retention training and qualification requirements for the industry (Killip & Robson, 2024). This lack of regulation significantly increases the risk of poor-quality work being carried out.

5.1.2 Recommendations for improving training and skills provision

Growing the retrofit workforce and shifting away from a low-skills equilibrium will require a collaborative effort to raise the availability, quality, accessibility and diversity of training. Government, industry, retrofit organisations (including retrofit hubs and NGOs), FE colleges and training providers should collaborate to produce a National Retrofit Skills Strategy. This would provide a coordinated, national framework for expanding the retrofit workforce, which would then need to be adapted to suit regional and local needs and requirements (Wade, Bush & Webb, 2020).

This national strategy could include:

- Introducing longer-term, increased policy support for retrofit. More continuous funding streams are required to create market demand for retrofit and incentivise SMEs to invest in skills and training. Policy should also focus more on promoting and funding 'whole house' retrofits rather than single measures.

- Developing SIC and SOC codes, including associated skillsets, for formally recognised retrofit roles. This would enable more granular data on the retrofit workforce to be collected, categorised, and used to analyse how the sector is evolving.

- Introducing minimum competency standards for retrofit roles. Quality assurance remains a major challenge for building energy renovation, largely due to the lack of trading licence requirements and minimum competency standards (Killip, 2020). Introducing minimum standards would help to ensure that workers have the competencies required to carry out quality retrofits. Examples exist in the EU, where the revised EU Energy Efficiency Directive requires member states to develop certification schemes or equivalent qualifications for workers providing energy efficiency audits, improvements or services (Macrorie et al., 2024). To minimise red tape and avoid administrative delays, existing certification schemes, such as the Microgeneration Certification Scheme (MCS) could be used as a model and be expanded.

- Expanding the scope of retrofit training courses and apprenticeships to include more holistic teaching. Skills should be developed that adopt a 'whole house' approach and tackle the building as an integrated system. This could help to create less siloed trades, increase holistic understanding within building teams, and reduce the 'design-performance gap', that is, the discrepancy between

predicted energy savings during the planning stage of a retrofit and the actual energy savings observed once the retrofit is completed.

- Increasing training for 'soft' skills, such as communication and customer care, which would help to create more constructive working relationships between tradespeople and homeowners; this is key since workers such as installers often take on advisory roles with customers (Owen, Mitchell & Gouldson, 2014).

5.2 Regional case study: electric vehicle manufacturing in the West Midlands

Regional context

The West Midlands currently accounts for one in six manufacturing jobs in the UK and boasts the largest share of the nation's automotive workforce, with a total 46,500 jobs supported by 1,100 businesses (WMCA, 2023, 2021b). These businesses include global vehicle manufacturers Aston Martin and Jaguar Land Rover, the latter of which represents a striking 50% of all employment in the region's automotive sector (De Ruyter et al., 2022). Accordingly, the West Midlands Combined Authority (WMCA) has identified EV and associated battery manufacturing as one of the region's eight primary economic clusters (Porter, 1998) set to see accelerated growth by 2030.

5.2.1 Training and skills for EV jobs: challenges

The West Midlands' ability to grow the EV manufacturing workforce depends on overcoming a range of regional challenges, as described below.

Working-age population challenges

The working-age population in the West Midlands has a comparatively low skills base, with a 11.3% share of working-age people without any formal qualifications, well above the UK average of 7.9% (WMCA, 2021b).. The region also has a high rate of young people (aged 16-24) 'Not in Education,

Employment or Training' (NEET) – 13.3%, the 4th highest for any region in England (WMCA, 2024). This low skills base poses a risk to the region's ability to source the labour required for expanding the EV industry and market.

Mismatch between current training options and future skills needs

In the West Midlands, training for roles required by the shift to EVs is lagging. While more FE courses which focus on EVs are appearing (e.g. the specialist Electric Vehicle Centre at the City of Wolverhampton College, or the Hybrid/Electric Vehicle System Maintenance course at Sandwell College), the majority are still focused on technical skills and training for ICE vehicles, and do not include 'green' modules e.g. for electrification-related skills. This lag may stem partly from the time it takes to identify emerging needs and adapt training curricula accordingly, and partly because training is industry-led, which means it is often driven by short-term market goals. Benjamin Silverstone, at WMG, highlights this tension between meeting short- and long-term skills needs for industry:

> *"Employers are an integral part of our design process, but that doesn't necessarily mean that [the course is] going to be fit for purpose. Because again, you sit down with these companies and I say to them, 'Tell me, what is it you need from a graduate?' and they tell me, and I design that, but five years down the line that isn't going to be what they want from a graduate. So there are still issues in terms of how we can design an education system that will allow it to flex over time."*

Lack of private and public investment in skills and training

A 2022 survey of workers in the West Midlands automotive sector identified that 85% had not been offered any training or upskilling by their employer to help them prepare for the transition to the production of low-carbon vehicles (De Ruyter et al., 2022).

Additionally, over half of automotive businesses in the West Midlands are SMEs who do not recruit apprentices (WMCA, 2021a). Reasons for this include being unable to afford to release staff for training days, being unable to access support or funds for training purposes, and lack of knowledge about the apprenticeship system (ibid). Manufacturing supply chains in the region are already

fragile, particularly in a post-Brexit era, and a lack of public and private investment in skills and training threatens the viability of smaller SMEs in the supply chain surviving the transition to Net-Zero (De Ruyter et al., 2022).

Training accessibility issues

In the West Midlands, apprenticeships are increasingly concentrated in larger employers (WMCA, 2021b). This means apprenticeship opportunities are becoming less evenly distributed across the region, and for people living in areas where these larger employers are not located, or where there are less developed transport networks as to be able to access them, they risk being isolated from training opportunities. One such example is the Black Country, an area with a historically strong manufacturing base, but which also ranks as one of the most deprived areas in the West Midlands (WMCA a., 2021). If local workers and young people are increasingly cut off from accessing training opportunities, and high-carbon manufacturing jobs are phased out without local alternative employment options appearing to replace them, communities in these areas risk being further locked into poverty.

5.2.2 Recommendations for improving training and skills provision

To scale up the supply and demand for workers in the West Midlands' low-carbon transport sector, targeted interventions to improve training accessibility, quality, and attractiveness will be required. For example, Benjamin Silverstone of WMG emphasised the case for a financial intervention to support smaller businesses to be able to send staff to be re-skilled, or take on apprentices:

> *"For smaller businesses that are going to struggle, for those that we require to retain part of the supply chain, or for those that we want to retain for a strategic purpose, then there's a role for intervening with some funding."*

Intervening in this way could also help to limit the risk of being removed from the UK by international parent companies as the transition progresses.

Additionally, Deepak Farmah from the Electric Revolution Skills Hub highlighted the importance of making training inclusive and accessible to a wide audience:

> *"We need to start looking at people who will need to re-skill, new entrants, and also, people who never thought they would be working in this space. What we don't want to do is scare them off [...] you only need to give them small snippets of competency-based training for them to be able to go into the space and start working. So, changing the way education works has been critical."*

Further recommendations, based on addressing identified barriers in the case study, are provided below:

- Partnerships between regional authorities (including combined authorities), FE colleges, and automotive businesses should be encouraged to help the sector more clearly assess and anticipate future skills needs. In the short-term, stakeholders involved in shaping skills for the EV sector should collaborate with each other to map out which green skills are most relevant to traditional automotive roles and embed these within local courses. In the longer term, this should include developing and rolling out courses which are explicitly focused on equipping people with skills relevant to roles within EV and battery manufacturing.

- Regional authorities should consider making FE colleges in areas with limited transport infrastructure primary recipients of funding for skills development. Channelling funding towards FE colleges in poorly connected areas so that they can develop courses centred around EV and electrification skills can help to address regional imbalances and create clear progression pathways into work for disadvantaged young people and current workers.

- Regional authorities should consider providing financial support for smaller SMEs unable to re-skill staff or take on apprentices, such that they can afford to re-skill or grow their workforce.

- Vehicle manufacturers should aim to ensure a socially responsible transition for current workers in high-carbon roles. Knowing that the transition to low-carbon transport will result in some job losses and traditional roles disappearing, vehicle manufacturers should create and put into action comprehensive transition plans, including re-skilling plans for current workers, and plans to create new employment opportunities in the EV sector. Focus should also be on

facilitating broader employment options, recognising that workers who may be phased out of their current high-carbon roles should be able to find suitable roles across various sectors, not necessarily within a low-carbon context.

- FE colleges and training providers should consider increasing the breadth and flexibility of courses related to EVs, helping to maximise participation rates and support the development of a wider range of required competencies. This could include providing a broader variety of courses, to suit different skill levels, as well as more accommodating course delivery methods, such as hybrid (in person and/or online) learning or evening classes.

5.3 Regional case study: offshore wind in Yorkshire and the Humber

Regional Context

Given its position along the eastern seaboard of the UK, the Yorkshire and the Humber region is well adapted to growing its offshore wind industry. The region is already home to eight offshore wind farms supplying a total 4.9 GW of clean electricity and has ambitions to deliver at least 13.8 GW by 2030. The sector currently employs 4,300 people in the region, making it the largest offshore wind workforce in the UK (OWIC, 2023). The Humber and East Yorkshire Local Economic Partnership (HEY LEP) estimates that based on planned projects, by 2032 it will have reached 21,000 workers (HEY LEP, 2022).

Yorkshire and the Humber also continues to be one of the UK's most active industrial regions (Clery & Gough, 2022). Around 360,000 jobs in the region are in energy-intensive sectors, including petrochemicals, steel and cement (Diski, Chapman & Kumar, 2021). It will therefore be key to consider how workers in these industries, which are expected to be phased down, can be re-trained to join the low-carbon energy sector.

5.3.1 Skills and training challenges

Working-age population and workforce challenges

HEY LEP's 2022 Local Skills Report highlights ongoing challenges in the region, including a below-average number of workers with higher-level qualifications, above-average deprivation levels—20% of all neighbourhoods in Yorkshire and Humber fall into the 10% most deprived nationally for education, skills, and training measures—and low productivity levels and wages compared to national averages (HEY LEP, 2022). For example, in Hull, only 19% of residents hold a qualification above A-level (HEY LEP, 2023). This is a point of concern given that most of the net job growth in the region by 2035 is expected to require qualifications at or higher than A-level (ibid).

Fragmented re-skilling routes

The lead time to competency for new entrants in the offshore wind industry through apprenticeships can be as long as six years (HEY LEP, 2023). This means the risk of future skills shortages is significant in the short to medium term, with industry needing to rely on recruiting experienced workers and those from industries with transferable skills, such as oil and gas. For floating offshore wind, for instance, oil and gas workers are considered well-suited to roles in fabrication (referring to the constructing or manufacturing of components, structures, or equipment used in the industry), subsea (relating to underwater operations and installations), and design and operation of floating platforms, moorings and cable solutions (OPITO, 2022).

Currently, however, re-skilling pathways for workers from oil and gas into offshore wind are unclear. Although skills transferability is thought to be high, training standards and qualifications are different across the two industries, which means that although a worker might have the skills to move from oil and gas into offshore wind, they may still be obliged to undertake unnecessary additional training. Ed Atkins, from the University of Bristol, addressed this issue and suggested that there is an opportunity to create common training and standards across the two industries where applicable:

> *"So as with lots of jobs, people have to take accredited training courses to fulfil the conditions of their work. So, [for] offshore oil and gas, for example, there would be a stipulation that you have to have had recent working from height training. Now, working*

in offshore wind would also stipulate the need for an accredited course being completed in working from height. So, there is a direct link there. We can have the same training for both things."

To address this re-skilling issue, skills passports—standardised documents detailing a worker's qualifications in a format which is recognisable across different industries—have been presented both by government and industry bodies (such as OWIC) as a solution. Both the 2019 Sector Deal and the 2021 North Sea Transition Deal outline commitments to delivering skills passports, although a lack of alignment between certification bodies across oil and gas has stalled its release (Pick, 2023).

Training availability challenges

A significant number of apprenticeships and courses specific to the offshore wind industry are not available in Yorkshire and Humber (Aura, 2018). For example, government Skills Bootcamps relevant to the offshore wind sector, such as Wind Technician Blade Repair, Wind Turbine Technician Electrical, and Wind Technician Painter, are largely unavailable in the HEY region, and this requires attention (HEY LEP, 2022).

Complex skills across the project lifecycle

Different stages of the project lifecycle for offshore wind farms, from seabed leasing through Contract for Difference (CfD) auctions (where offshore wind developers bid for contracts that guarantee a fixed price for the electricity they generate), require notedly different skill sets. This can create misaligned requirements at various stages of project planning. Moreover, competition between wind farm developers throughout these stages disincentivises long-term investment in training and skills. Scott Young, of Renewable UK and OWIC, described these complex, sometimes conflicting, skills required at different phases of the project lifecycle:

"If you look at the skill requirements that are placed on developers at the point at which seabed is leased by The Crown Estate, and through the planning process by local authorities as they seek development consent, and then subsequently again through the CfD auctions, all of those skills demands are not necessarily working in tandem to deliver

the same outcome. So, wind farm developers may find themselves having to meet multiple different skill requirements through each of those stages of a programme lifecycle, that actually, are seeking to do different things."

5.3.2 Recommendations for improving skills and training provision

Increased collaboration within the offshore wind industry could help tackle challenges, including fragmented re-skilling pathways and training availability, specific to Yorkshire and the Humber's offshore wind workforce. For instance, Scott Young suggested that collective efforts among offshore wind developers could help to streamline apprenticeship opportunities and ensure that industry workforce needs are effectively met: "If we all need people in electrical trades, it's not always possible for a single developer to make a cohort of apprenticeships viable for a training provider, but actually, if they all work together and have a number of apprentices, that suddenly makes a cohort viable for a training provider."

Similarly, James McIntosh, formerly at CATCH[9], advocated for a more collaborative industry-led approach: *"At the moment you get a lot of institutions, ourselves included, who go into a school or college, and their message is 'apply for me, come and sign up for my course' and that needs to change. There needs to be more industry advocates saying 'here's what our industry can do, here are the job roles that are available, and here are the different routes you can go down to access one of those jobs' [...]. That's the only way that you'll grow engagement by the numbers required."*

An example of industry collaboration in the region and nearby areas is a partnership between SSE Renewables, Equinor and Vårgrønn to build and operate the Dogger Bank Wind Farm (DBWF) in the North Sea off the Yorkshire coast (ekosgen, 2023). The construction of the DBWF begun in 2019, and this partnership has invested £1 million of an Offshore Community Fund to support Science, Technology, Engineering and Mathematics (STEM) education projects in the local authority areas of East Riding of Yorkshire, Redcar and Cleveland, and South Tyneside. Local education and skills stakeholders can propose STEM learning activities to the DBWF partnership based on locally

[9] An industry-led training partnership supporting the process, energy, engineering and renewable industries in the Yorkshire and the Humber region.

identified needs, with approved activities to date focusing mainly on schools. More time will be required to evaluate the longer-term effectiveness of this initiative in encouraging young people to take up STEM careers (ibid).

Additional recommendations, based on addressing barriers identified in the case study, are detailed below:

- Enhancing partnerships between high- and low-carbon energy industries to accelerate the rollout of skills passports and micro-courses for transitioning workers. Micro-courses, suited to re-skilling specific roles for entry into offshore wind, could work as additional accreditations and promote increased worker mobility. To support these initiatives and establish the UK as an international centre of excellence, the Government could provide funding for capital projects such as regional state-of-the-art facilities and training centres.

- The Government should review the regional availability of Skills Bootcamps and other free training schemes, ensuring that courses which may be important to reaching regional targets are accessible. It could also consider providing extra support to areas with below-average qualifications and higher deprivation levels, to address potential labour mobility limitations, and facilitate better access to training opportunities.

- Creating more awareness about jobs in offshore wind, based on promoting jobs and career progression opportunities for roles which are at risk of being in shortage. Doing this across the skills and learning sector, including schools and colleges, could help to encourage and inspire younger people to pursue relevant training. Given the size of regional ambitions for offshore wind, there could be value in industry collaborating on engagement and outreach strategies. This could be done on an international scale, through partnerships sharing best practices and training methodologies, and creating training programmes that allow prospective and actual workers to gain experience in offshore wind projects abroad.

- Increasing cross-industry collaboration to address the skills needed at different stages of the project lifecycle. Given the complexity of the project lifecycle for offshore wind, it could be beneficial for large- and small-scale developers to partner to create more standardised qualifications and courses for different roles. This would also help to provide smaller developers with more flexibility to take on apprentices and trainees.


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Section 6. Discussion and policy recommendations

This briefing paper has set out how the skills profiles of jobs across the UK's energy system, with a deeper focus on England, are shifting as a result of the transition to Net-Zero. Existing barriers to low-carbon skills development have been highlighted, as have the negative implications of emerging skills gaps. The previous sections have also drawn attention to the fact that the exact size and impact of these gaps remains elusive, with a paucity of data preventing a more in-depth understanding of how employment and competencies in sectors across the energy system are evolving. This section returns to these discussions, first providing a summary of findings, and then presenting policy recommendations for establishing clearer, more inclusive, skills development and training pathways into Net-Zero jobs.

6.1 Step change needed in skills policy for the Net-Zero transition

Energy transitions can take decades or generations (Bray, Mejía Montero & Ford, 2022). To realise a Net-Zero energy system in the UK by 2050, most low-carbon sectors will need to grow at pace. In particular, electricity generation and transmission, building heating and energy efficiency retrofit, and low carbon transport, will require significant workforce expansion and realignment (Reay, 2023). As set out in Section 3, there have been some initiatives from the Government in recent years to address the need for training centred around Net-Zero jobs and skills, but the scale of action and investment has so far been inadequate (Balata et al., 2023). Training pathways into green sectors are fragmented (Cedefop, 2018; Reay, 2023), and our case studies have identified significant skills gaps in offshore wind, EV manufacturing, and building energy retrofit. The fact also remains that the future direction for Net-Zero skills development and training is unclear, with no national strategy in place providing a framework for how the hundreds of thousands of appropriately skilled workers needed to sustain the Net-Zero energy system will be secured.

Across this briefing paper, the absence of clear, long-term policy commitments has been flagged as a key challenge to investing in skills and training. The impact of this is also exacerbated by the fact that sectors involved in the transition are often still in the early stages of development—even the offshore wind sector, where the UK is considered a world leader, has been described in a Global Wind Energy Council report as "comparatively young" when considered against long-established industries such as mining, ports and petrochemicals (Williams & Zhao, 2023). Given that Net-Zero sectors are mostly emergent, a lack of long-term policy direction creates conditions where employers are not incentivised to commit to longer-term training initiatives unless they are sure there is a need, and prospective workers are unlikely to take on training unless they believe there is employer demand (Aura, 2018). This lack of demand from either end then makes training providers reluctant to develop and supply suitable courses, even when this is an essential requirement for achieving Net-Zero across various sectors. Jagger, Foxon and Gouldson point to how this translates into a 'vicious cycle' where lack of skills creates policy uncertainty, and this dissuades the development of skills provision (Jagger, Foxon & Gouldson, 2013). In the long run, this adds to costs, reduces competitiveness and capabilities, and increases time spent providing on-the-job training (ibid).

Private sector training organisations and partnerships will continue to play an important role in developing skills and providing training, and this can include innovative delivery models such as apprenticeship schemes shared between employers, helping to support SMEs (Bieler et al., 2019), and renewable energy community benefit funds (e.g. Dogger Bank Wind Farm). However, the current low demand for private sector training in nascent Net-Zero sectors suggests that the market alone will not be able to stimulate the required levels of investment in training for low-carbon jobs (Briggs et al., 2022). Indeed, the Net-Zero transition also distinguishes itself from previous transitions by being policy-driven rather than market-driven (Botta, 2018), a fact which must be acknowledged when considering the required step change for boosting demand for training courses and apprenticeships. External policy drivers will be required to alleviate uncertainties and give both industry and individuals the confidence to invest in and pursue training. Specifically, current financing mechanisms for skills, including the Apprenticeship Levy, the Adult Education Budget and the National Skills Fund, do not explicitly address the need to 'green' the education and skills system (Balata et al., 2023). To this end, increased public investment—specifically designed with Net-Zero in mind—will be needed to enable the market (Briggs, 2022). The launch of recent schemes, including the Home Decarbonisation Skills Competition, suggests things are moving in a positive direction, but more action is needed to catalyse growth of the energy workforce across all key sectors, and avoid making the transition more costly (Jagger, Foxon & Gouldson, 2013).

In a similar vein, whilst increased devolution of skills policy should be beneficial to the Net-Zero transition, given that regions are able to adapt training provision to build on existing competencies (Froy et al., 2022), this change has also coincided with funding cuts, limiting the agency of regional actors. Essentially, creating space for regional and local decision-making will not be sufficient to ensure alignment with the Net-Zero transition if there is no additional funding support to accompany it. To this end, increased investment in regional centres of excellence and training facilities has been recommended (Whittard et al., 2024), and these could be sectorally-focused based on regional needs for the Net-Zero transition and the presence of existing and planned industrial capacity in each region. Additionally, more regionally allocated investment in skills, for instance, would provide regional authorities, such as Local Economic Partnerships (LEPs) and Mayoral Combined Authorities (MCAs), the autonomy to develop more ambitious, greener local skills improvement plans (LSIPs), and support FE colleges and other training providers to prepare for new and emerging skills requirements. As the case studies highlighted, this is important for regions whose working population faces additional challenges (including difficulties gaining the requisite skills due to a lack of labour mobility or flexibility).

In particular, FE colleges are already playing a crucial role in addressing the green skills gap. This paper has highlighted several examples of training courses and apprenticeships emerging in the UK which aim to attract more individuals into the low-carbon workforce. These examples are, however, too often the exception, with many education providers continuing to offer courses for jobs that are at risk of being entirely phased out. Additionally, as Dave Reay, from the University of Edinburgh suggests, Net-Zero principles and skills will need to be embedded across all types and stages of training—a 'greening' of the curricula will need to take place across the education and skills landscape, while ensuring that the competencies being developed are flexible enough to respond to unknown and changing industry needs (Reay, 2023). In the short term, this means that traditional FE courses for jobs in energy should be adapted to include green modules and incorporate low-carbon skills where relevant to current and future roles. In the longer term, this means courses focused explicitly on providing high-quality training for low-carbon jobs will need to be developed and rolled out in large numbers across the UK.

The case studies in this paper illustrate that whilst the skills requirements across sectors may vary, different sectors face shared challenges, e.g., issues related to a lack of training availability and demand, and unclear project pipelines. Given that energy sectors are at different

stages of maturity in decarbonising to Net-Zero—with more established sectors better able to estimate emerging and future skills needs—further collaboration and knowledge-sharing between sectors should be encouraged. The offshore wind sector, for instance, has a comparatively clear sense of specific roles and associated skills which will be needed to support workforce growth. Increased cooperation and transparency across sectors at varying stages of maturity would also allow more nascent sectors to adopt best practices from the outset.

6.2 Re-skilling, diversifying and growing the workforce

Different approaches will need to be taken when creating training pathways into low-carbon jobs, depending on whether the intention is to attract and train younger workers, or to re-train transitioning workers.

For people working in industries which will need to be phased down, ready access to high-quality re-skilling programmes will be acutely important. Sectors expected to decline, such as oil and gas, will need to form closer links with industries needing to grow, to ensure that there are clear and direct routes into new jobs. Workers who are vulnerable to job losses will need to be consulted throughout this process, since engagement with affected communities is a prerequisite for a just transition (Diski, Chapman & Kumar, 2021), and previous instances of industrial restructuring highlight the importance of including all impacted stakeholders in planning (Botta, 2018). Additionally, considerations should be made on how to strengthen national labour market regulations to ensure that company transition plans include socially inclusive policies and create 'flexicurity' (a combination of security and flexibility) for transition-vulnerable workers (Botta, 2018). Effective approaches in previous industrial transitions include regulations requiring employers to provide sufficient termination packages and early dismissal notices, and collective bargaining agreements to provide early access to re-skilling opportunities, as done for example via Job Security Councils in Sweden (ibid).

> Ed Atkins, from the University of Bristol, stated: *"We need this kind of re-evaluation of how education can be provided to support that pipeline of workers at risk, because right now we're saying to them, 'your job that you have been told would be a good job is no longer that, and we're going to phase it down'. We need to say 'this is how you're going to do better, this is your future, and this is your control over it'"*

Our review of literature and the case studies reveal that training options for those needing to be re-skilled should consider possible labour mobility and accessibility limitations. Ensuring there are locally present, flexible opportunities to learn will help to overcome these challenges. Specifically, this could include developing more training courses which include hybrid (in-person and online) teaching methods and are delivered at flexible times, as well as introducing more modular courses or micro-credentials for those who only need a topping up of existing skills. Skills passports could be particularly valuable to those moving across sectors into comparable roles, for instance, from oil and gas to decommissioning and subsea network projects (Robert Gordon University, 2021). Re-skilling support also goes beyond considerations about the training itself; it could also include removing financial barriers by providing paid time off for training and sabbaticals, and funding skills vouchers (Green Jobs Taskforce, 2021).

It has been proposed that green jobs are more skills-intensive than non-green jobs (Valero et al., 2021; Sato et al., 2023), suggesting that new green job opportunities may be less accessible to low-skilled workers. Sato et al. propose to this effect that one of the key challenges in maintaining vital public support for Net-Zero is making sure that displaced workers, particularly those in 'low-skill (mostly manual) occupations' are able to find new jobs of a similar quality (Sato et al., 2023). A review of recent international evidence on low-carbon job creation suggests, however, that while green jobs may generally require higher skills than non-green sectors, renewable energy jobs vary in skill level and are not always or necessarily more skilled than occupations in higher carbon energy sectors (Hanna, Heptonstall & Gross, 2024). For example, the transition to renewable energy is likely to also generate demand for lower-skilled, manual occupations in solar PV installation and offshore wind construction activities (ibid). To ensure societal support for Net-Zero, action will need to be taken to make individuals across the skills spectrum aware of, and able to access, these new green jobs as they appear.

Training pathways will also need to be created to bring new, diverse talent into low-carbon sectors. Recent international analyses have brought the gender and ethnicity implications of the transition into focus, suggesting that unless active measures are taken to address discriminatory barriers, low levels of diversity are likely to persist (ILO, 2018; IRENA, 2021). To this end, the need for dedicated, gender- and ethnicity-sensitive labour market policies has been underlined (IRENA, 2021; Aldersgate, 2020; Sofroniou & Anderson, 2021; Green Jobs Taskforce, 2021). The Green Jobs Taskforce report presents possible avenues for improving recruitment practices, including through diverse representation in recruitment panels, introducing anonymous application forms, creating a

culture of inclusivity within organisations, and providing diversity and inclusion training for leaders and recruitment teams (Green Jobs Taskforce, 2021). To attract a wider pool of talent, low-carbon energy sectors will need to be inclusive and respectful places to work, where underrepresented groups are not liable to be discriminated against. Creating more inclusive training pathways into low-carbon careers could also involve connecting younger students with female or BAME role model workers and ensuring that promotional campaigns for green courses feature diverse representation.

Systematically creating a more diverse workforce will also require more detailed labour market information and data collection, so that stakeholders can map where and how targeted interventions for diversifying the workforce can be brought in. Given that data is often not disaggregated at gender and ethnicity level (as illustrated by the LCREE survey), it is recommended that government and employer surveys take action to widen the scope of demographic data collected. As far as possible, metrics related to gender, ethnicity, and social background should be included, published, and regularly updated.

6.3 Improving data for monitoring progress

One of the most critical challenges to developing training courses that respond to the needs of the labour market is the lack of national, consistent, granular data. The existing Standard Industrial Classification (SIC) and Standard Occupational Classification (SOC) do not provide the detailed data needed to understand changes in occupational skill profiles. Drawing inspiration from U.S. databases such as O*NET, it would be beneficial to have more detailed lists of associated skills and activities for defined occupational roles, including information about skill level, the 'greenness' of skills, and the required soft and hard skills. In relation to the latter, Alison Greig, from Anglia Ruskin University, observed:

> *"I think people talk about green jobs and what they mean by that largely are jobs in the environmental goods and service sector, [...] absolutely we need those jobs. There are technical requirements for those jobs, and we can't escape that, and we need to transition people from maybe the technical skill set that they have at the moment, to different technical skills. However, sitting alongside these is also a set of critically important soft skills, and these are often overlooked. Furthermore, these soft skills are important for all job roles in all sectors, not only those in the environmental goods and service sector."*

Introducing new roles specific to green industries, along with their associated skillsets, into existing databases would additionally help to keep track of the evolving labour market. For instance, the National Retrofit Hub is currently developing a list of occupational standards for jobs in the retrofit sector. Similarly, the ONS have begun to ask questions related to green jobs in their standard surveys (ONS, 2024). These are important steps towards understanding the green skills gap, but it will be most effective if integrated on a national level.

6.4 Introducing a national Net-Zero Skills Commission

To specifically meet these extensive data needs, it is recommended that the Government establish a new, independent statutory body—a national 'Net-Zero Skills Commission'—which would take on monitoring, research and advisory roles to support the development of skills for the Net-Zero transition in England. This commission would collaborate closely with Skills England and devolved administrations in Scotland, Wales and Northern Ireland, given the devolved structure of skills and education policy. A comparable international example to the proposed commission is the French "Observatoire national des emplois et métiers de l'économie verte", which has monitored the sectoral and economic impact of the transition since 2010, providing regular reports on green jobs and skills. Specifically, it is charged with defining what occupations and skills fall under the scope of the 'green economy,' monitoring and updating on how these are evolving, and providing recommendations for policy accordingly (GOUV FR, 2023). The Net-Zero Skills Commission would be set up to review existing occupational standards, identify and analyse ongoing and emerging skills gaps, and provide expert advice on improving training routes into the low-carbon workforce. As an independent statutory body, structurally comparable to the Climate Change Committee (CCC), this commission would not be subject to the same risk of being discontinued as with previous government-led skills units. It could also be mandated to release yearly progress reports against job creation and skills development targets, providing recommendations which the Government would be required to respond to.

This commission would also be charged with developing a national Net-Zero skills strategy, accounting for now until 2050. The strategy would present a policy roadmap for preparing the skills system for the Net-Zero transition, considering regional and sectoral differences. It would provide recommendations for leveraging private and public investment in skills, while also focusing

on making the skills aspect of the transition socially inclusive and resource efficient. A range of stakeholders would need to be included in this process, namely representatives from the national government, industry (including SMEs), local authorities, citizen groups, worker unions, education and training providers. The commission would incorporate the principles of a 'just transition,' ensuring that systematically disadvantaged or vulnerable communities are centred within decision-making. One strategy to achieve this could be to integrate representatives from these communities into the governance structure of the commission, providing them with a platform to influence policies and initiatives directly.

6.5 Policy recommendations

Based on the discussion above, we set out a range of recommended actions that should be prioritised between now and 2050:

- To tackle the green skills gap, we need a coordinated national Net-Zero strategy. It is recommended that a new, independent statutory body be established to monitor, research and advise on the development of skills for Net-Zero in England. While accounting for similar or parallel initiatives in Scotland, Wales and Northern Ireland, this national 'Net-Zero Skills Commission' would:

  - Develop a national Net-Zero skills strategy, accounting for now until 2050, with actionable, long-term plans for transforming the skills system to meet Net-Zero requirements. This would additionally include producing sectoral national skills plans, such as a National Retrofit Skills Strategy. A range of stakeholders would need to be included in this process, namely representatives from the Government, industry (including SMEs), local authorities, citizen groups, trade unions, education and training providers. This strategy should consider different regional, local and sectoral needs, and take into account how the skills aspect of the transition can be made socially inclusive.

  - Review existing occupational standards for Net-Zero jobs, analyse and identify ongoing and emerging skills gaps, and provide expert advice on improving training and education pathways accordingly. This could include being mandated to release yearly progress reports against Net-Zero targets, providing recommendations for the Government to respond to.

- Review and update occupational metrics to include distinct classifications for low-carbon jobs and skills. This should involve developing detailed lists of associated skills and activities for defined occupational roles, and introducing new roles specific to green industries within existing data and classifications, such as the ONS LCREE survey, SIC and SOC.

- Private sector training organisations and partnerships have an important role to play in developing Net-Zero skills and providing training, and these can include innovative delivery models such as shared apprenticeship schemes and renewable energy community benefit funds. Clearer, more consistent and long-term policy support is needed to create conditions where employers are incentivised to commit to longer-term training initiatives, thereby increasing the likelihood of prospective workers taking on training where they have higher confidence that sustainable employer demand in low-carbon jobs exists.

- Current public financing mechanisms for skills, including the Apprenticeship Levy, the National Skills Fund, and the Adult Education Budget, should be reviewed to see how funding can be better directed towards the development of training for green jobs. Additional public funding should also be leveraged to support long-term development of skills for Net-Zero, specifically for FE colleges and training providers to be able to develop new, high-quality green courses and overcome low participation rates. There is also a case for targeted funding for SMEs who cannot afford to send staff to be trained or take on apprentices.

- To ensure that the skills being taught are flexible enough to respond to evolving industry needs, a 'greening' of the curricula will need to take place across the skills system. This means that FE college training courses for traditional, non-green jobs should consider how and which green skills may be relevant to both current and future roles and integrate these within teaching where practicable. It also means that the current number of low-carbon FE courses will need to be significantly upscaled.

- Increased public investment in the development of regional centres of excellence is recommended. These centres can act as focal points for training, research and development related to Net-Zero jobs and skills. They can also specialise in different low-carbon energy sectors according to regional decarbonisation needs and the presence of transitioning industries, and help to ensure that opportunities for scaling up the low-carbon workforce are more evenly geographically distributed.

■ Training and education providers will need to consider possible labour mobility and accessibility limitations faced by individuals aspiring to join the Net-Zero workforce. Ensuring there are locally present, flexible opportunities to learn will help to address these challenges. More specifically, this could include developing more training courses which include hybrid (in-person and online) teaching methods delivered at flexible times, as well as introducing more modular courses or micro-credentials for those who only need a topping up of existing skills.

■ For people working in industries which will need to be phased down, ready access to high-quality re-skilling programmes will be important. Closer links between sectors expected to be displaced, such as oil and gas, and sectors expected to grow, will help to create clear and direct routes into new jobs. Additional financial support should be made available for overcoming barriers to re-skilling, such as paid time off for taking on training, sabbaticals, and skills vouchers. In cases where employment termination is inevitable, decent termination packages, early dismissal notices, and early access to re-skilling opportunities could be provided. It is also recommended that workers who stand to be affected are involved in the transition planning process.

■ To increase public awareness of green job opportunities and career pathways, engagement with local and regional community groups and schools (e.g. through media campaigns, workshops and talks) is recommended. This could help to demystify what is meant by 'green jobs', and stimulate more public interest in joining local, low-carbon industries.

■ To attract a wider pool of talent, green sectors will need to be inclusive and respectful places to work, where underrepresented groups are not liable to be discriminated against. The Green Jobs Taskforce report presents possible avenues for improving recruitment practices, including through diverse representation in recruitment panels, introducing anonymous application forms, creating a culture of inclusivity within organisations, and providing diversity and inclusion training for leaders and recruitment teams (Green Jobs Taskforce, 2021).

■ Systematically creating a more diverse workforce will also require more detailed labour market information and data collection. Metrics related to gender, ethnicity, and social background should be included, published, and regularly updated within industry and government surveys. This would provide a clearer understanding of where targeted interventions for diversifying the workforce could be implemented across different sectors, at varying levels of governance (including local, regional and national) as well as training providers and industry.

Appendices

Appendix 1: Table of keywords used for the rapid evidence assessment (REA) search

Green jobs	Policies	Training and skills	Energy (general)	Energy system (green)	Energy system (brown)
"labour market"	standards	education	"energy sector"	retrofit	"brown sector"
"green jobs"	regulations	training	"energy efficiency"	"energy efficient renovation"	"natural gas"
"low carbon jobs"	strategy	skills	"low carbon"	"renewable energy"	"shale gas"
"green skills"	"net zero"	TVET	renewable	solar	"fossil fuels"
"supply chain"	"just transition"	"further education"	clean	"offshore wind"	
		apprenticeship	green	"onshore wind"	
		college		hydropower	
				"electricity grids"	
				"low carbon heat"	
				"heat pumps"	
				"electric vehicles"	

Table note

" ..." indicates a phrase where the complete phrase has been searched for, as opposed to individual words from which it is comprised.

Appendix 2: List of interviewees

The primary interview research carried out for this briefing paper received ethics approval from the Research Governance and Integrity Team at Imperial College London. All interviewees who participated in the research for this briefing paper are listed here. All quotes included in the briefing paper and the below attributions have been approved by the relevant interviewees.

- Scott Young, Head of Skills, Renewable UK (the UK's trade association for wind power, wave power and tidal power industries) and OWIC (Offshore Wind Industry Council).
- Ian Heptonstall, Director, Supply Chain Sustainability School (a collaborative initiative providing educational resources to promote sustainability across construction industry supply chains).
- Misato Sato, Assistant Professorial Research Fellow, Grantham Research Institute on Climate Change and the Environment, London School of Economics.
- Ed Atkins, Senior Lecturer, School of Geographic Sciences, University of Bristol.
- Alison Greig, Professor, Director of Education for Sustainability, Anglia Ruskin University.
- James McIntosh, currently Managing Director at Cogent Skills Apprenticeship Training; former Chief Operating Officer, CATCH (an industry-led training partnership supporting the process, energy, engineering and renewable industries in the Yorkshire and the Humber region).
- Deepak Farmah, Director, Electric Revolution Skills Hub (a digital platform providing a national skills resource for jobs and training in electrification).
- Benjamin Silverstone, Associate Professor, Head of Skills Policy and Strategy, Warwick Manufacturing Group (WMG, a department at the University of Warwick providing research and education in engineering, manufacturing and technology, and working closely with the automotive industry).
- Joe Kelly, Director and Co-founder, Baxter Kelly (an SME installing energy efficiency measures in homes (including insulation, heat pumps and solar panels).
- Pippa Palmer, Polln / LSBU & Co-Chair of National Retrofit Hub Working Group 3, National Retrofit Hub (a non-profit organisation that brings together stakeholders working in the retrofit sector).

Appendix 3: Sources for data in Table 1

Sector	Current workforce	Future workforce
Offshore wind	OWIC (2023) Offshore Wind Skills Intelligence Report 2023	OWIC (2023) Offshore Wind Skills Intelligence Report 2023
Onshore wind	ONS (2023) Low carbon and renewable energy economy, UK: 2022	Renewable UK (2021) The onshore wind industry prospectus
Solar PV	ONS (2023) Low carbon and renewable energy economy, UK: 2022	Renewable Energy Association (2023) Renewable Energy Review 2023
Nuclear	ONS (2024) Experimental estimates of green jobs, UK: 2024; Nuclear Skills Delivery Group (2023) Nuclear Workforce Data 2023	Nuclear Skills Delivery Group (2023) Nuclear Workforce Data 2023
Hydrogen	ONS (2024) Experimental estimates of green jobs, UK: 2024.	DESNZ (2024f) Green Industries Growth Accelerator: hydrogen and carbon capture, usage and storage supply chains
Carbon capture (utilisation) and storage (CCS / CCUS)	ONS (2024) Experimental estimates of green jobs, UK: 2024	BEIS (2019a) Energy Innovation Needs Assessment Sub-theme Report: Carbon Capture, Utilisation and Storage
Energy storage, smart systems and flexibility	ONS (2023) Low carbon and renewable energy economy, UK: 2022	BEIS (2019b) Energy Innovation Needs Assessment Sub-theme Report: Smart Systems
Energy efficiency and low carbon heating	ONS (2023) Low carbon and renewable energy economy, UK: 2022	CCC (2023) A Net Zero workforce
Low emission vehicles and supporting infrastructure	ONS (2023) Low carbon and renewable energy economy, UK: 2022	CCC (2023) A Net Zero workforce
Oil and gas (energy supply and refining)	Experian (2024) Estimating Employment and GVA impact of the UK Oil and Gas Industry: Stakeholder information document	CCC (2023) A Net Zero workforce

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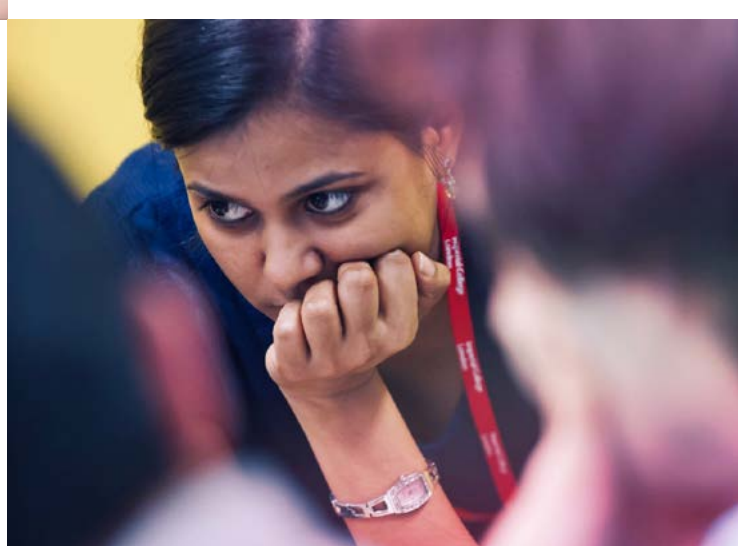
Founded in 2005, Energy Futures Lab is Imperial's oldest Global Challenge Institute. The Institute was set up to address global energy challenges by identifying and leading new opportunities to serve industry, government and society at large through high quality research and advocacy for positive change.

The institute aims to promote energy innovation and advance systemic solutions for a sustainable energy future by bringing together the science, engineering and policy expertise at Imperial and fostering collaboration with a wide variety of external partners.



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