Net zero workforce

An analysis of existing research

November 2022

Contents

1. Executive Summary

1.1. Introduction

Much of the decarbonisation required across the UK economy to achieve 'net zero' emissions, including energy and power, transportation and industry, will depend on new, innovative engineering solutions as well as the expansion of existing low-carbon engineering solutions. This will, in turn, require a workforce with the necessary numbers of engineers, technicians and scientists to deliver these solutions. Whilst much of the workforce that will deliver this transformation are already in employment, many are now coming through the education system.

This report attempts to summarise recent (2018 to 2022) reports on the 'green jobs' and engineering skills required to meet this challenge and presents recommendations for addressing some of the issues found.

1.2 Findings

The research for this paper covered 28 reports, most of which were published between 2020 and 2022. These reports tended to fall into one of 2 groups:
- original research and analysis for a specific economic sector; and
- an assessment of or a synthesis of existing research and analysis, often across multiple sectors.

Reports tended to take very different approaches to developing their jobs forecasts and there is a need for a consistent, standardised approach. It is therefore difficult to provide an overall picture of the jobs needs due to the disparities in the way figures were derived, and figures may not be comparable from sector to sector nor accumulative. Some of these inconsistencies are discussed below.

When reviewing the 28 reports, the following issues were identified.
- **New and direct jobs:** Jobs forecasts frequently neglected to state the proportion of future jobs that represented new jobs (that is, due to expansion of the market) and how many jobs currently existed. Few forecasts provided an estimate of the replacement jobs expected (to compensate for those leaving the sector). Similarly, forecasts often neglected to state whether the figure represented direct jobs only or included indirect jobs too.
- **Technical jobs:** Jobs forecasts rarely distinguished between those requiring engineering and technical skills (meaning those that would be classified as engineering occupations) and those that may arise within the engineering industry but do not require such skills, such as procurement or HR.
- **Back-casting**: In order to ensure that future jobs can be filled it is important to 'back-cast' to estimate the implications for engineering & technology apprenticeships and graduates, A levels and T levels. However, only one report mentioned STEM uptake in schools.
- **SICS and SOCS**: The ONS uses Standard Industrial Classification (SIC) and Standard Occupational Classification (SOC) codes to classify jobs. One key limitation is that these are created by coding jobs and industries retrospectively, which means that they may not reflect the latest job types or industry types.
- **Timescales**: All reports used different timescales to forecast jobs.

Some reports identified opportunities for re-training within their sector to balance areas of declining and increasing jobs demands, such as domestic gas boiler installation to heat

pump installation, internal combustion engine manufacture to electric motor manufacture, oil and gas to offshore wind or CCS and coal power to nuclear power. However, opportunities for movement between different sectors were rarely highlighted.

It is clear from the review that there is a strong demand for engineering skills. For some industries, this coincides with expected disruptions - for example, in the engineering construction sector, where an ageing workforce means the industry expects to lose 20,000 employees per year over the next 6 years[1]. Other sectors face steep re-skilling and recruitment forecasts due in large part to the UK decarbonisation target, for example:
- The energy sector will need to fill 400,000 roles by 2050, 260,000 of which will be new roles (equating to 65% and 10,000 each year)[2]
- In the buildings sector, retrofitting will require the training of 45,000 technicians each year at its peak in 5 to 10 years' time (30,000 each year in fabric improvement and 15,000 each year in heat pump installation)[3]

1.3 Recommendations

To address the issues identified above, and to enable government to deliver on its carbon reduction targets, we recommend that government:
- develop a clear definition of 'green jobs' or skills taxonomy that can be readily operationalised in frameworks such as the Standard Occupational Classification (SOC)
- review the SIC and SOC codes more frequently so as to develop up-to-date skills taxonomies which can differentiate between:
  - 'direct' and 'indirect' jobs
  - 'expansion' and 'replacement' jobs (as workers retire and so on)
- provide regular (for example, annual) statistics on:
  - numbers currently employed in each role
  - workforce demand forecasts
  and make the data derived from this analysis available to the different sectors in a timely fashion to enable them to act on those forecasts, particularly those sectors expecting significant disruptions, such as energy, engineering construction and the buildings sector
- strengthen the Unit for Future Skills to become the hub guiding government on workforce issues. The Unit should provide:
  - a regular national labour market forecast, ensuring it applies a holistic 'systems approach' that recognises the interdependencies between different industries
  - publicly available forecast data so that industries wishing to undertake more granular sector-level analysis can do so
  - regular 'back-casting' to identify the number of technical and engineering students needed to be entering STEM subjects from A level, T level and advanced apprenticeship level onwards
  - insights into the needs for reskilling and upskilling across different sectors of the UK economy
  - early warnings to government on anticipated skills shortages, together with policy recommendations as to how such shortages might be addressed
- use this information to develop an approach to STEM education that will ensure that these student numbers, and ultimately workforce needs, are met

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[1] ECITB 'Towards Net Zero: The implications of the transition to net zero emissions for the Engineering Construction Industry' 2020
[2] National Grid 'Building the Net Zero Energy Workforce' 2020
[3] CITB 'Building Skills for Net Zero' 2021

2. Introduction

In July 2019, the UK parliament passed legislation committing the country to become a 'net zero' economy by 2050. This pledge built upon an earlier commitment to reduce the UK's greenhouse gas emissions by at least 80% in 2050, compared to 1990 levels. Scotland has a net-zero emissions target year of 2045.

Since 2019, the United Nation's COP26 (held in 2021) has underlined the urgency of the need to decarbonise, both in the UK and abroad. The UK's Climate Change Committee has set a target of a 40% reduction in greenhouse gas emissions from 2020 to 2030, with an additional 20% fall required by 2035[4]. This equates to a massive 60% reduction in 15 years.

Meanwhile, the Labour Party has committed to 100% renewable electricity across the UK by 2030[5].

As one of the papers reviewed here[6] summarises: "Achieving this will mean that many decarbonisation projects – retrofitting the UK's 28 million homes, increasing public transport and cycling infrastructure, shifting from internal combustion engines to electric vehicles, expanding renewable power, creating new woodlands – need to be primarily delivered within the next decade".

Much of the decarbonisation required across the economy, including energy and power, transportation and industry, will depend on new, innovative engineering solutions (such as hydrogen networks and low-carbon air travel) as well as the expansion and optimisation of existing low-carbon engineering solutions (such as wind power). This will, in turn, require a workforce with the necessary numbers of engineers and scientists who have the sufficient knowledge and skills to deliver these solutions.

Whilst much of the workforce that will deliver this transformation during 2022 to 2035 are already in employment, many will require retraining or are now coming through the education system.

2.1. Purpose of this report

The purpose of this report is to provide the reader with a better understanding of the future demand for engineering and technical jobs in the UK as it responds to the 'climate emergency' (as declared by numerous developed jurisdictions and local authorities). The report attempts to summarise recent (2018 to 2022) published research on the 'green jobs' and engineering skills that will be required in the UK to meet this challenge and presents recommendations for addressing some of the issues found when reviewing and comparing the existing research.

A short glossary can be found in Appendix A.

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[4] CCC 'Progress in reducing emissions' 2021 (p.23)
[5] "…doubling onshore wind, trebling solar power, quadrupling offshore wind, tidal power, nuclear, hydrogen power and all underpinned by… £60 billion over a decade to insulate 19 million… homes…" (Ed Miliband, 2022)
[6] Transition Economics / Friends of the Earth 'An emergency plan on green jobs for young people' 2021 (p.17)

3. Findings

The research for this paper covered 28 reports, most of which were published between 2020 and 2022. These reports tended to fall into one of 2 groups:
- those presenting original research and analysis for a specific economic sector
- those synthesising existing research and analysis, often at a UK level

Table 1 summarises the job numbers found for each major sector of the economy which needs to respond to the net zero challenge; please note that not all jobs are necessarily engineering and technical jobs, an issue discussed in section 3.3. Source documents (including their reference numbers) are listed in Appendix C, Table 2 together with a more in-depth summary of their findings. Each section of Table 1 represents a sector of the UK economy that align approximately with those used by the Climate Change Committee, an independent, statutory body whose purpose is to advise the UK and devolved governments on emissions targets and to report to parliament on progress made in reducing greenhouse gas emissions.

Whilst many engineering roles already require green skills, environmental sustainability is something that all roles and sectors will need to factor into their work. The sectors highlighted below, and focussed on in this paper, are those that will need to deliver the lion's share of sustainability improvements across the UK.

A useful baseline is EngineeringUK's estimate[7] that 124,000 engineers and technicians are required every year to meet current and future demand for 'core engineering' roles to 2024.

Table 1: Main findings

			Source Report	
			Ref.	Date
TRANSPORTATION				
Electric vehicles		**Number**: 78,000 new jobs by 2040 (but loss of 28,000 jobs) **Location**: No data **Skills**: 60% at Qualification Levels 1 to 3, 20% Levels 3 to 5, 15% Level 6+	8	Mar 2020
Rail		**Number**: 7,000 to 12,000 additonal each year 2020 to 2030 **Location**: No data **Skills**: Qual Levels 3 and 5; Maintenance operative, engineer	11	Nov 2020
Aviation		**Number**: Up to 5,200 in sustainable aviation fuel **Location**: No data **Skills**: No data	12	Nov 2020
Shipping		No jobs forecasts found. ('Maritime 2050' (HM Government, 2019) foresees 'new, highly-skilled jobs' but does not quantify this forecast)		
Public transport & active travel		**Number**: 3,000 by 2025 **Location**: No data **Skills**: No data	12	Nov 2020
ENERGY & POWER				
Energy (all)		**Number**: 260,000 new and 140,000 replacement jobs, by 2050 **Location**: Across the UK, though 25% in north of England **Skills**: Skilled scientists and engineers in designing: data, new tech (CCUS, H_2), renewables, grid infrastructure. Skilled technicians in installation and maintenance of clean energy.	7	Jan 2020

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[7] Royal Academy of Engineering 'Engineering skills for the future: The 2013 Perkins Review revisited', 2019 (p.17)

			Source Report	
			Ref.	**Date**
Wind power		*Offshore* **Number**: 97,000 jobs by 2030 (61,000 direct, 36,000 indirect), an increase of 210% from today's 31,000 **Location**: Predominately Scotland and east coast of England **Skills**: 52% at Qualification Levels 5 to 7+	16	May 2022
		Onshore **Number**: 27,000 jobs by 2030; 31,000 jobs by 2035 **Location**: 60% in Scotland	28	Oct 2021
Solar PV		**Number**: 64,000 by 2035 **Location**: '…spread across the whole UK…' **Skills**: Various	25	Mar 2022
Wave & tidal		No jobs forecasts found. (However, The British energy security strategy' HM Government, 2022, commits to '…aggressively explore… opportunities afforded by… tidal…')		
Hydropower		No jobs forecasts found. (The 'British energy security strategy' 2022 did not include any reference to hydropower.)		
Nuclear		**Number**: 10,000 construction jobs (peak, per plant), 130,000 O&M (operation & maintenance) jobs in 2030 to 35 **Location**: Coastal **Skills**: No data	12 26 27	Nov 2020 Apr 2022 Q4 2020
Hydrogen	H	**Number**: 44,000 jobs across value chain by 2030 **Location**: North east (for 16,700 hydrogen production jobs) **Skills**: No data	23	Nov 2021
BUILDINGS				
Retrofit		**Number**: Heat pump installers: 12,400 by 2025, 50,200 by 2030, 70,000 by 2035 (N.B. there are 100,000 gas engineers; 22 training centres could retrain 7,000 installers p.a.) - Hydrogen boiler technicians: additional 200 to 1,500 per year - Fabric insulation install: Train 12,000 to 30,000 annually **Location**: Nationwide **Skills**: See above + Heat pump installers	9 13	Jun 2020 2021
INDUSTRY & CONSTRUCTION				
Engineering construction		**Number**: 120,000 replacement jobs by 2026 due to aging workforce **Location**: Nationwide **Skills**: CCUS-related, incl. hydrogen storage and ammonia cracking	6	2020
Climate adaptation		No jobs forecasts found.		
OTHER				
Energy-efficient products		**Number**: No significant increase **Location**: No data **Skills**: Highly skilled NVQ level 4+ in software engineering	10	Jun 2020
Circular economy		No recent jobs forecasts found.[8]		
CO2 removal (BECCS/DAC)		No jobs forecasts found. Climate Change Committee expects sector to ramp up rapidly from 2027 (p.198 of The Sixth Carbon Budget).		

As these findings indicate, the reviewed reports tended to take very different approaches to developing their jobs forecasts and there is a need for a consistent, standardised

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[8] 'Employment and the circular economy: Job creation in a more resource efficient Britain' (2015, by Green Alliance/WRAP) contains the most recent forecasts, but this was prior to the government's waste & resources strategy for England (2018), which does not contain jobs forecasts.

approach. It is therefore difficult to compare jobs forecast made in different reports or to provide an overall picture of the jobs needs due to the disparities in the way figures were derived, and figures may not be comparable from sector to sector nor accumulative. Some of these inconsistencies are discussed below.

3.1. What are 'green' jobs?

Our review has highlighted the lack of a clear definition of 'green jobs' and, correspondingly, an approach to quantify them. In the absence of this and a centralised approach to labour market forecasting, different sectors have sought to predict the number of jobs that are likely to arise in their respective industries. It is evident from these figures that there will be significant demand for engineering skills across a range of industries if we are to achieve net zero.

A review of 'green job' definitions is provided in Appendix A.

3.2. New jobs vs. existing jobs

When forecasting the future number of 'jobs supported', government reports did not state how many jobs were currently supported in the sector, nor whether these figures referred to 'direct jobs' only or 'indirect' jobs too (the latter being created in the value chain as a result of direct jobs). This makes it hard to quantify the number of new, additional direct jobs that can be expected.

Similarly, reports often did not distinguish between expansion demand versus replacement demand – that is, the number of job openings as a result of growth in the sector or occupation compared with the number of openings created by people leaving the labour market on a temporary basis (such as maternity leave or sickness) or a permanent basis (those retiring). Again, this makes it hard to quantify the number of new, additional direct jobs that can be expected.

Some reports identified opportunities for re-training within their sector to balance areas of declining and increasing jobs demands, such as domestic gas boiler installation to heat pump installation, internal combustion engine manufacture to electric motor manufacture, oil and gas to offshore wind or CCS and coal power to nuclear power[9]. However, opportunities for movement between different sectors were rarely highlighted.

3.3. Engineering jobs vs. all jobs

Many reports refer to jobs in the round, perhaps distinguishing between 'unskilled', 'skilled' and 'professional' but did not identify the number of jobs that require engineering and technical skills.

3.4. Back-casting from these forecasts

There appears to be no UK-level estimate of the number of engineers and technicians required to support the UK's net zero transition, and therefore no breakdown of the engineering specialisms needed, for example the number of electrical, chemical or mechanical engineering graduates and higher level apprentices. Extrapolating backwards further, there is no UK-level assessment of the required number of A level and T level students and apprentices in STEM subjects each year to satisfy the future engineering and technical needs. Only one report considered the number of students currently taking STEM A levels.

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[9] In particular, 'North Sea Transition Deal' (DBEIS/OGUK, March 2021) and 'UK Offshore Energy Workforce Transferability Review' (Robert Gordon University, May 2021) provide analysis within the energy sector.

3.5. SICs and SOCs

One key limitation to using existing data frameworks such as Standard Industrial Classification (SIC) and Standard Occupational Classification (SOC) codes is that these are created by coding jobs and industries retrospectively, which means that they may not reflect the latest (or future) jobs.

Although SOC codes have typically been revised every 10 years (SOC90, SOC2000, SOC2010, 2020) and SIC codes have been revised 7 times since they were first introduced in 1948, it is highly likely that these will need to be updated more frequently than once a decade if we are to capture emerging industry segments and new occupations in a rapidly evolving economy, such as 'EV charging point installer'.

3.6. Other issues

It should be noted that the job forecasts often utilise different time periods and methodologies. Consequently, it is difficult to obtain an overarching picture of the demand of green jobs. Moreover, because these forecasts have been estimated in isolation from each other, there is a risk that they do not take into account the considerable interdependencies between sectors to achieve net zero. Many of these sectors are inextricably linked. As we increase investment into renewable energy technologies, for example, we need to also consider the investment (and skills) required to enable the nation's grid infrastructure to distribute this energy.

3.7. Early warnings

It is clear from the review that there is a strong demand for engineering skills. For some industries, this coincides with expected disruptions – for example, in the engineering construction sector, where an ageing workforce means the industry expects to lose 20,000 employees per year over the next 6 years[10]. Other sectors face steep re-skilling and recruitment forecasts due in large part to the UK decarbonisation target, for example:

- the energy sector will need to fill 400,000 roles by 2050, 260,000 of which will be new roles (equating to 65% and 10,000 each year)[11]
- in the buildings sector, retrofitting will require the training of 45,000 technicians each year at its peak in 5 to 10 years' time (30,000 each year in fabric improvement and 15,000 each year in heat pump installation)[12]

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[10]ECITB 'Towards Net Zero: The implications of the transition to net zero emissions for the Engineering Construction Industry' 2020
[11] National Grid 'Building the Net Zero Energy Workforce' 2020
[12] CITB 'Building Skills for Net Zero' 2021

4. Recommendations

To address the issues identified above, and to enable government to deliver on its carbon reduction targets, we recommend that government:

- develop a clear definition of 'green jobs' or skills taxonomy that can be readily operationalised in frameworks such as the Standard Occupational Classification (SOC)
- review the SIC and SOC codes more frequently so as to develop up to date skills taxonomies which can differentiate between:
  - o 'direct' and 'indirect' jobs
  - o 'expansion' and 'replacement' jobs (as workers retire and so on)
- provide regular (for example, annual) statistics on:
  - o numbers currently employed in each role
  - o workforce demand forecasts

  and make the data derived from this analysis available to the different sectors in a timely fashion to enable them to act on those forecasts, particularly those sectors crucial to the UK economy achieving net zero, such as energy, engineering construction and the buildings sector
- strengthen the Unit for Future Skills to become the hub guiding government on workforce issues. The Unit should provide:
  - o a regular national labour market forecast, ensuring it applies a holistic 'systems approach' that recognises the interdependencies between different industries
  - o publicly available forecast data so that industries wishing to undertake more granular sector-level analysis can do so
  - o regular 'back-casting' to identify the number of technical and engineering students needed to be entering STEM subjects from A level, T level and advanced apprenticeship level onwards
  - o insights into the needs for reskilling and upskilling across different sectors of the UK economy
  - o early warnings to government on anticipated skills shortages, together with policy recommendations as to how such shortages might be addressed
- use this information to develop an approach to STEM education that will ensure that these student numbers, and ultimately workforce needs, are met

Appendix A – Glossary

CCC   Climate Change Committee
CCS   Carbon Capture & Storage
CCUS Carbon Capture Utilisation & Storage
COP26 26th UN Climate Change Conference of the Parties (held in Glasgow)
LCREE Low Carbon and Renewable Energy Economy
NUTS Nomenclature of Territorial Units for Statistics
O&M   Operations & Maintenance
ONS   Office of National Statistics
PEI   Professional Engineering Institutes
SIC   Standard Industrial Classification
SOC   Standard Occupational Classification

Appendix B – What are 'green jobs'?

The ONS has highlighted[13] different definitions within the 'green jobs' landscape, as set out in the table below, and concludes that "...there is no simple answer to the question "what is a green job?"."

Source	Term	Definition
United Nations System of Environmental Economic Accounting	Environmental Goods and Services Sector (EGSS)	"...areas of the economy engaged in producing goods and services for environmental protection purposes, as well as those engaged in conserving and maintaining natural resources."
International Labour Organization (ILO)	Green Jobs	"...They [green jobs] reduce the consumption of energy and raw materials, limit greenhouse gas emissions, minimize waste and pollution, protect and restore ecosystems and enable enterprises and communities to adapt to climate change. In addition, green jobs have to be decent."
UK Office for National Statistics	Low Carbon and Renewable Energy Economy (LCREE) survey	"economic activities that deliver goods and services that are likely to help the UK generate lower emissions of greenhouse gases, predominantly carbon dioxide"

The House of Commons Environmental Audit Committee [Source Report Ref. No. **21**] noted that "The government has not set out a definition of 'green jobs', or how it will measure progress towards its ambitions. There is no generally-accepted standard definition of a 'green job', nor single way to quantify them."

However, several of the source reports assessed within this document (see Appendix C) used the term 'green jobs' - two offered a definition of the term whilst others did not. The following table summarises the two, differing definitions offered:

Report [Ref. No.]	Term	Definition
Green jobs taskforce: report to government, industry and the skills sector [18]	green jobs	"...employment in an activity that directly contributes to – or indirectly supports - the achievement of the UK's net zero emissions target and other environmental goals, such as nature restoration and mitigation against climate risks."
Qualifying for the race to net zero [19]	net zero jobs	"...jobs related to the industries identified in the ONS Low Carbon and Renewable Energy (LCREE) survey."

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[13] See 'The challenges of defining a "green job"' (ONS, April 2021)

Appendix C – Source documents and research

This appendix summarises the key findings from each of the 28 source reports. It has avoided more general assessments of the engineering skills shortage (such as 'The Farmer Review of the UK Construction Labour Model: Modernise or Die' (2016)) or those focussing on a particular geographical area (for example 'Climate Emergency: Skills Action Plan 2020-2025' (not date) which deals with Scotland only). The reports considered are listed in Table 2.

Table 2: Reports considered

Ref. No.	Title	Publisher	Date of publication
1.	UKCS Workforce dynamics 2018 to 2035 – Shaping the skills of tomorrow	OPITO / Oil & Gas Institute	May 2018
2.	Skills and labour requirements of the UK offshore wind industry: 2018 to 2032	Energy & Utility Skills	Oct 2018
3.	Engineering skills for the future: The 2013 Perkins review revisited	Royal Academy of Engineering	Jan 2019
4.	Maritime 2050: Navigating the future	Dept. for Transport	Jan 2019
5.	Energy innovation needs assessment	Dept. for BE&IS	Oct 2019
6.	Towards net zero: The implications of the transition to net zero emissions for the engineering construction industry	ECITB (Engineering Construction Industry Training Board)	2020
7.	Building the net zero energy workforce	National Grid	Jan 2020
8.	UK electric vehicle and battery production potential to 2040	The Faraday Institution	Mar 2020
9.	Building the installer base for net zero heating	Heat Pumps Association	Jun 2020
10.	Local green jobs – accelerating a sustainable economic recovery	Local Governments Association	Jun 2020
11.	Back on track: gearing up to meet the increased demand for talent in the rail industry	City & Guilds Group and NSAR	Nov 2020
12.	The ten point plan for a green industrial revolution	HM Government	Nov 2020
13.	Building skills for net zero	CITB (Construction Industry Training Board)	2021
14.	Manufacturing sector net zero roadmap and Unlocking the skills needed for a digital and green future	Make UK (The Manufacturers' Organisation)	2021
15.	IET skills for net zero and a green recovery	IET (The Institution of Engineering & Technology)	Jan 2021
16.	Offshore wind skills intelligence model report	Offshore Wind Industry Council	May 2022
17.	An emergency plan on green jobs for young people	Transition Economics / Friends of the Earth	Mar 2021
18.	Green Jobs Taskforce: Report to government, industry and the skills sector	Green Jobs Taskforce	Jul 2021

19.	Qualifying for the race to net zero: How to solve the net zero skills challenge	Onward	Jul 2021
20.	Net zero strategy: Build back greener	HM Government	Oct 2021
21.	Green jobs	House of Commons, Environmental Audit Committee	25 Oct 2021
22.	Green jobs barometer	PwC	Q4 2021
23.	Hydrogen in the UK: Moving from strategy to delivery	Hydrogen UK	Nov 2021
24.	Closing the UK's green skills gap	Green Alliance	Jan 2022
25.	Solar's role in addressing the energy crisis	Solar Energy UK	Mar 2022
26.	British energy security strategy	HM Government	Apr 2022
27.	NSSG Strategic plan, winter 2020	Nuclear Skills Strategy Group	Q4 2020
28.	The onshore wind industry prospectus	RenewableUK	Oct 2021

Other publications were reviewed (such as the industrial decarbonisation strategy) but did not provide any quantitative analysis of the workforce impact, and so are not included in the list of source documents.

1. Oil and gas: 'UKCS Workforce Dynamics 2018 to 2035 – Shaping the skills of tomorrow' (2018)

This report envisages a range of pressures having a major impact on both the number and mix of jobs. These pressures are "…a significant number of fields … reach[in] the end of their life resulting in increased decommissioning activity… a drive for a lower carbon economy and an increased use of technology and automation…"

The report anticipates a fall in overall jobs from 170,000 (in 2017) to around 130,000 in 2035 - a fall of 24% over 18 years (or 1.3% each year). However, with 80,000 workers expected to retire or leave the sector over this same period, there will be a need to recruit '…over 40,000 people…' to make up the shortfall, meaning 2,220 new recruits each year. Around 10,000 of these will be "…in new areas such as data science, data analytics, robotics, material science, change management and remote operations."

However, this is just one (though considered the most likely by the report) of 3 scenarios presented; the other 2 scenarios have anticipated workforce levels of 65,000 and 110,000 in 2035.

How were the figures developed?
"The analysis was based on interviews and information received from over 35 companies and organisations. The information collected comprised representative data from both the operator and supply chain communities… The data was split into 23 job families comprising 74 distinct job functions, representing the majority of roles in the industry… The data was scaled up to reflect the total UKCS workforce as per the Oil and Gas UK 2017 Economic Report… A scenario planning approach was used to assess the possible 2035 UKCS workforce and skills requirements."

2. Offshore wind: 'Skills and Labour Requirements of the UK Offshore Wind Industry: 2018 to 2032' (2018)

The report anticipates a "…3-fold increase the number of operational turbines…" and consequently direct employment "…increasing from 10,000 jobs in 2017 to 36,000 in 2032…". These jobs are expected to be based in Scotland and along the east coast of England.

Whilst jobs will be created in all 7 project lifecycle stages (from site planning to decommissioning), 'construction and installation' and 'operation and maintenance' will together represent around 50% of jobs. When considering the skill levels of the new jobs, around 65% will be either 'management' or 'technical/professional'. In fact: "Employment demand will be strongest for technicians and engineers, with an estimated additional requirement for 10,200 by 2032."

How were the figures developed?
The report's employment projections were based on earlier research[14] which used "…an employment model originally developed for RenewableUK…". This was supplemented by a literature review and expert interviews.

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[14] Future UK Employment in the Offshore Wind Industry, Cambridge Econometrics, June 2017.

3. 'Engineering skills for the future: The 2013 Perkins review revisited' (2019)

This Royal Academy of Engineering report summarises progress made on the original (2013) report's recommendations to government and the engineering community (including Professional Engineering Institutions and business) which aimed to improve the 'supply of skills for engineering in the UK'.

Whilst the report's executive summary notes that the engineering profession is "…working to devise the solutions to many of today's global challenges including clean, affordable energy, ensuring safe and resilient infrastructure, supporting advanced healthcare, mitigating the effects of climate change…" there is no analysis of the skills requirements specific to these areas.

Instead, the report provides estimates of future cross-sector engineering employment, including the estimate that: "…124,000 engineers and technicians are required every year to meet current and future demand for 'core engineering' roles to 2024…" This figure is supported in the report by a quick analysis of current demographics: 6,000,000 existing engineers and technicians have a 50-year career span, suggesting a required replacement rate of around 120,000 each year.

How were the figures developed?
The report draws on a number of sources, including the 2 EngineeringUK sources included in this report as well as the ONS. However, it does not provide a methodology or approach.

4. Maritime: 'Maritime 2050: Navigating the future' (2019)

This 338-page government strategy includes the UK's ambitions for tackling both air pollution and greenhouse gas emissions associated with the maritime sector (vessels and ports). The strategy also anticipates the sector being 'radically transformed' by new technology (for example, autonomous shipping and smart ports). The impacts of each of these factors on the maritime sector's skills and jobs is not reported on separately. Instead, the strategy sets out qualitative (but not quantitative) predictions for skills and jobs in the sector overall.

The strategy predicts that "…the skills profile of the maritime industry will change as more technology and automation is used in the sector, resulting in more highly skilled and technical roles in the workforce…"

The strategy estimates that "…The marine industries employed over 99,500 people in 2015. These industries include the leisure marine and marine engineering sectors which encompasses shipbuilding, marine renewable energy, marine oil and gas support, and marine scientific and technical activities…" Whilst a figure for future employment is not offered, the report predicts that "…There will be a need for highly qualified personnel with the ability to create, operate, and maintain autonomous and technological systems. This will call for increasing numbers who have studied STEM subjects."

How were the figures developed?
A call for evidence invited contributions from both inside and outside the maritime sector. A series of stakeholder workshops were then held based on 6 strategic themes (such as technology and trade). A 'policy stress was then applied to emerging recommendations.
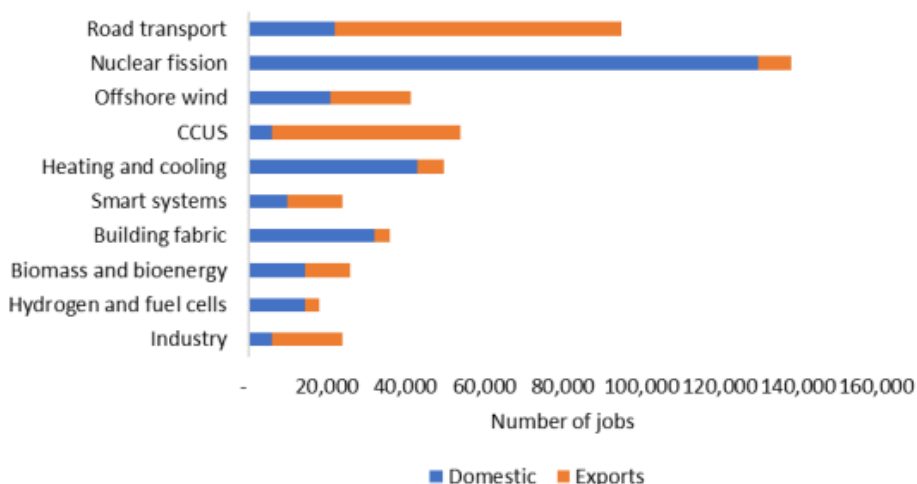
5. Energy: 'Energy innovation needs assessment' (2019)

This report, led by Vivid Economics, attempts to "…identify the key innovation needs across the UK's energy system, to inform the prioritisation of public sector investment in low-carbon innovation…"

It estimates that "The business opportunities analysed in the EINA could support approximately 500,000 jobs in the UK by 2050…" with the domestic market supporting 300,000 and the export market around 200,000. A supporting graph, reproduced below, indicates that nearly half of these jobs are expected to be created in just 2 of the 10 sectors analysed. These are:
- nuclear fission (140,000 jobs)
- road transport (100,000 jobs)

The assessment also notes that "…in particular nuclear fission, heating and cooling and building fabric support a relatively high number of jobs, primarily driven by O&M [operations and maintenance]…"

Figure 6.   **Overview of jobs supported in 2050**

Note: Domestic business opportunities were not sized for the tidal sub-theme
Source: Vivid Economics

However, "…not all jobs … will be additional. In particular, jobs associated with, for example, installation of heat pumps are likely to displace existing jobs associated with gas boiler installation. On the other hand, jobs associated with export opportunities are more plausibly additional."

How were the figures developed?
The EINA list was developed with the help of the Energy Technologies Institute's ESME (energy system modelling environment) prior to validation by energy experts. An analysis business opportunities and barriers led to their prioritisation.

6. Engineering construction: 'Towards net zero: The implications of the transition to net zero emissions for the engineering construction industry' (2020)

The engineering construction industry is involved with the "…the design, construction, maintenance and decommissioning of critical industrial and energy infrastructure…" and covers multiple sectors, including oil and gas, power generation (conventional, nuclear and renewables), water treatment, waste management, and the processing industries such as chemicals, pharmaceuticals, and food and drink.

"The industry employs over 190,000 staff, with a wide set of skills ranging from medium and high education qualifications to supporting and technical roles" in fact "…145 occupations...".

The report notes that "…The engineering construction industry is already facing the prospect of an aging workforce, with 91,000 engineers and 29,000 engineering technicians expected to retire or be close to retiring by 2026 and difficulties in recruiting new talent." Thus, the industry expects to lose a staggering 120,000 employees (63%) over the next 6 or more years (20,000 per year).

Of the 9 decarbonisation technologies that are anticipated to be introduced during the 2020s, none are expected to have a 'high impact' on skills. Five technologies, all associated with carbon capture and storage, are considered as 'medium impact' but these "…require similar skills to the chemicals and oil and gas industry...". In the 2030s, both hydrogen storage and ammonia cracking technologies are expected to have high impacts on skills.

How were the figures developed?
This study started with the identification of different decarbonisation technologies. Skills gaps were then identified using a combination of literature review and face-to-face workshops.

7. Electricity distribution: 'Building the net zero workforce' (2020)

"…the UK's energy sector needs … to fill 400,000 roles in the net zero energy workforce. Of this, 260,000 will be in new roles, while 140,000 will be replacing those who have left the workforce. The 400,000 breaks down as:
  • 117,000 between 2020 to 2030
  • 152,000 between 2031 to 2040
  • 131,000 between 2041 to 2050"

"…One fifth [20%] of people currently working in the energy sector are set to retire by 2030 as the 'baby boomer' generation reaches pensionable age."

"…UK adults cited lack of relevant qualifications as the biggest barrier to getting a job tackling climate change."

"Although more young people are choosing to study STEM subjects, building a net zero energy workforce will require a significant increase."

"**STEM uptake in schools**: Britain still needs to increase the number of students studying STEM A levels over the next decade. In 2019, 37,000 students took physics A level and 91,000 completed maths A level. Research … found that we need to

increase the number of A level candidates for physics by 24% and maths by 19% to maintain the pipeline of qualified talent Britain needs." Also, "…only 22% of 37,000 A level physics students…" were girls.

"**Apprenticeships**: Between 2016 and 2017 England's apprenticeship starts in engineering and manufacturing technologies fell … from 75,000…" to 59,000 (a 21% decrease)." Also, '…only 8% of all STEM apprentices…' were women.

"**Degree qualifications**: In 2017/18, around 42,000 undergraduates took engineering and technology courses... research estimates this number must grow by over 30% over the next 30 years, to 56,000 annual enrolments." Also, only '…15% of engineering and technology undergraduates…' were women.

A quarter of the 400,000 jobs are expected to be created in the north of England: 60,000 in the north west and 40,000 in the north east, due partly to the development of offshore wind.

The skills required are expected to be:
- **Digital and data**, including AI (artificial intelligence) and 'big data' which, for example, might be required to forecast power generation from renewables
- **Designing and implementing new technologies**, highly skilled scientists, engineers and designers will be needed to design & test new technologies such as effective carbon capture and hydrogen gas
- **Scientists and engineers skilled in renewable energy**, will be needed to install new wind farms and to build solar capacity
- **Skilled technicians to install and maintain clean energy solutions**, such as heat pumps in homes and a nationwide EV charging network

How were the figures developed?
The study started by estimating the likely clean energy mix required to reach net zero, using the Climate Change Committee's net zero 2050 report and National Grid Electricity Systems Operator's Future Energy Scenarios report. By understanding the contribution of each form of energy each year over the period 2020 to 50, "…Development Economics then sought to ascertain the levels of employment required to build, operate, manage, maintain and decommission the network of increasingly clean energy generation, transmission and distribution infrastructure…" using ONS data as well as other sources.

8. Automotive: 'UK electric vehicle and battery production potential to 2040' (2020)

N.B. This report by The Faraday Institution (March 2020) was based on the UK government's EV strategy of the time, 'The Road to Zero' strategy (July 2018), which pledged to "…end the sale of new conventional petrol and diesel cars and vans by 2040…" However, the government later revised the phase out target date to 2030, in a November 2020 announcement (that is to say, after the Faraday report).

The key to maintaining jobs in the UK automotive industry, the report points out, is to "…ensure that the UK has sufficient battery assembly plants…". This will ensure co-location of the other elements of the automotive manufacturing sector.

A 'central scenario' projects "…that battery pack, battery cell and electrode manufacturing will all be located in the UK. In this scenario, the overall industry

workforce of the EV and EV battery ecosystem would grow by 29% from 170,000 to 220,000 employees by 2040", a growth of 50,000 jobs: 78,000 new jobs which would offset a loss of 28,000 jobs in ICE (internal combustion engine) production. The 78,000 new jobs would be in:

- battery manufacturing: 24,500 jobs
- battery supply chain: 43,500 jobs
- EV manufacturing: 10,000 jobs

The following skills levels are anticipated:

Job types and skills required for a typical gigafactory

Job types	Typical employment activities undertaken	% split & qualification level
Production Operators	Material handling, machine loading, machine unloading, pack assembly, logistics, module/pack assembly, inspection	60% Level 1-3
Equipment Technicians	Machine service, machine maintenance, optimising machine performance, quality control, reviewing cost & delivery	15% Level 3-5
Engineers & Senior Staff	Facility engineers, process/production engineers, IT and data management, achievement of KPIs, legislation checks	10% Level 6 and up
Quality Technicians	In-process controls, confirmation of specifications (parts and supply), performance evaluation, assessment of defects	5% Level 4
Quality Engineers	In-process controls, confirmation of part /supply specification, performance evaluation, defect analysis	5% Level 6
Management & HQ functions	HR, finance, purchasing, IT and data management	5% Level 6 and up

In July 2021, planning permission for Britishvolt to build a battery 'gigafactory' in Northumberland was approved, and is expected to create 3,000 jobs, thus supporting the 'central scenario' assumptions.

How were the figures developed?
No methodology is provided in this paper (which is an update of a similar paper produced in 2019).

9. Buildings: 'Building the installer base for net zero heating' (2020)

This report estimates that around 70,000 heat pump installers will be needed by 2035 (12,400 by 2025, 50,200 by 2030), few of whom exist today. This works out as an average of 4,700 new installers per year over 15 years. However, the report also points out that "…there are over 100,000 registered gas engineers in the UK who are well capable of retraining to deliver low carbon heating…" Also, that the retraining capacity is already in place through 22 training centres with "…the ability to train an estimated 7,000 heat pump installers per year…"

How were the figures developed?
No methodology is offered.

10. 'Local green jobs – accelerating a sustainable economic recovery' (2020)

This report takes as its starting point the UK government's/ONS's definition of the "…low-carbon and renewable energy economy…" (LCREE) which is made up of 6 groups:
1. Low-carbon electricity
2. Low-carbon heat
3. Alternative fuels
4. Energy-efficient products
5. Low-carbon services
6. Low-emission vehicles & infrastructure

The ONS estimates (2018, see graph below) that the majority (71%) of the 185,000 full-time workers in the LCREE sector are employed in the energy efficiency sub-sector, which covers: insulation, lighting, monitoring and control systems. This pattern is similar to the latest ONS data (2019) where 60% of all LCREE workers are in the energy efficiency sector.
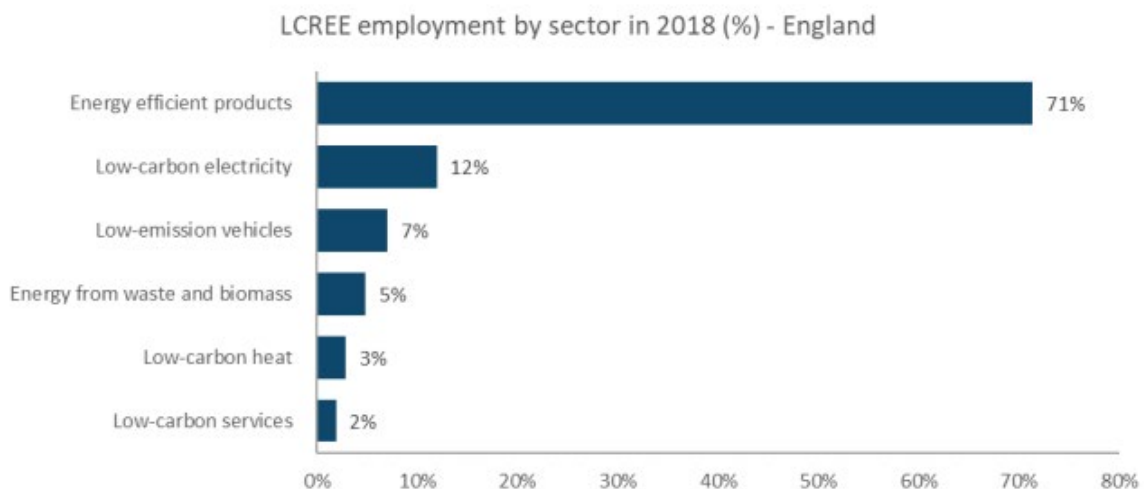

Figure 1 - current employment by LCREE sector (source: ONS)

The paper then estimates the number employed in each group in 2030 (694,000) and 2050 (1.8 million). The balance of jobs in the energy-efficiency sector is greatly reduced in these projections, with a much more even balance across the groups, as shown below. These estimates "…cover the value chain from manufacturing, construction and installation, to operation and maintenance…"

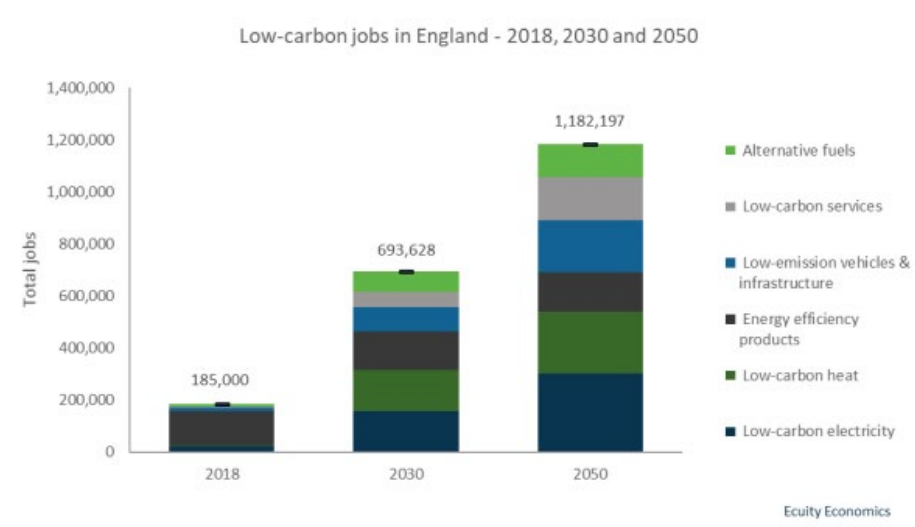Low-carbon jobs in England – 2018, 2030 and 2050

Figure 3 – low-carbon jobs in 2018, 2030 and 2050 (sources: ONS and Ecuity estimate)

The number of low-carbon jobs in 2050 is projected to be split fairly evenly across the 9 regions of England, ranging from 7% (north east) to 14% (north west, Yorkshire and the Humber).

The report assesses the anticipated skill level gaps for some of the sub-sectors, as summarised below.

Sub-sector		Comment on skill gap areas	Time horizon
Low-carbon electricity	Solar	Supply chain considered relatively secure, however an uptick in demand would require technicians to be trained at **NVQ level 3** equivalent to develop a larger installer base to deliver grid connected solar for utility scale/decentralised generation.	🟧
	Nuclear	Entire supply chain in need of upskilling to meet emerging demand; **NVQ level 1 to 3** for construction; **NVQ level 4+** for design and planning	🟥
Low-carbon heat	Heat pumps	Key skills gap area to meet increasing demand is in the design, specification and installation of heat pumps; **NVQ level 2 to 3**.	🟥
Alternative fuels	Anaerobic digestion	To meet forecasted demand, higher skill levels would be required **NVQ 4+** to design and connect AD plants to the grid and ensure biomethane is of sufficient quality for DNOs	🟧
	Hydrogen fuel cells	Highly skilled jobs (**NVQ level 4+**) for R&I required in future; a good stock of technicians expected to be available from existing automotive sector to meet manufacturing demand (meaning NVQ 1 to 3)	🟧
Energy efficient products	Smart controls	Highly skilled **NVQ level 4+** in software engineering is considered as a key skill to enable future innovations within the sub-sector; good stock of manufacturing technicians expected to be available (NVQ 1 to 3) for manufacturing demands	🟧
Low-carbon services	Consultancies and financial services	Highly skilled **NVQ level 4+** demand is ongoing and required to ensure service sector organisations can exploit emerging opportunities.	🟥
Low emission vehicles & infrastructure	Electric vehicles	Sector is expected to preserve jobs across all NVQ levels as existing, large automotive capacity in UK switches to ULEV technology. Ongoing R&I activities demands highly skilled researchers **NVQ Level 4+**	🟧

Key	Sub-sectors that are considered to have key near-term (2020 to 2025) skills gaps	🟥
	Sub-sectors considered to have a skills gap emerging in the longer-term (2025 to 2035)	🟧

21

"To inform the pathway over the next 30 years, Ecuity developed a time series for the uptake of each low-carbon technology. For example, the annual installed capacity of offshore wind was estimated between 2020 and 2050 based on the trajectory projected by the CCC or National Grid. This method would enable estimation of the annual workforce demand between 2020 and 2050 dependent on the projected installed capacity of each technology."

The insights on skill gap areas were developed from "…interviews have … undertaken with experts from individual sub-sectors to provide critical perspectives on the future requirements for green jobs, skills and training…"

11. Rail: 'Back on Track: Gearing up to meet the increased demand for talent in the rail industry' (2020)

This report is not a direct response to the UK's sustainability agenda, though it does acknowledge that "A growing area of skill requirement in the sector in the coming years will be linked to the rail industry's bid to become greener." Instead, it sees the key challenges for the rail sector being an aging workforce, retention issues, reliance on contract and oversees talent, and reputational issues.

It estimates that "…on average, between 7,000 - 12,000 additional people will be required every year over the next 5 to 10 years…with the biggest skills gaps due to open at levels 3 and 5…"

How were the figures developed?
"All … quantitative data cited in this report is taken from a survey commissioned by City & Guilds and undertaken by YouGov in October 2020. Research was undertaken amongst a sample of 2,057 adults between 6 and 7 October 2020, of which 1,532 were not retired. The survey was carried out online. The figures have been weighted and are representative of all UK adults (aged over 18). Unless stated otherwise, YouGov data cited in the report refers to an analysis of a sample of 1,532 UK adults not retired. Other data cited in the report comes from analysis provided by the National Skills Academy for Rail."

12. 'The ten point plan for a green industrial revolution' (2020)

This report states that "…our low-carbon industries already support of 460,000 jobs[15]…" It then provides estimates of "…the impact on jobs in the relevant low carbon sector and its supply chain in 2030…" which it estimates to be "…up to 250,000 by 2030…". Whilst only those jobs associated with 'Zero Emission Vehicles' are clearly identified as new jobs, the implication is that all are new jobs.

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[15] This figure claims to be sourced from the ONS's 'Low Carbon and Renewable Energy Economy (LCREE) Survey' but the 2019 LCREE dataset's central estimate is 412,000 FTEs across the UK: Low Carbon and Renewable Energy Economy (LCREE) Survey direct and indirect estimates of employment, UK, 2014 to 2019 - Office for National Statistics (ons.gov.uk)

Area	Jobs supported
1. Offshore wind	60,000 in 2030
2. Low carbon hydrogen	8,000 by 2030, potentially 100,000 by 2050
3. Nuclear power	10,000 during construction
4. Zero emission vehicles	40,000 **new** jobs in 2030
5. Green public transport, cycling & walking	3,000 by 2025
6. Aviation and shipping	5,200[16]
7. Buildings	50,000 in 2030
8. Carbon capture, usage & storage	50,000 by 2030
9. Protecting our natural environment	20,000 by 2027[17]
10. Green finance and innovation	100,000s by 2030

It should be noted that 'protecting our natural environment' covers nature conservation and restoration (non-engineering jobs), though the jobs forecast relates solely to improving flood defences (engineering jobs).

'Green finance and innovation' covers R&D in technology and engineering fields, such as Direct Air Capture and nuclear fusion, as well as finance, such as the Sovereign Green Bond. It anticipates "…300,000 jobs in exports and domestic industry…" by 2030 though does not provide a split between technical and non-technical jobs.

Not including 'Green finance and innovation', the above table totals 246,000 jobs in 2030, which is in line with the earlier estimate of "…up to 250,000 green jobs…"

How were the figures developed?
The guidance on methodology for jobs impacts states that: "…figures estimate the impact on jobs in the relevant low carbon sector and its supply chain in 2030. In most cases estimates are based on the number of full-time equivalent jobs and sustained HMG support required to deliver the deployment levels of low carbon technologies set out in the plan…"

13. Construction: 'Building skills for net zero' (2021)

This report focuses on buildings (residential and commercial) rather than built infrastructure (roads, bridges, drainage and so on). New build represents only 5% of the decarbonisation required, with retrofit of existing buildings representing 95%.

Retrofit will require a range of technical building skills including:
- Converting gas-supplied boilers to hydrogen boilers
- Upgrading building fabric, including insulation, airtightness and glazing
- Heat pump installation
- Photovoltaic panel and energy storage installation

The study states that "In 2018 … between 1.3 million and 2.7 million people were employed in the UK construction sector, depending on how it is measured." The following forecasts are provided:

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[16] Related to SAF (Sustainable Aviation Fuel)
[17] Improving flood defences

Skill areas	1 to 4 years	5 to10 years
Hydrogen (boilers)	Additional 200 FTE p.a.	Additional 1,500 FTE p.a.
Fabric (retrofit)	Train 12,000 p.a.	Train 30,000 p.a.
Heat pumps (installers)	Train 7,500 p.a.	Train 15,000 p.a. peak
Heat networks	Train 9,500 additional p.a.	Train 870 additional p.a.
On-site energy (PV etc.)	Additional 5,000 FTE p.a.	Additional 450 FTE p.a.

The report also provides projections of skills required (measured as additional FTEs above a 2019 baseline). This projection peaks at around 350,000 additional FTEs in 2028 (a 27% to 13% increase, depending on the 2018 baseline assumed) before levelling off to around 250,000 additional FTEs (a 19% to 9% increase) from 2029 through to 2045.

An alternative breakdown of skills is also offered. "…There are several CSN Occupational Groups where significant recruitment will be required in the early 2020s. These include:
- Construction project managers where a peak of 20,000 additional workers per year will be required
- Plumbing and HVAC trades where a peak of 15,000 additional workers a year will be required
- Labourers not elsewhere classified (n.e.c.) where almost 12,000 additional workers will be required
- Building envelope specialists where nearly 8,500 additional workers will be required."

How were the figures developed?
The 4 main elements of the methodology are:
- Literature review, using the Rapid Evidence Assessment (REA) methodology
- Interviews, 48 in-depth sessions with government, industry bodies, construction companies, academics and others
- Online survey, which received 280 responses
- Modelling, starting with the Committee on Climate Change (CCC)'s scenario of decarbonisation interventions, sufficient to deliver net zero emissions from the built environment, datasets were added to estimate the number of workers, and qualifications required to deliver the scenario

14. Manufacturing: 'Manufacturing sector net zero roadmap' (2021) and 'Unlocking the skills needed for a digital and green future' (2021)

This report covers "…manufacturing sub-sectors including food and drink, electronics, chemicals, paper, metal, and steel industries."

"The manufacturing sector also sees the need to develop the right skills within the industry to achieve net zero, in particular through the 'greening' of existing jobs, creation of new green jobs and educating employees across manufacturing businesses."
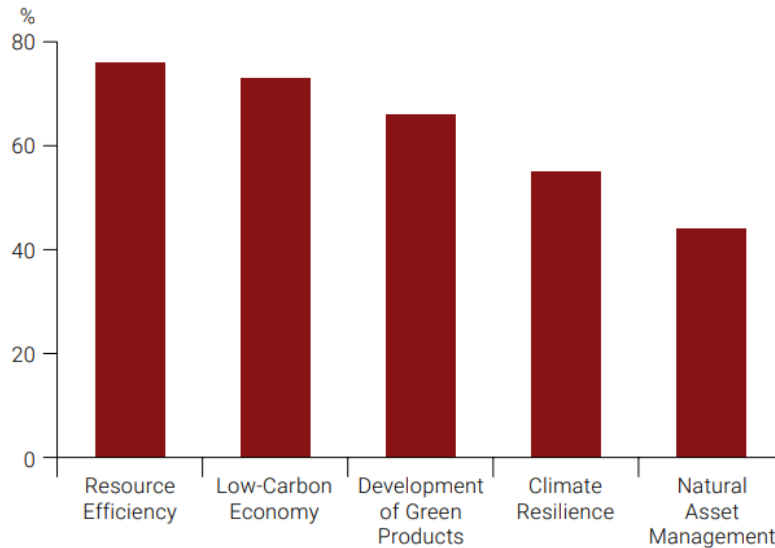
"…research tells us that the 3 technical skills that will be in most demand are:
- Resource efficiency, such as carbon accounting, lean manufacturing
- Low-carbon economy, such as nuclear, and renewable energy generation, carbon emission minimisation
- Development of new or amended products, such as design and production of

electric vehicles"

Note, however, that the manufacturing sector does not cover nuclear power or renewable energy generation.

The following chart shows "…where manufacturers expect to see skills demand changing in the next 5 years…":

Source: Make UK Green Skills Survey, August 2021

How were the figures developed?
Whilst both papers provide a list of references, neither provides a methodology.

15. 'IET skills for net zero and a green recovery' (2021)

This report "…focused on the skills requirements for delivering the UK government's net zero target by 2050…" as well as the impact of Covid-19 and the engineering skills gap. It does not attempt to estimate the number of jobs lost or generated during the transition to net zero.

When considering 'skills needed to reduce environmental impact', the top 3 anticipated changes were associated with reduced business travel and commuting. When considering 'skills needed to deliver organisation's sustainability strategy', the top 3 skills were: 'innovative thinking', 'management/strategic skills' and 'agility', with 60% of respondents expecting to meet these skills by 'upskilling/retraining existing employees'

How were the figures developed?
This report is based on research commissioned by the IET, conducted in partnership with YouGov in summer 2020. Employer's "…had to have a minimum of 6 employees and employ at least one engineering or technology staff member…" The survey was completed by 1,010 "senior decision makers". The sample was then "…weighted to be representative of engineering employers by size and region…"

16. Offshore wind: 'Offshore wind skills intelligence model report' (2022)

This report estimates that the offshore wind sector currently employs some 31,000 (of which 20,000 are 'directly employed'). This is forecast to grow to 97,000 jobs (of which 61,000 will be 'direct') by 2030, representing an increase of 210%.

The current workforce is made up of around 18% women, and 96% are white. The median age is 36-40 years old. Most jobs are located in Scotland (30%) and the east coast of England (31%), and this pattern is expected to remain the same in 2030.

Greatest jobs growth is anticipated in 'Skilled Manual', 'Semi Skilled Operative', 'Professional' (incl. lawyers) and 'Technical' (incl. engineers), as the following graph illustrates:

Figure 24 - Breakdown of UK offshore wind jobs by Job Role

How were the figures developed?
A survey was used to capture current workforce data; this was then extrapolated in order to develop a model representing the total current workforce. RenewableUK's Project Intelligence Database, as well estimated future investment, were then used to estimate the future workforce requirements.

17. 'An emergency plan on green jobs for young people' (2021)

This report makes the case for the creation of a 'Green Apprentice' programme to address the youth (aged 16 to 24) 'unemployment emergency' of 500,000 out of work with the possibility of '…over 1 million unemployed young people…' later in 2021. In fact, "453,000 young people aged 16 to 24 were unemployed in September to November 2021, a decrease of 45,000 from the previous quarter and a decrease of 137,000 from the year before[18]…" so the worst-case scenario did not materialise and the immediate

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[18] Youth unemployment statistics - House of Commons Library (parliament.uk)

problem eased slightly.

The report provides some interesting and potentially useful analyses of areas of the economy which may need green skills. These are categorised as:
- Agriculture, forestry, and land management
- Utilities (including energy and water)
- Manufacturing (including circular economy and hydrogen)
- Construction (including retrofit, climate adaption and EVs)
- Transport and logistics (including public transport)
- Services
- Education

Each category is then assessed qualitatively (so, 'yes' or 'no'), including whether:
- It has a 'current skills shortage'
- Whether it will require an 'expanded workforce' to achieve decarbonisation'

How were the figures developed?
Whilst each employment category's occupation is mapped to SOC codes, there is no explanation of how the qualitative "yes/no" assessments have been undertaken.

18. 'Green Jobs Taskforce: Report to government, industry and the skills sector' (2021)

This report draws on many of the reports referenced above. It defines a 'green job' as "…employment in an activity that directly contributes to … the achievement of the UK's net zero emissions target and other environmental goals, such as nature restoration and mitigation against climate risks."

"Across the UK there are already over 410,000 jobs in low carbon businesses and their supply chains, with turnover estimated at £42.6 billion in 2019, and the value of goods and services exported by UK low carbon businesses exceeding £7 billion."

The report focuses on 7 areas of the economy:
- Power
- Business and industry
- Homes and buildings
- Transport
- Natural resources
- Enabling decarbonisation
- Climate adaptation

It states that: "science, technology, engineering and mathematics (STEM) skills will underpin jobs that are key to taking forward the green recovery and delivering net zero…"

Finally, the report draws heavily on existing reports (see 'How were the figures developed?', below), most of which are already referenced above. Consequently, no new data or jobs figures are presented by the Green Jobs Taskforce.

How were the figures developed?
The Taskforce started by reviewing "…over 200 reports published by industry, academia, and government to form a robust evidence base…" This was followed by "…4 workshops with stakeholders from industry, academia, the skills sector, trade unions and community

groups [which] led to the development of over 300 policy ideas…" These ideas were then "…distilled…into 15 recommendations…" which were "…tested at multiple workshops with a wider set of stakeholders…"

19. 'Qualifying for the race to net zero: How to solve the net zero skills challenge' (2021)

Using the ONS 4-tier classification of skill, ranging from 1 (low skilled) to 4 (high skilled), this report by a "campaigning thinktank" estimates that "…the average occupational skill level of an employee in the UK is 2.74. Among net zero industries specifically, the average is 3.19, around 26% higher, demonstrating the considerable upskilling requirement inherent in net zero."

There are 139 NUTS level-3 regions in the UK. The report estimates that only 6 of these regions have "…a skill level sufficient for net zero, all located in London and the south east".

The report then provides a series of regional analyses, broken down by NUTS level-3 regions. These analyses include:
- **Skills gap**: the difference between the skill level required by net zero jobs (meaning 3.19) and the region's current skills level: "Scotland, the north west and the East Midlands suffer from the most acute skills gaps".
- **Low skills, high risk**: those areas that have a combination of low skill levels and a high proportion of jobs in carbon-intensive industries: "The regions that are most affected are disproportionately located in Scotland, the East Midlands and the north west of England".

The report presents additional analysis of upskilling needs by parliamentary constituency, as well as qualitative analysis (based on two focus groups, where "…respondents were not enthused by the moral imperative of environmental jobs… instead, they were motivated by higher pay, progression and social status…").

The report makes 9 policy recommendations, the most relevant to EngineeringUK's interests being:

2. Urgently develop new Apprenticeship Standards, T Levels and degree apprenticeships to support net zero industries
3. Specific funding should be offered to encourage the take up of net zero apprenticeship standards by women
6. Commission a review of occupation and industry data to improve the ability for departments and organisations to understand the green economy

The report concludes that "The UK's workforce is chronically ill-equipped for the transition to a green economy. If we are to hit the net zero target, we need many more scientists, mathematicians, engineers, technicians and retrofit installers than are currently available."

How were the figures developed?
A full 'Skills Gap Methodology' is provided in the report, explaining how the 2019 Annual Population Survey provided "…estimations of employment in each SOC code by …NUTS3 region…" and that the SOC code led to classification of skill level. Also, "…we define "net zero jobs" as jobs related to the industries identified in the ONS

Low Carbon and Renewable Energy (LCREE) survey…"

20. 'Net Zero Strategy: Build Back Greener' (2021)

This 367-page government strategy has a 19-page section devoted to 'Green Jobs, Skills, and Industries'. It states that "…We will need tens of thousands of engineers to build and maintain new offshore wind farms off the coasts of northern England and Scotland, construct nuclear power stations in the south of England, and manufacture electric vehicles in the Midlands; skilled builders and trades people to retrofit homes and buildings across the country…" It predicts that 1 in 5 (6.3 million) jobs "…are likely to be affected by the transition to a green economy…"

Whilst the strategy does provide forecasts of jobs in the green economy, they are all taken from the reports cited earlier in this paper. These forecasts cover:
- Offshore wind ("…60,000 jobs in 2030…")
- Construction & heating ("…230,000 skilled trades people could be required by 2030 to deliver retrofitting of houses and … installing…heat pumps… will need to increase the number of qualified installers from around 3,000 to 35,000 within the next 7 years…"
- Automotive manufacturing ("…50,000 workers… could need reskilling by 2025…")

The Technical Annex provides the following additional table (page 331) which "…the policies and sectoral ambitions across the net zero strategy are estimated to support…"

Table 12: Estimate of jobs supported in Net Zero Strategy pathways, by sector and date

Sector	Jobs supported by 2024/5	Jobs supported in 2030
Power	59,000	120,000
Fuel Supply	N/A	10,000
Industry	5,000	54,000
Heat and buildings	100,000	175,000
Transport	22,000	74,000
Natural resources, waste and F-gases (forestry only)	2,000	2,000
Greenhouse Gas Removals	N/A	N/A
Total	190,000	440,000

How were the figures developed?
The technical annex states that "…Skills evidence presented in the net zero strategy is largely drawn from the work carried out by the Green Jobs Taskforce and found in the published Green Jobs Taskforce report…"

21. 'Green Jobs: Third report of session 2021 to 22' (2021)

This Environmental Audit Committee "…inquiry into green jobs and the just transition…" examined:
- how green jobs could help tackle the anticipated rise in unemployment due to

> covid-19 in a sustainable way
- the jobs, skills and training needed to achieve the UK's longer-term climate and environmental ambitions
- the planning and work taking place to meet the government's green jobs ambitions

The report calls for the government to define the term 'green jobs' but does not present any analysis of green job numbers. However, it does states that:

"Key among the skills needs for a future, greener economy will be science, technology, engineering and mathematics (STEM) skills. Richard Kendall, of the Humber Local Enterprise Partnership, told us while it was difficult to predict employers' future skills demands exactly, the foundations would be 'STEM subjects primarily'…"

One recommendation (page 65) is:

"…that by the end of 2021, the Skills and Productivity Board, or similar body, is tasked with ongoing monitoring of skills needs, with regular periodic reviews, to ensure forward-looking and responsive skills planning which encompasses the needs of the economy in reaching the government's net zero and long-term environmental ambitions."

The government responded in its 'Green Jobs: Government response to the committee's third report: Fourth special report of session 2021 to 22' (10 Jan 2022).

How were the figures developed?
The inquiry's call for evidence received written submissions as well as oral evidence from witnesses. A roundtable event with young people was also held.

22. 'Green jobs barometer' (2021)

This quarterly report is structured around 5 'pillars' one of which is 'green job creation'. It does not attempt to forecast future levels of green job, Instead, it analyses 'green' job UK advertisements over the previous 12-month period.

Having defined 'green jobs' as "…work in roles that seek to either produce/provide environmentally friendly products and services or adapt work processes to become more environmentally friendly or use fewer natural resources…", it found that only 1.2% of advertise jobs were 'green' with the greatest proportion in the following sectors:
- Electricity, gas, steam and air-conditioning supply (21%)
- Water supply, sewerage and waste management (19%)
- Mining and quarrying (19%)

Other engineering-based sectors had very low proportions:
- Manufacturing (2.1%)
- Construction (1.6%)

PwC commissioned an agency to "…analyse more than 11.2 million unique [online] job vacancies advertised over 12 months, from July 2020 to June 2021…"

23. 'Hydrogen in the UK: Moving from strategy to delivery' (2021)

This report was used by the author to estimate the number of jobs associated with the British Energy Security Strategy (2022) ambition of 10GW of hydrogen by 2030.

The report, published after the ten point plan but before the energy security strategy, presents the following table:

		Government 10pt plan	Scenario 1 Low	Scenario 2 Central	Scenario 3 High
Production – installed capacity (GW)		5	7	14	22
Blue			5	8	13
Green			2	6	9
Demand – TWh		42	44	90	151
Industry			26	40	57
Blending for domestic and commercial heat			6	14	31
Power			9	27	37
Transport			1	5	12
100% domestic and commercial heat			0	0	6
Other (e.g. CHP, ammonia)			2	4	8
Impact					
Carbon abatement (MtCO$_2$e)		42 (cumulative)	13.7 (annual)	16.9 (annual)	29.1 (annual)
GVA – £bn			7.2	14.2	23.6
Jobs		8000	29,700	58,500	96,800

Table 4: The UK Government's 10 Point Plan as compared to Hydrogen UK's Three Scenarios

The energy security strategy includes target for hydrogen of 10GW of capacity by 2030, which sits approximately mid-way between Scenario 1 (Low) and Scenario 2 (Central). Extrapolating between the 2 suggests that around 44,000 jobs would be associated with 10GW of capacity. Note that this includes jobs in 'upstream' (production), 'midstream' (transmission & distribution) and 'downstream' (end use) - production jobs would be around 38% or 16,700[19].

"Offshore wind and CO2 storage assets are currently concentrated in the north, meaning that investment in hydrogen production is likely to create and protect more jobs in [these] areas…"

How were the figures developed?
No methodology is offered for either the government strategy or the infographic.

24. 'Closing the UK's green skills gap' (2022)

This report aligns with the Green Jobs Taskforce definition of 'green jobs' as those that

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[19] Implied from 'Economic Impact Assessment' (Hydrogen Taskforce, August 2020) where 38% of jobs (28,578 of 74,646) are "upstream" (i.e. production)

"…directly or indirectly contribute to reaching climate and environmental goals…" which "…includes both nature restoration and the circular economy…".

The report focuses on 6 sectors of the UK economy:
1. Buildings
2. Circular economy
3. Transport
4. Agriculture and land use
5. Power
6. Heavy industry

Buildings: The report draws on 4 previous reports, 2 of which have been reviewed earlier in this paper:
- Heat pump installers: 12,400 needed by 2025, 50,200 needed by 2030 [as identified in Source Report Ref. No. **9**]
- Building retrofitters: 12,000 upskilled workers annually rising to 30,000 each year. [as identified in Source Report Ref. No. **13**]
- Heat networks: 20,000 to 35,000 new direct jobs [source: Heat Networks Industry Council website]
- Manufacturing heat pumps: 10,000 jobs [source: 'Heat and buildings strategy' BEIS, October 2021]

The report also notes that most of the current 1.3 construction jobs are based in London, the south east and the east of England with far fewer in, for example, the north east (which has ~20% of the number employed in London).

Circular economy: This draws upon a single previous report[20] that an increase in reuse, repair, remanufacturing and recycling could generate 40,000 to 472,000 jobs by 2035.

Transport: Figures are drawn from 5 previous reports, 3 of which have been reviewed earlier in this paper:
- Automotive manufacturing: "…will require 50,000 people to be reskilled by 2025, increasing to 100,000 by 2035 to 2040…" [From in Source Report Ref. No. **18** which in turn uses an early Faraday Institute report as its source; the latest is in Source Report Ref. No. **8**]
- Battery cell manufacturing: "Between 7,500 and 10,000 workers could be needed … in 2030 [sourced from a 2019 Faraday Institute report; a more up to date figure is 24,500 as identified in in Source Report Ref. No. **8**]
- Aviation: "There could be up to 45,000 new jobs in the aviation sector by 2035" [sourced from 'The economics of aerospace: the economic impact of UK aerospace industrial strategy' (2017) Aerospace Technology Institute] but this figure is pre-pandemic, pre-COP26 and does not appear to be driven by any decarbonisation efforts.
- Rail: "…will need between 7,000 and 12,000 additional workers per year over the next 5 to 10 years…" [sourced from Source Report Ref. No. **11**]
- Public transport: the paper refers to Source Report Ref. No. **12** which anticipates 3,000 jobs by 2025.

Agriculture and land use: new jobs identified in this sector are principally non-engineering, for example, 16,000 jobs "…improving woodland, peatland and urban parks…" and elsewhere 'farm advisers'. However, monitoring of land use is increasingly dependent on the use of drones, GIS (geographic information systems)

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[20] 'Levelling up through circular economy jobs' The Green Alliance (August 2021)

and satellite-derived data, supporting highly skilled digital and high-tech jobs.

Power: Figures are drawn from 3 previous reports, one of which has been reviewed earlier in this paper. Please note, however, that this report pre-dates the British Energy Security Strategy (see Source Report Ref. No. 26).
- "Offshore wind employment is expected to increase 170% by 2026, to 70,000 employees…" [from Source Report Ref. No. **16**]
- "Tidal power employment is expected to grow to 4,000 jobs by 2030 and 14,500 by 2040…" [sourced from 'Offshore Renewable Energy Catapult', 2018, Tidal stream and wave energy cost reduction and industrial benefit]. The same source also forecasts that wave energy "…would also support a total of 8,100 jobs by 2040…"
- "…the North Sea Transition Deal is expected to support up to 40,000 direct and indirect supply chain jobs in…" the CCUS and hydrogen sector [sourced from BEIS, 2021, 'North Sea Transition Deal', though the source points out that this figure "…will include some of the jobs already set out in the PM's ten point plan".]

Heavy industry: Figures are drawn from 2 previous reports, neither of which has been reviewed earlier in this paper:
- "43,000 jobs in the decarbonisation of industrial sectors, like steel and cement, reaching 221,000 if the UK becomes a major hydrogen exporter…" [The source is given as 'UK concrete and cement industry roadmap to beyond net zero' (2020) by MPA UK Concrete, however this author could find no analysis of the impact on jobs in that document.]
- "Port upgrades could create over 150,000 jobs…" [the source is given as 'Can an infrastructure stimulus replace UK jobs wiped out by COVID19 crisis?' (2020) by TUC, however "upgrading ports and shipyards" is identified as providing 28,478 jobs.]

How were the figures developed?
No methodology is offered as all figures are derived from existing publications.

25. 'Solar's role in addressing the energy crisis' (2022)

From a current deployment of 14.6 GW of solar PV in the UK, this paper "…calls on the government to increase the capacity … and commit to a target of 40GW by 2030…" It estimates that "There are currently around 6,500 people employed in the UK solar industry…[which could]… increase to more than 42,000 [35,000 new jobs] if the UK commits to 40GW of solar by 2030." The called for increase in capacity is x2.74.

The British Energy Security Strategy (see below) expects a "5-fold increase in deployment by 2035". This suggests around 64,000 new jobs will be generated (from (5/2.74) x 35,000) by 2035.

"The solar industry recruits for roles ranging from business development experts, data analysts, distribution and logistics specialists, electrical engineers, energy finance professionals, environmental planners and natural capital experts, maintenance advisors, product researchers and developers, scientific and technical staff, solar cleaning specialists, and system designers, planners, and installers."

"Because of the distributed nature of the industry, these jobs will be spread across the

whole UK and not solely concentrated in any one region…"

No methodology is offered.

26. 'British Energy Security Strategy' (2022)

This UK government paper focuses on the following areas:
- **Oil and gas**: 2050 may see the UK still using "…a quarter of the gas that we use now…" and a "new lease of life for the North Sea…" from the development of CCUS (Carbon Capture Usage and Storage) sites which utilise depleted oil and gas caverns. No jobs forecast is provided.
- **Nuclear**: The paper looks to triple the amount of nuclear power, where "…each large-scale nuclear power plant could support up to around 10,000 jobs at peak construction."
- **Solar**: "We expect a 5-fold increase in deployment by 2035." No jobs forecast is provided.
- **Wind**: The ambition is 2 double offshore wind capacity by 2030; "We expect the sector will grow to support around 90,000 jobs by 2030". Onshore wind development will be considered where there is local support.
- **Hydrogen**: "We will double our UK ambition for hydrogen production to up to 10GW by 2030, with at least half of this from electrolytic hydrogen." No jobs forecast is provided, although one project alone (ITM's Gigastack) has the "…potential to support up to 2,000 jobs over time."
- **Energy efficiency (demand reduction)**: A variety of measures, including an increase in the "…deployment of heat pumps to 600,000 installations per year by 2028". No jobs forecast is provided.

No methodology is offered.

27. 'NSSG Strategic plan, winter 2020' (2020)

From a current capacity of 8 GWe of nuclear power, this paper considers 2 scenarios:
- Only "…well-established projects at Hinkley Point, Sizewell and Bradwell…"
- "…an indicative profile that doubled the final capacity to 18 GWe, constructed according to an arbitrary but realistic time scale…"

The British energy security strategy (above) plans to triple nuclear capacity i.e. goes well beyond the NSSG's second scenario, represented by the yellow lines in the images below:
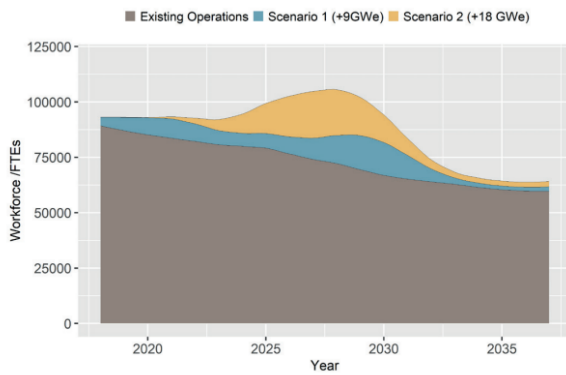
Figure 1 Overall demand for existing operations with two scenarios for civil new build
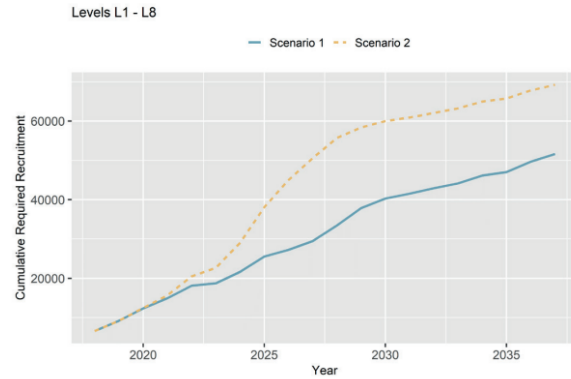

Figure 2 Calculated Cumulative Required Recruitment for two scenarios. Scenario 1 reaches 40,000 new or replaced FTEs, and Scenario 2 60,000.

Both scenarios show a decreasing workforce size, but "…with an ageing workforce and natural turnover, the replacement demand is still sizable…"

From these graphs, we can extrapolate approximately in line with a tripling of capacity to:

- An overall demand of ~130,000 FTEs in 2030-35, declining to ~75,000 FTEs by 2040.
- A cumulative required recruitment of ~80,000 new or replaced FTEs by 2030 (average 8,000 each year) and 85,000 FTEs by 2035 (average 5,600 each year)

How were the figures developed?
No methodology is offered.

28. 'The onshore wind industry prospectus' (2021)

This report states that "To meet the challenge of net zero, we must scale-up the growth of renewables and the industry has set an ambition for 30GW of onshore wind by 2030". This will have the added benefit of creating "27,000 high quality jobs" in the UK, 17,000 of which (63%) would be in Scotland. These jobs would be "…across development, supply chain and operations activity… peaking at 36,000 in the 2020s".

Most (64%) of the skills needed from 2021 to 2030 would be in 'Wind farm OMS' (which we assume stands for operations management systems).

How were the figures developed?
No methodology is offered. Modelling was undertaken by BVGA Associates.