Industry insights and analysis

Building Skills for Net Zero

Report prepared by Eunomia for CITB

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Study prepared by Eunomia from a commission by CITB.

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E.1.0 Executive Summary

E.1.1 Introduction

The United Kingdom is legally required to achieve net-zero greenhouse gas emissions by 2050[1]. Emissions from the construction sector account for as much as 40% of total national emissions, almost all of which will have to be eliminated over the next thirty years.

This will require a co-ordinated programme of interventions, such as energy efficiency retrofit, deployment of low-carbon energy, on-site generation, energy storage and smart systems. These interventions will need additional workers, equipped with the skills required to deliver them. This research characterises the skills required and proposes a route map to develop them.

The project has received input from a wide range of stakeholders, including:

- Construction Industry Training Board
- Department for Business, Energy & Industrial Strategy
- Committee on Climate Change
- Scottish Government
- Welsh Government

E.1.2 Methodology

The project has drawn on a wide range of sources of information, together with close collaboration with stakeholders, particularly CITB, BEIS and CCC. The four main elements of the methodology are set out below:

E.1.2.1 Literature review

An initial review of available literature was undertaken using the Rapid Evidence Assessment (REA) methodology to search documents for references to terms relating to the research questions. As the project progressed, the initial REA was supplemented with materials suggested or provided by interviewees and stakeholders. Additionally, during the research, several related research projects have published reports, which have also been integrated into this research.

[1] The Climate Change Act 2008 (2050 Target Amendment) Order 2019, https://www.legislation.gov.uk/ukdsi/2019/9780111187654

E.1.2.2 Interviews

A programme of 48 in-depth interviews was conducted across a wide range of respondents, representing government, industry bodies, construction companies, academics and other specialists. A topic guide was developed to ensure consistency, and interviews were recorded and transcribed to ensure accuracy. The findings of this exercise have been fundamental to development of the report, but were also used more immediately to inform a quantitative survey.

E.1.2.3 Survey

Based on the research questions and the findings of the qualitative interviews, an online survey was developed to gather more widely representative views. This received 281 responses and demonstrated a high level of engagement with the net-zero agenda.

E.1.2.4 Model

The Committee on Climate Change (CCC) has supplied an illustrative scenario of decarbonisation interventions, sufficient to deliver net-zero emissions from the built environment across the UK. To this scenario was added the results of additional research to establish the time and qualifications required to deliver the interventions, including generic skill levels (e.g. NVQ) and specific qualifications (e.g. F-gas). These datasets were used to develop a model which calculates the number of workers, and qualifications required to deliver the scenario.

The model itself is a deliverable of this project, so it can be used to assess the impact on training and employment of different scenarios. This report uses the output from running the illustrative scenario provided by the CCC, which is a balanced approach based on achieving the net-zero commitment.

E.1.3 Findings

Decarbonisation of the built environment can be usefully split into new-build and existing buildings. New-build tends to receive a lot of attention, and it is important that it should be considered, but in decarbonisation terms it represents around 5% of the problem and is much easier to address.

Zero-carbon new-build solutions have been available for decades and can be built at a small premium on existing build costs. Given the government's legal commitment to net-zero, every year that a requirement for zero-carbon new-build is delayed only builds in even greater costs in the future, and the cost and disruption of upgrading buildings is far greater.

The overwhelming weight of effort required to decarbonise must be focussed on net-zero retrofit of existing buildings. Apart from some case studies and demonstrators, there is currently very little activity in net-zero retrofit, and very little capacity. Over the next 29 years, every building in the country needs to undergo a major retrofit, and the people who will do it need to be recruited and trained. This research shows that this can

be done, but the amount of effort, and the degree of active planning and direction required, are unprecedented in peacetime.

Net-zero retrofit can only be achieved by the diligent implementation of carefully designed retrofit programmes, which are effectively bespoke for every building. It cannot be achieved by the blanket application of support for individual measures, as has been the case in recent policy interventions. Net-zero retrofit costs tens of thousands of pounds per household, and there are almost thirty million households, so the total cost for the domestic sector alone will be hundreds of billions; with non-domestic retrofit adding around another 50%, the total cost of net-zero retrofit of the built environment is expected to be in the region of £1 trillion, or about £35 billion a year.

This project is concerned with delivery of the skills required to achieve net-zero across the UK built environment. However, stakeholders and interview respondents representing a wealth of experience across the sector have been consistent in characterising what else is required before decarbonisation can be achieved.

The UK will not achieve net-zero without making immediate and significant changes to the construction sector. There is currently little incentive to reduce greenhouse gas emissions from buildings and not enough financial support to do so, the quality of work is not good enough and there are not enough skilled workers to do it. To achieve net-zero, all of these issues must be resolved. This report focusses on the last of these but, where commentary has been provided or recommendations proposed to address the other points, this too is reported. Taken together, the proposed solutions, or alternatives, are enough to deliver the net-zero commitment.

In 2018 (the most recent year for which data are available), between 1.3 million[2] and 2.7 million[3] people were employed in the UK construction sector, depending on how it is measured. The model developed for this research is intended to provide insight into particular approaches to achieving net-zero, not to represent government policy. However, if the CCC scenario were followed without modification, the model predicts a requirement for a maximum increase in skilled workers of 93,348 in one year, which is a growth rate of 3.45% in one year. As a simple rate of growth, this is manageable, but of course it requires the training infrastructure to be in place.

Also, this headline figure hides important detail. For example, the modelled scenario is based on a programme of energy-efficiency retrofit, focussing first on building fabric. Retrofit projects require co-ordinated design, which needs qualified retrofit designers, and retrofit designers need experience and take time to train, so there are some

[2] Office of National Statistics Construction statistics annual tables 2018 dataset: https://www.ons.gov.uk/file?uri=%2fbusinessindustryandtrade%2fconstructionindustry%2fdatasets%2fconstructionstatisticsannualtables%2f2018/csa2019maintables.xlsx

[3] Construction Skills Network Report (CITB) https://www.citb.co.uk/Documents/research/CSN-REPORTS-2019-2023/CSN%20report%20for%20UK%202019-2023.PDF

bottlenecks that emerge from modelling the scenario. Similarly, there are issues that must be carefully managed around re-skilling and just transition: there are around 30 million homes in the UK and most of them would benefit from better insulation, but once they have all been insulated, there will no longer be much requirement for insulation installers. The purpose of the model is to identify such issues so that inputs can be modified, or steps can be taken to manage the consequences.

Skills development in the construction sector is demand-led but there is currently little demand for decarbonisation, so little incentive to develop the skills required. If demand is created without planning for skills development, there will be a lag in the supply of skilled workers which will cause a delay to net-zero implementation that we cannot afford. It is therefore important to forecast what skills will be required, and to ensure that the resources are in place ahead of demand. The following recommendations set out the main actions that are required to plan ahead, so that net-zero can be achieved efficiently across the UK built environment.

E.1.4 Recommendations

The following is a summary of the recommendations deriving from the project, which are discussed in greater detail in Section 5.0:

Business as usual demand-led development and provision of training will not be enough to achieve net-zero.

A working group of stakeholders should be convened to conduct a gap analysis of existing course content, and agree responsibility, resources and timescales for the rapid development of revised and improved course content and new courses required to achieve net-zero.

A commitment to a specific decarbonisation pathway is required, including adopting a position on the use of hydrogen for heating, and planning of zones for heat networks and heat pumps (and hydrogen). Low-carbon retrofit or new-build in zones must then be in accordance with these plans.

Based on the example decarbonisation scenario used for this report, immediate action is required to build up the resources and facilities to address a critical shortage in retrofit design roles, which require experience and take time to train, with particular gaps in non-domestic and traditional buildings; there is also a shortage in specialist building envelope installer roles which requires immediate attention. Training of these and other skills required should be supported, so that it is delivered in advance of demand, in accordance with the planned decarbonisation scenario.

The gap between design and operational performance (the performance gap) is by itself sufficient to preclude the achievement of net-zero. Steps must be implemented to close this gap, including e.g. updating procurement to make operational performance a condition of contracts, implementing, improving institutional competence (e.g. through management systems) and implementing increased on-site scrutiny (e.g. through Clerk of Works role).

Support for deployment of no-regrets interventions (e.g. cavity wall, loft insulation, smart meters, smart thermostats etc.) should be rolled out immediately, while developing resources to deliver those with more complex training requirements. In particular, there is potential for early wins through the deployment of smart metering and BEMS (particularly in a non-domestic context) to model consumption, target efficiency improvements and modulate demand in periods of high grid carbon intensity.

E.1.5 Summary

This research has shown that net-zero for UK construction can be achieved, but not without radical changes to the sector.

Training provision must be planned and managed actively; demand-led training will not be sufficient.

Care must be taken to manage the growth and decline of trades, as the built environment and the construction sector are transformed at an unprecedented scale and pace.

More support is required across the board for retrofit skills, and additionally for skills in traditional buildings, and in modern methods of construction.

A transformation is required in individual and institutional competence, to close the "performance gap" between design and operational performance.

The recommendations of this report can deliver net-zero emissions from the built environment, but only if they are supported by robust and consistent policy to create confidence in long-term demand for net-zero skills, and funding to support retrofit in the public sector, housing association, rented and owner-occupied buildings.

Implementation of the recommendations in this report will ensure that the construction sector is ready to deliver net-zero without delay when policy requires it to do so.

Contents

1.0 Introduction

The Construction Industry Training Board (CITB) is the industry training board for the construction sector in England, Scotland and Wales. Its role is to help the construction industry attract talent and to support skills development.

This report sets out the findings of the project undertaken by Eunomia Research & Consulting Limited (Eunomia) for CITB, to identify the skills and training requirements generated by the commitment by the governments of the United Kingdom and devolved administrations to achieve net-zero greenhouse gas emissions (by 2050 for the UK, 2045 for Scotland and 95% by 2050 for Wales).

1.1 Aims

Based on the recommendations of the Climate Change Committee's (CCC) Net-Zero Report[4] and related research, the aims of the project are to:

- understand the implications for the built environment workforce of the UK Government's commitment to a legally binding target of net-zero carbon emissions by 2050 (and related targets in devolved administrations);
- demonstrate that government ambition can be achieved and that evidenced skills barriers can be addressed;
- prioritise action for industry, government, and other stakeholders.

The CCC in its Net Zero report[4] has identified several critical skills-related problems that are hindering progress:

- availability of skills to support the deployment of measures such as heat pumps and insulation;
- skills gaps that lead to the performance gap in new build and retrofit;
- skills for alternative approaches to improving heritage buildings;
- support to train designers, builders and installers for low-carbon heating (esp. heat pumps), energy and water efficiency, ventilation and thermal comfort and property-level flood resilience.

Within the context of the overall plan to achieve net-zero greenhouse gas emissions by 2050, the project aims to consider:

- current issues

[4] Net Zero: The UK's contribution to stopping global warming (Committee on Climate Change) May 2019. https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf

- issues emerging in next 1 – 4 years
- potential issues in next 5 – 10 years
- pathways to look at impact 10 years

It is important to note that skills are distinct from jobs, and that the skills required in coming years will include both those that are currently in operation and new ones. As the net-zero plan for the built environment progresses, the skills required will change, which will in turn require workers to re-skill and move from one job to another. Managing these transitions is a critical element of this programme.

1.2 Scope

The project includes the whole of Great Britain, excluding Northern Ireland (although the CCC net-zero modelling does include Northern Ireland). The devolved administrations and other jurisdictions (e.g. local authorities) have decarbonisation pathways and/or timescales which differ from the UK's overall 2050 target.

Within the context of various possible net-zero pathways (e.g. different deployment rates of retrofit energy efficiency, heat pumps, hydrogen etc.), the project identifies what skills are required, related to design, construction and maintenance to reduce energy demand and shift to lower carbon heat sources for new and existing domestic and commercial built assets, large scale domestic retrofit, non-domestic retrofit, and zero carbon new build. This includes, e.g. smart temperature controls, and low carbon energy systems (including the construction of heat networks) but excludes the deployment of off-site renewable energy, transmission and distribution infrastructure.

Direct and indirect emissions from the construction industry itself, from its supply chain and waste management, are not included, only emissions from the "operation" of the built environment. Embodied emissions are already a significant part of the sector's carbon footprint, which will become increasingly important as operational emissions are reduced.

1.3 Methodology

A variety of methodologies were employed to maintain a broad perspective of the industry skills challenges in transitioning to net-zero buildings and infrastructure. The project was carried out from March to September 2020 and was broken down into the following main tasks.

Table 1-1: Key project tasks

Task	Approach
Desk-based research - Literature review of baseline evidence	This research comprised a review of: • immediate skills gaps and shortages • challenges to compliance; • relevant stakeholders; • advice provided by the Committee on Climate Change; • key technology changes in the built environment; • forecasts for economic growth; • lessons learnt from the mass deployment of technologies; and • deployment trajectories likely to impact skills and labour market profiles. The data found was mapped against the research questions as listed in Appendix A.1.1.1 using a matrix approach.
Qualitative research - Stakeholder Interviews	• Confidential interviews were conducted with industry-leading experts and practitioners working in construction form across the UK. A sample frame was established to ensure an even representation of interviewee backgrounds and interests. • 48 interviews were completed and the findings were summarised into themes to form an interview matrix.
Quantitative research - Survey	A GB-wide survey of construction clients/contractors was carried out to verify the extent to which organisations agree with the findings from the previous interviews. Responses were collected according to the business type of the respondents; either i) self-employed tradespeople or ii) respondents answering on behalf of an organisation. The questions and data points collected in each route were the same, with slight wording variations for clarity. Using an online survey, a total of 281 responses contributed to the project.
Tool - Forecast/Scenario Planning/Analysis	Development of an excel based tool that allows users to input different net-zero deployment trajectories for key low carbon technologies and systems, and analyse the jobs and skills implications (e.g. the number of technology installers by type and their associated technical qualifications and skills) and explore the implications of accelerating the UK's journey to net-zero.

Recommendations and route map	Recommendations were developed to overcome the skills barriers identified to achieve net-zero. This was supported by a route map that sets out the critical steps required to develop the skills and training needed.

1.3.1 Reference and citation

Throughout the report, the views, comments and opinions stated are taken from published literature or are those of respondents to the qualitative interview process or quantitative survey. In the case of the former, references are given; otherwise, the source is confidential but the text indicates how commonly the view is held, and with what authority. Direct quotes are in quotation marks. If any statement is made, which includes the opinion of the researchers, this is explicitly stated.

More information about the methodologies is presented in Appendix A.1.0.

1.4 Structure of report

This report follows the following structure:

- **Section 2.0: Demand for net zero skills**. This section sets out how the demand for net-zero skills is created by the requirement for the governments of the UK and devolved administrations to achieve net-zero, and the associated legislative drivers;
- **Section 3.0: Supply.** This section sets out the existing supply of the skills required, with reference to the capacity and abilities of the sector at the moment;
- **Section 4.0: Skills requirements.** This section sets out what skills and training are required to achieve the net-zero target, along with observations on potential pathways;
- **Section 5.0 Recommendations.** This section sets out recommendations to overcome identified barriers in delivering the required provision.

2.0 Demand for net-zero skills

This section sets out how the demand for net-zero skills is created by the requirement for the governments of the UK and devolved administrations to achieve net-zero, and the associated legislative drivers.

2.1 Net-zero

In June 2019, the UK government signed into law a commitment to achieve net-zero greenhouse gas emissions by 2050. Net-zero means any remaining emissions would be balanced by schemes to offset an equivalent amount of greenhouse gases from the atmosphere, such as planting trees or using technology like carbon capture and storage.

This legal requirement replaced the previous target to reduce emissions by 80% compared to a 1990 baseline. It was recommended by the CCC, in response to developments in climate science communicated through the work of the Intergovernmental Panel on Climate Change. Although the increase from 80% to almost 100% may appear a small step, eliminating nearly all emissions is considered to be extremely challenging and will require a step change in how we use energy, travel, eat and house ourselves.

The achievement of net-zero does allow flexibility to offset some emissions using sequestration technologies. However, it should be noted that the scale, readiness, robustness and cost-effectiveness of these technologies is not sufficient for them to make a significant contribution. Currently, the only sure way to achieve net-zero by 2050 is the deployment of low-carbon technologies at an unprecedented pace.

Devolved Administrations

The devolved administrations also have specific targets and programmes addressing decarbonisation of the built environment and have responsibility for training and skills development aimed at delivering net-zero.

The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019, which amends the Climate Change (Scotland) Act 2009, sets targets to reduce Scotland's emissions of all greenhouse gases to net-zero by 2045 at the latest, with interim targets for reductions of at least 56% by 2020, 75% by 2030, and 90% by 2040[5] and published annual targets.

The Welsh Government agreed with the CCC's assessment that the Welsh economy includes more "hard to decarbonise" aspects than the UK as a whole[6], but has recently upgrade its target of achieving a 95% reduction in greenhouse gas emissions by 2050 to 100%[7].

2.1.1 Emissions from the UK built environment

Depending on the definition and scope, the built environment in the UK is said to account for somewhere around 40% of all greenhouse gas emissions[8]. However, this headline figure includes new construction materials, operational energy use (such as heating and cooling), electrical appliance use and emissions from transport). Total

[5] Scottish Government Climate Change Policy.
https://www.gov.scot/policies/climate-change/reducing-emissions/

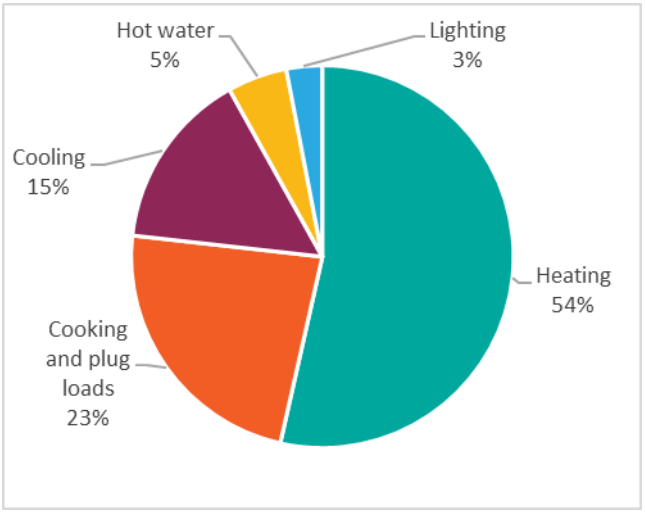
[6] Prosperity for All: A Low Carbon Wales (Welsh Government) 2019
https://gov.wales/sites/default/files/publications/2019-06/low-carbon-delivery-plan_1.pdf

[7] https://gov.wales/wales-commits-net-zero-2050-sets-out-ambitions-get-there-sooner

[8] https://www.ukgbc.org/climate-change/

emissions from new construction and operation of existing built assets amount to around 22%, with about three-quarters of this coming from the operation of existing buildings. This operational load is comprised of heating (54%), cooking and plug loads (23%), cooling (15%), hot water (5%) and lighting (3%).

Figure 2.1: UK existing built asset operational demand

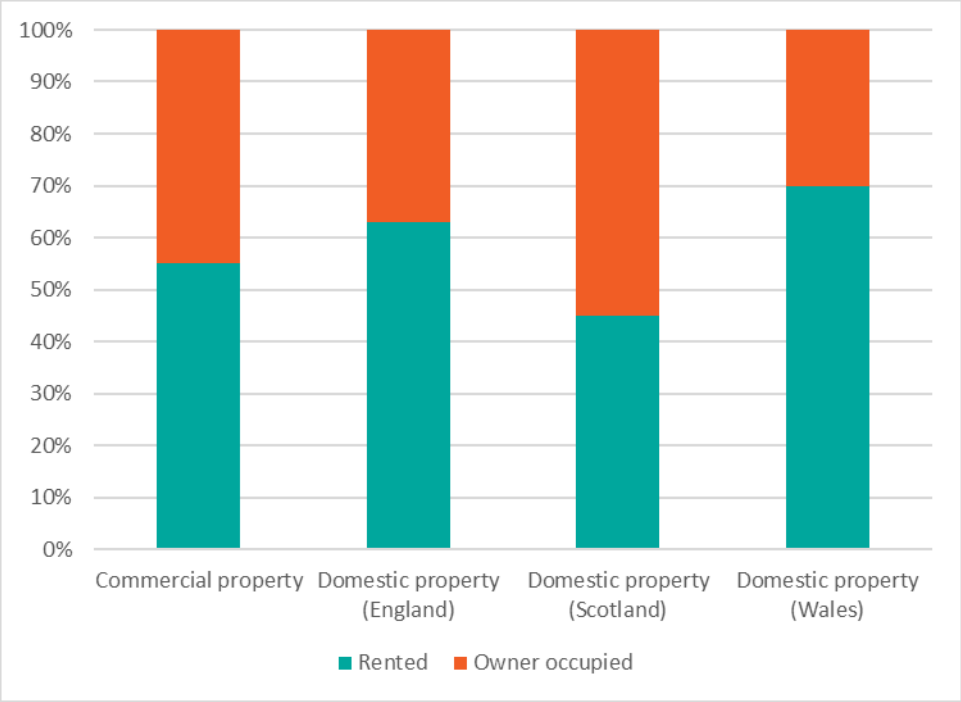


Source: Buildings FactSheet, CCC.

Operational emissions are approximately split between residential (64%), commercial (27%) and public (10%)[9]. 55% of commercial buildings are rented[10], and 45% owner-occupied. 63% of domestic buildings are owner-occupied in England[11], with a lower figure of around 45% in Scotland[12] and higher (70%) in Wales[13], the balance being made up of rent from private landlords, registered social landlords, housing associations and local authorities. It is widely held that the ownership of public buildings makes them more amenable to addressing greenhouse gas emissions.

[9] https://www.theccc.org.uk/wp-content/uploads/2014/08/Fact-sheet-buildings-updated-July-2015.pdf
[10] Property Data Report (PIA) 2017. https://www.bpf.org.uk/sites/default/files/resources/PIA-Property-Data-Report-2017.PDF
[11] English Housing Survey data on owner occupiers, recent first time buyers and second homes https://www.gov.uk/government/statistical-data-sets/owner-occupiers-recent-first-time-buyers-and-second-homes
[12] Housing statistics 2019: key trends summary (Scottish Government) https://www.gov.scot/publications/housing-statistics-scotland-2019-key-trends-summary/pages/5/
[13] Dwelling Stock Estimates for Wales, as at 31 March 2019 https://gov.wales/sites/default/files/statistics-and-research/2019-09/dwelling-stock-estimates-april-2017-march-2019-225.pdf

Figure 2.2: Percentage split of rented and owner-occupied property by type and nation



Source: PIA Property data report 2017

Around a third of buildings across the UK are considered "traditional," which is usually taken to mean that they were constructed before 1919 and have solid, breathing walls, rather than modern cavity walls[14]. These buildings require specific skills to maintain and improve, as described in Sections 2.2.2.1 and 5.2.3.

For decades, the UK has enjoyed accessible and relatively cheap gas from North Sea gas fields. As a result, the UK building stock is inefficient and 85% of domestic heating systems run on gas (non-domestic 70% and industry 72%)[15]. At the time of writing, each kWh of energy supplied in the UK will cost 14-15p if delivered through electricity and less than 3p by gas.[16] This differential of five times in cost presents a significant barrier to decarbonisation via electrification.

[14] http://www.understandingconservation.org/
[15] Estimates of heat use in the United Kingdom in 2013 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/386858/Estimates_of_heat_use.pdf
[16] https://www.ofgem.gov.uk/publications-and-updates/infographic-bills-prices-and-profits

2.1.2 Pace and scale

The pace at which decarbonisation is undertaken can influence the intensity of the task, with shorter timescales leading to more intensity required. In the context of this study, the shorter the timescales, the greater the demand for more people with the correct skills. This is inherently more costly and risky.

> *"A 2050 target means that the process needs to be complete by then, at full speed by 2040, and well on the way by 2030, so we have maybe five years to get underway, and we're only just starting to talk about it."*
>
> ***Interview Quote***

Several authoritative respondents also noted that the scale and pace of the change required is much greater than most of those involved appear to have taken on board. For example, various studies have looked at the cost of retrofit to the required standard to meet the net-zero target[17]; these estimates range from around £15,000 to £50,000, or more for difficult buildings. There are almost 30 million homes in the UK, so if tens of thousands of pounds must be spent on each, the lowest end of the cost range is for domestic retrofit alone is £300bn.

Framing the scale of the problem in this way provides context for efforts undertaken to date, for example the announcement by the Chancellor of the Exchequer in June 2020 to spend £3bn as "a significant down-payment" on residential energy efficiency[18]. Although by historical standards, this was a significant investment, by future standards it was not. The level of investment required, and the associated growth in employment and prosperity, is unprecedented; all stakeholders need to stop thinking in terms of what has been done before, and start thinking in terms of what is required.

2.1.3 Pathways

As outlined in section 2.1.1, the built environment delivers a significant contribution to UK greenhouse gas emissions. It is also clear that there isn't a single measure or approach that can be used in isolation to reduce these emissions and decarbonise the UK. Rather, there are likely to be a more predominant use of certain technologies and approaches. The deployment of these, and the scale to which they are implemented, will impact the skills needed in the sector.

This section therefore describes the main pathways for decarbonisation of the built environment. They are not exclusive, and the pathway taken will probably be a combination of elements of all of them.

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[17] E.g. http://urbed.coop/projects/beyond-decent-homes, https://www.theccc.org.uk/wp-content/uploads/2019/07/The-costs-and-benefits-of-tighter-standards-for-new-buildings-Currie-Brown-and-AECOM.pdf and others

[18] https://www.gov.uk/government/news/rishis-plan-for-jobs-will-help-britain-bounce-back

The skills model developed as part of this project therefore does not specify any one route through these pathways but allows the user to pick interventions and to see the impact of different choices.

2.1.3.1 Hydrogen

If the natural gas currently running through the gas network were replaced by hydrogen, greenhouse gas emissions from this source would be eliminated, as burning hydrogen emits only water. However, there are some obstacles as described in the table below.

Table 2-1: Obstacles to hydrogen switchover

Category	Description
Source	Hydrogen can be derived from fossil fuels (known as grey), fossil fuel-based hydrogen production combined with carbon capture, utilisation and storage (blue), or by electrolysis from renewables (green). Clearly, if the goal is decarbonisation then grey hydrogen is not appropriate but the deployment of blue hydrogen is not necessarily CO_2-free. CO_2 capture efficiencies are expected to reach 85-95% at best, which means that 5-15% of all CO_2 will not be captured[19]. Utility-scale CCS does not exist, will not be free and, even if the technical and economic hurdles are overcome, faces significant political, ethical and insurance barriers. Generating hydrogen from renewable energy is expected to become the cheapest approach in the near future, with significant scaling-up already in train.
Energy	If renewable electricity is used to generate hydrogen, which is then used for heat, there are energy losses at each process step (electrolysis, distribution, combustion). If the electricity generated is used directly, these losses are much lower (transmission). If the electricity is used to run a heat pump, the disparity increases further. So, to provide the same amount of carbon-free energy for heating, more generation capacity is required to do so using hydrogen.

[19] Hydrogen: a renewable energy perspective. Report prepared for the 2nd hydrogen ministerial meeting in Tokyo, Japan, September 2019.
https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Sep/IRENA_Hydrogen_2019.pdf

Cost	Currently, per unit of energy delivered, hydrogen costs between 1.5 and 5 times as much as natural gas, however, the cost of generating hydrogen through hydrolysis powered by renewable energy is likely to fall significantly. If the cost of delivered hydrogen falls to a level comparable with natural gas, the built environment could be rapidly decarbonised with limited investment.
Transmission and storage	Hydrogen molecules are very small, making it difficult to prevent the compressed gas from diffusing through many materials used to make tanks and pipes. It also reacts with the steel in pipework, making it brittle. These issues are being addressed, with several utilities implementing programmes of pipework replacement to allow the deployment of hydrogen. However, storage of hydrogen (or synthetic fuels generated using renewable hydrogen) is currently easier and cheaper than storing electrons directly.
NOx	Hydrogen burns hotter than natural gas and can oxidise the nitrogen in the air, generating emissions of nitrous oxide, which has a global warming potential (GWP) around 300 times that of carbon dioxide. It can be blended into the existing gas network up to 10%[20] but requires specifically designed boilers to be burned in pure form. As well as being resistant to the higher temperatures, these boilers ensure that the temperature is kept low enough to minimise NOx emissions. Currently, the Energy Related Products (ErP) Directive restricts NOx emissions to 56mg/kWh. If this maximum were the actual emission level across the country, it would be equivalent to around 16 gCO_2/kWh because of the high GWP of NOx. The carbon intensity of natural gas is around 180 gCO_2/kWh, so this would represent a 91% reduction, but might still preclude achieving net-zero[21], even if the production and distribution process emits no greenhouse gases.

Assuming these obstacles can be overcome, hydrogen has the potential to make a significant contribution to decarbonisation of the built environment. Work on developing renewable hydrogen is envisaged to take place in parallel with other interventions which

[20] Admissible hydrogen concentrations in natural gas systems. DIV Deutscher Industrieverlag GmbH https://www.gerg.eu/wp-content/uploads/2019/10/HIPS_Final-Report.pdf

[21] Appraisal of Domestic Hydrogen Appliances Frazer-Nash Consultancy Prepared for BEIS, February 2018. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/699685/Hydrogen_Appliances-For_Publication-14-02-2018-PDF.pdf

would be useful whether the hydrogen project succeeds or not, such as “fabric first” energy efficiency interventions, the deployment of heat pumps to properties off the gas grid, and the development of advanced heat networks.

2.1.3.2 Fabric First

In many discussions (and in many of the interviews for this research), there is a view that energy efficiency must come first. This view is known as “fabric first,” and it holds that energy efficiency interventions such as insulation, draft-stripping and improvements to glazing should be made to reduce demand before consideration is given to how remaining energy demand is delivered. These types of measures can often be done alongside adaptation measures to increase resilience to climate change.

At face value, this makes sense: simple energy efficiency interventions are cost-effective within a useful timescale and often contribute directly to a reduction in emissions. Simple interventions like loft insulation and draft-stripping are cheap, effective and hardly intrusive. However, for many buildings the kind of deep retrofit required to make enough difference through energy efficiency alone is expensive and disruptive.

Various studies have shown that the cost of effective retrofit programmes is tens of thousands of pounds, making them beyond the reach of most. [22, 23, 24] However, Section 5.5.1 includes some recommendations from respondents to address this barrier.

Fabric first may not always be the best solution, particularly in the context of a rapidly decarbonising electricity grid[25].

2.1.3.3 Heat pumps

An alternative could be to focus on decarbonising the electricity grid and developing technologies and mechanisms to balance supply and demand, while replacing fossil fuel heating systems with heat pumps, leaving the building fabric largely unchanged.

Heat pumps are more efficient when they provide lower temperature heat to buildings. Therefore, they often require well-insulated and air-tight buildings with high surface area (or forced air) heat distribution systems, as found in new-build, or existing buildings that have undergone deep retrofit. While there is significant variability (depending on internal and external conditions, as well as operational factors) in a well-designed

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[22] Reinventing retrofit How to scale up home energy efficiency in the UK. https://www.green-alliance.org.uk/resources/reinventing_retrofit.pdf

[23] “UK's housing stock 'needs massive retrofit to meet climate targets” Guardian, 11th October 2018. https://www.theguardian.com/environment/2018/oct/11/uks-housing-stock-needs-massive-retrofit-to-meet-climate-targets#

[24] Retrofit Factfile. http://urbed.coop/sites/default/files/2016%20URBED%20Tyndall%20The%20Retrofit%20factfile%20-%20facts%20and%20publications.pdf

[25] STBA / Cadw Workshop at Caerphilly Castle, 23/10/2019.

installation, heat pumps can consistently deliver a coefficient of performance (COP) of four or above (meaning that each kWh of electrical energy supplied to the heat pump yields 4 kWh of useful heat energy).

The new generation of efficient high-temperature heat pumps, based around new refrigerants such as R-32 and R-290, can achieve temperatures as high as 70°C, making them suitable as drop-in replacements for existing heating systems, without any requirement to alter heat distribution systems or building fabric. Achieving such high temperatures does come at a cost: the COP drops to around 2. However, UK grid carbon intensity is currently about the same as the carbon intensity of gas, at around 180g/kWh, and falling rapidly. This means that a straight swap of gas boilers for high-temperature heat pumps would result in an immediate reduction in emissions (from this source) of 50%, which could be improved year on year by incrementally improving building envelope performance, and continuing to decarbonise the grid.

While such an approach would address decarbonisation, it would exacerbate fuel poverty: at a COP of 2 and current fuel costs (see Section 2.1.3.1), average bills would more than double. This, in turn, could be mitigated by combining elements of energy efficiency with heat pump installation, by levelling up the levy imposed on fuels with different climate impact, or through other measures.

2.1.3.4 Heat networks

Heat networks have not been as popular in the UK as in some of our neighbouring countries, although there are around 14,000 in operation, providing some 18 TWh of heat[26], [27].

[26] https://www.theade.co.uk/assets/docs/resources/Heat%20Networks%20in%20the%20UK_v5%20web%20single%20pages.pdf

[27] Energy Trends: March 2018, special feature article - Experimental statistics on heat networks. UK Government.

Figure 2.3: Residential heat distribution in EU

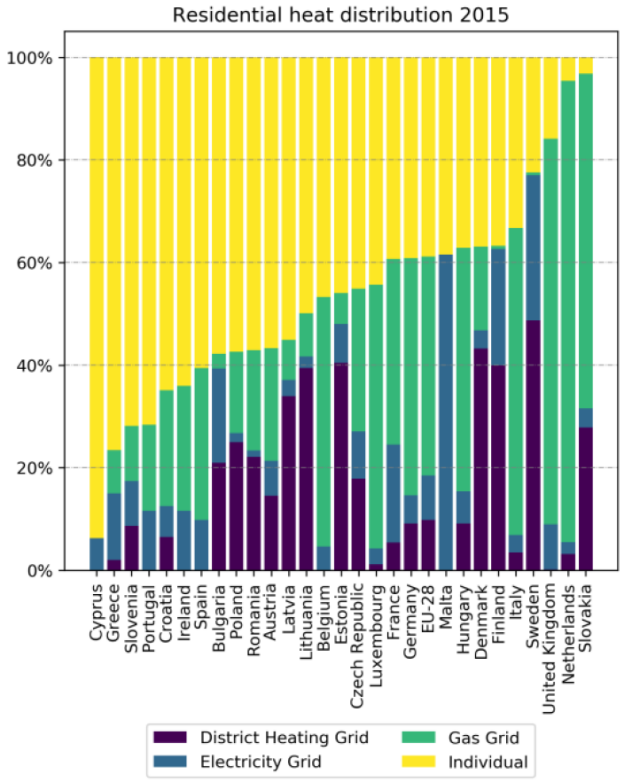


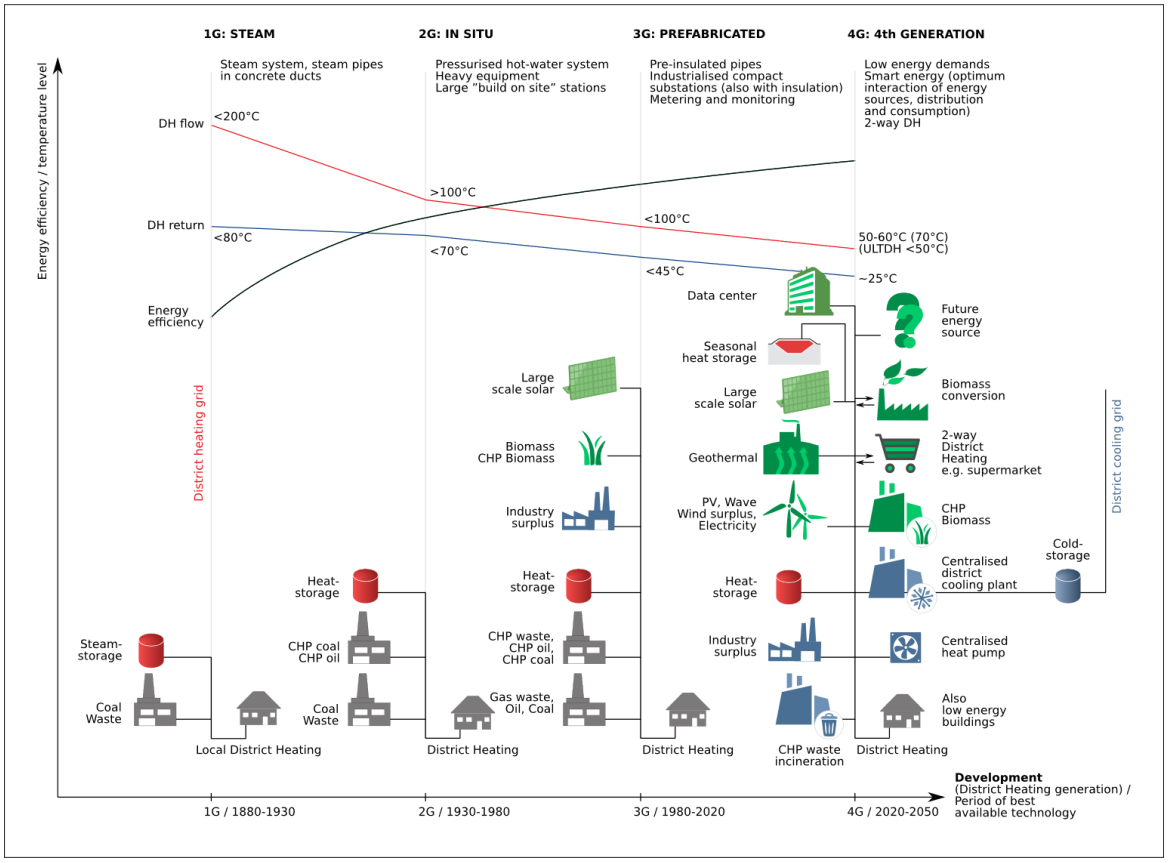
Figure 2.3 shows the proportion of residential heat distribution systems across the EU in 2015, with the UK amongst the most poorly represented, in terms of heat networks. Traditional heat networks use a boiler, or at best a combined heat and power (CHP) engine to provide heat. Gas CHP is can deliver marginally lower greenhouse gas emissions than a conventional boiler but, like any fossil-fuel based heating technology, it is incompatible with net-zero. Additionally, heat losses in poorly-designed systems of up to two-thirds have been reported[28].

As heat network technology has developed, the loop temperature has reduced. This leads to lower heat losses, allows the use of sources of free, low-grade heat (e.g. from water-courses, ground-loops, boreholes, industry and effluent streams), and opens up opportunities for inter-seasonal storage. Low-temperature systems do, however, require a heat pump to raise the temperature to a useful level (or conversely, to lower it when the system is being used for cooling), which has implications for integration with existing heating systems.

[28] Distribution loss factors for heat networks supplying dwellings in SAP. Consultation Paper CONSP:04. https://www.bre.co.uk/filelibrary/SAP/2016/CONSP-04---Distribution-loss-factors-for-heat-networks---V1_0.pdf

Most existing heat networks in the UK, and many of those in development or planning are dependent on gas boilers, CHP, Energy from Waste, or other primary energy sources which contribute to greenhouse gas emissions. These are not compatible with the net-zero commitment, but well designed and executed heat networks, using low-carbon primary energy sources, can make a significant contribution, particularly in high-density areas.

Figure 2.4: Evolution of heat networks



Source: Wikimedia Commons[29]

The current pipeline of proposed heat network projects suggests a healthy appetite for this technology, although on the basis of those involved with the Heat Network Delivery Unit[30] in England and Wales, a depressing number of projects (87 out of 112; 77.7% in the latest report) still propose to lock in greenhouse gas emissions by using gas boilers,

[29] Andol and Henrik Lund et al: 4th Generation District Heating (4GDH): Integrating smart thermal grids into future sustainable energy systems. Energy 68, 2014, 1-11, doi:10.1016/j.energy.2014.02.089

[30] (England and Wales only). Heat Networks: 2020 Q3 Pipeline. BEIS.

CHP and waste incinerators as the primary energy source. Information on Scottish projects[31] is harder to analyse systematically but the story appears to be similar.

The recently closed UK Government consultation "Heat Networks: Building a Market Framework" included some questions relating to the decarbonisation of future networks, relating to consumer information, the requirement for regulation (or other mechanisms) to decarbonise heat networks, and changes that could be made to the Environmental Permitting Regulations to encourage the use of waste heat, and heat from waste incineration.

The Green Heat Network Fund Call for Evidence, which closed on 13th October 2020, included questions regarding technology options for heat network decarbonisation, which referred to primary energy systems including waste heat from industry and incineration.

This suggests that Government is aware of the issues and is seeking expert advice. Specifically in the context of waste heat from industry, and particularly from incineration, it is important that proposals should be consistent with net-zero and with interim decarbonisation targets.

2.1.3.5 On-site energy

Finally, an important aspect of any decarbonisation pathway is likely to rest on the development of on-site energy generation, storage and management systems.

The scope of this report excludes the type of large-scale renewable energy generation that has been so successful in decarbonising the UK electricity grid, but there is still a wide range of technologies that should be considered.

Depending on the building and energy requirements, roof-mounted solar photovoltaic, thermal or thermodynamic panels can make a significant contribution. When combined with electrical or thermal energy storage systems, smart meters and building energy management systems (BEMS), this impact is even greater.

Recent developments in smart, connected systems, together with developments in the UK electricity market, mean that even individual domestic-scale systems can now learn usage patterns and predict grid carbon intensity and electricity price. Without any requirement for intervention from the user, these systems can optimise energy use and storage to minimise emissions and costs. As the transport fleet is decarbonised, these systems can increasingly be integrated with EV batteries as well as domestic batteries, to provide grid-balancing services which will in turn allow greater deployment of renewable energy generation to the grid.

These systems are developing and improving rapidly, which can make it difficult to predict what their role may be in decarbonisation. However, they also tend to be

[31] (Scotland) District Heating Scotland website. https://districtheatingscotland.com/map/

designed to be installed easily, and to be compatible with a wide range of existing systems, so the skills implications of their deployment can be less onerous than other approaches. Intelligent Energy systems will be essential for optimising the deployment of intermittent renewable energy, as well as the rate of decarbonisation of the built environment. They form an integral part of the Welsh Optimised Retrofit Programme.

2.1.3.6 Implementation

It should be noted that this approach to assessing and modelling the requirement for skills to deliver net-zero in the built environment is not intended to imply that implementation of these measures should follow the same path. For example, the deployment of large numbers of heat pumps will be required, but not in one go. A critical aspect of successful implementation of net-zero retrofit is that it must be bespoke, with each project being designed specifically for each building (albeit with opportunities for economies of scale in situations where there are multiple identical buildings, such as the co-ordinated retrofit of entire streets).

Nonetheless, this bespoke approach will ultimately result in deployment of individual measures in the numbers measured, which will in turn lead to a requirement for skilled workers. The devolved administrations were particularly keen to emphasise that mass implementation of measures was not their policy, however as discussed, this is not intended to be implied by the structure of the model.

2.1.3.7 Example scenario

The route map, described in Section 4.1.1, aims to provide an overview of these possible pathways, how they interact, and how to find the best route to rapid decarbonisation.

2.1.4 Related research

In addition to the publications reviewed in the Rapid Evidence Assessment undertaken at the start of the project, consideration has also been given to related research that has been published while the project was underway, relating to the impact of net-zero on training and other aspects of the construction sector and related sectors. These publications are summarised in Appendix A.1.2.2.

The skills implications of decarbonisation of the UK built environment is a theme being researched by a range of organisations, highlighting the scale of change required to meet the net-zero obligation. For example, RICS[32] in its net-zero policy position paper identified key skills gaps in retrofitting heritage buildings, delivery of PAS 2035, and construction and built environment related Apprenticeships and T-levels. The CBI's Net-

[32] Retrofitting to decarbonise UK existing housing stock report, RICS July 2020. https://www.rics.org/globalassets/rics-website/media/news/news--opinion/retrofitting-to-decarbonise-the-uk-existing-housing-stock-v2.pdf

Zero: The road to low carbon heat report[33] recommended that a national low-carbon skills programme was needed to ensure that the breadth and balance of skills is developed. National Grid's research[34] revealed 400,000 job opportunities for a 'Net Zero Energy Workforce'. Whilst the Heat Pump Association[35] highlighted the significant upskilling required to install the number of heat pumps required for net zero, with BEIS[36] similarly reporting on the large scale upskilling of heating engineers to meet hydrogen boiler deployment scenarios. This demonstrated that this is not just a message coming from this particular study, but one that is being repeated by many different stakeholders in the sector.

Although these publications vary in their focus and methodology, they all reach similar conclusions: the scale of change required to mobilise the economy to achieve net-zero is unprecedented but possible, provided immediate, sustained and decisive action is taken. The reports support the conclusions of this study, but with a caveat: although there are instances where declining industries can supply the construction sector with much-needed workers with transferable skills, a lot of other sectors will be competing for them.

2.2 Current situation

80% of the buildings which will exist in 2050 already do[37], and the emissions associated with today's buildings are about a quarter of the average, so in terms of operational emissions, 95% of the effort required to decarbonise the built environment should be directed at existing buildings, through retrofit to improve energy efficiency and by replacing fossil-fuel heating systems with low-carbon alternatives.

However, annual emissions from new construction, (including products, transport and construction activities) account for around a quarter of annual emissions from the sector[38] It is recognised that lowering the energy (or carbon) efficiency of new-build is relatively straightforward, and that retrofitting improvements in existing buildings is the bigger, and harder problem.

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[33] Net-Zero: The road to low carbon heat report. CBI July 2020. https://www.cbi.org.uk/media/5123/heat-policy-commission-final-report.pdf

[34] Building the Net-Zero Energy Workforce, National Grid, January 2020. https://www.nationalgrid.com/document/126256/download

[35] Delivering net zero: a roadmap for the role of heat humps, HPA. https://www.heatpumps.org.uk/wp-content/uploads/2019/11/A-Roadmap-for-the-Role-of-Heat-Pumps.pdf

[36] BEIS - Logistics of Domestic Hydrogen Conversion Oct 2018. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/760508/hydrogen-logistics.pdf

[37] https://www.ukgbc.org/climate-change/

[38] ibid

What is not widely recognised is the importance of embodied carbon and emissions from the direct activities of the sector. These emissions are, unfortunately, outside the scope of this report (Section 1.2), as it is concerned with the training implications of net-zero, but it is worth noting that achieving net-zero emissions from the construction sector is not possible without addressing them. As the carbon associated with using energy in buildings is reduced, the relative importance of embodied and direct construction emissions will only increase. The Welsh Optimised Retrofit Programme is working with the Active Building Centre on this subject.

Respondents reported that the predominant focus across the sector is currently on new-build, and furthermore on traditional, on-site construction techniques, and that within this focus, consideration of embodied emissions is negligible. This has resulted in a poor match with decarbonisation goals in new-build and limited capacity and capability in repair, retrofit, traditional buildings, and modern methods of construction, and a widely reported lack of support for these disciplines at all levels of training.

One respondent, representing a significant proportion of the sector, noted that in a recent (pre-coronavirus) survey, builders were generally busy, but the average proportion of time spent on energy-related work was only 4%, suggesting that the UK construction sector is not currently doing this work. This also suggests that net-zero can only be achieved through an increase in capacity that is largely additional to the existing sector. Net-zero will result in a major increase in the size of the sector, through direct entrants training to deliver the required interventions, and training to replace existing construction sector workers who have re-trained to do so. Across the existing sector, energy is seen as a useful opportunity to diversity, particularly as traditional customers are likely to have less money in their pockets post-coronavirus.

2.2.1 New build

In the UK, the private new-build construction sector integrates the functions of developer and builder, with the former driving profitability and putting pressure on the latter to minimise construction costs. The Letwin Review[39], issued in October 2018, observed that this structure is a significant contributor to the lack of housing in the UK, as it is in the interests of developers to keep prices high by restricting supply. The recommendations of the report have not been implemented.

Notably, housing associations have a reputation for building to a higher standard than private developments. In the housing association model, the same entity is responsible for the costs of building and operating, so the incentive to build at least first cost is replaced by an incentive to build at least lifetime cost. This leads to higher quality, better

[39] Independent Review of Build Out Final Report. Rt Hon Sir Oliver Letwin MP. October 2018. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/752124/Letwin_review_web_version.pdf

attention to detail and improved energy efficiency. Many respondents from industry and government are particularly aware of this distinction, and the ability to use public sector procurement as an incentive to improve standards.

The UK construction sector is thought to be quite capable of building to higher standards if demand were there, but initiatives to promote low-carbon buildings have been unsuccessful for decades, albeit for policy, rather than technical reasons. Most recently, in 2007 the Zero Carbon Homes policy was developed to ensure that new-build homes achieved net-zero greenhouse gas emissions. It was due to be implemented from 2016 but was cancelled only months before it was due to start. A report by the Energy & Climate Intelligence Unit[40] estimates that the cost of scrapping the policy (paid by homeowners in higher energy bills) will approach £1bn by the end of 2020. Building to Zero Carbon Homes standard is estimated to cost an additional 1.2% over Business as Usual.

At the time of writing in 2020, an update to Part L of the Building Regulations (Conservation of Fuel and Power) and Part F (Ventilation) is in process. The proposal is for an improvement of 31% over current emissions standards, which is still some way off what was proposed for Zero Carbon Homes. The proposed Future Homes Standard is due to be implemented in 2025. In the context of the observations regarding embodied carbon set out in the introduction to this section, it is worth noting that the Future Homes Standard is concerned only with emissions from operation[41].

There are additional requirements for improved new-build operational performance, such as improved insulation levels, airtightness, energy systems, and for contractual quality requirements, institutional and individual competence, and most likely oversight, but respondents did not consider any of these obstacles insurmountable.

2.2.2 Retrofit

Even without considering future improvements in energy efficiency, new-build currently operates at about a quarter[42] of the average energy intensity of the UK built environment so, given that 80% of the buildings that will exist in 2050 already do, if no action were taken to decarbonise the built environment, around 95% of operational emissions would come from buildings that already exist today. Put another way, from the perspective of 2020, 95% of the problem is already here, so retrofit is clearly going to be an important part of any decarbonisation solution. Of course, improvements to

[40] Zero Carbon Homes. How owners of new homes are paying over the odds for energy. Energy & Climate Intelligence Unit, February 2019. https://ca1-eci.edcdn.com/reports/ECIU_Zero_Carbon_Homes_Final.pdf
[41] https://www.gov.uk/government/consultations/the-future-homes-standard-changes-to-part-l-and-part-f-of-the-building-regulations-for-new-dwellings
[42] Building Energy Efficiency 2014-2015: Overarching Report. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/565748/BEES_overarching_report_FINAL.pdf

efficiency standards are already in process; these will further improve the energy efficiency of new-build, further increasing the relative importance of retrofit.

As discussed above, among other factors, decades of cheap gas from the North Sea have created limited incentive for energy efficient buildings, and the same applies to energy efficiency through retrofit. Publicly-owned and managed buildings are usually subject to rolling programmes of repair and maintenance which may include an energy efficiency element, and there are recent requirements for minimum standards of energy efficiency in private rental properties (although domestic landlords are subject to a £3,500 cap on investment that is low enough to exempt most meaningful interventions). This is driven by the Minimum Energy Efficiency Standards (MEES) regulation. As a result of this, it is now unlawful to let properties with an Energy Performance Certificate (EPC) below an 'E' rating. This has been introduced by government to improve the quality of private rented buildings and reduce the overall CO_2 emissions in accordance with the UK's targets for decarbonisation. That having been said, the majority of homes are owner-occupied, and the majority of commercial property let, or sub-let, which has resulted in little pressure to retrofit, and often substantial obstacles.

The UK has seen various retrofit initiatives that have been single-measure or several-measure focused, but there have been gaps in the linkages between those measures. For example, buildings have been insulated without considering ventilation systems, which can compromise natural ventilation, leading to condensation, damp and rot. To implement the recommendations of the Each Home Counts review, Publicly Accessible Specifications (PASs) 2035 and 2038 were developed to help address these issues and support the Trust Mark Government endorsed quality scheme.

These specifications were developed specifically for the deployment of effective energy retrofits of existing buildings. PAS 2035 covers how to assess dwellings for retrofit, identify improvement options, design and specify energy efficiency measures and monitor retrofit projects; PAS 2038 will cover non-domestic buildings when it is issued in the first half of next year. PAS 2030, which was redeveloped in conjunction with PAS 2035, covers the installation, commissioning, and handover of retrofit projects. Organisations which trade using the Trustmark quality scheme are required to comply with PAS 2035. The recent announcement of a £3bn Green Homes Grant, contributing toward retrofit energy efficiency improvements in England requires that anyone accessing the scheme is registered with Trustmark, so in principle all interventions undertaken through the scheme should take into account the holistic design implications.

Although there are reservations about it (see Section 5.2.1), the emerging PAS 2035 framework represents an important step forward in managing and improving retrofit projects. Once the policy to support the required retrofit programme is implemented, this framework is likely to be an essential component of the decarbonisation programme.

It should be noted that improving energy efficiency through retrofit is only part of the story. The climate has already changed so much that buildings are being challenged to cope with conditions that they were never designed for, and the rate of change is

accelerating. This means that retrofit programmes designed today to achieve net-zero will also have to take into account the very different climatic conditions that will apply, not just in 2050 but this winter, next summer, and so on.

2.2.2.1 Traditional buildings

Traditional buildings are generally defined as those consisting of vapour permeable fabric that both absorbs moisture and readily allows evaporation; they are often those constructed before 1919. There are various estimates of what proportion of the UK's current building stock falls into this category, but it is in the region of one third currently, which will become around one quarter by 2050. These buildings are older, and tend to be less energy-efficient, which represents a significant challenge for the net-zero target.

Throughout the construction industry there has been a lack of training in the skills required to maintain these older buildings - the industry has been dominated by new build construction and its techniques. The Skills Needs Analysis Report (Repair, Maintenance and Energy Efficiency Retrofit of Traditional (pre-1919) Buildings in England and Scotland)[43] found that 87% (95% in Scotland) of surveyed contractors do not hold formal qualifications relating to work on traditional buildings. Only 4% (2% in Scotland) of contractors surveyed had undertaken energy efficiency retrofit work on traditional buildings.

Similar research in Wales[44] found that "the vast majority of craft-based employers (tradesmen) (95%) reported that their workforce does not hold any qualifications directly relating to heritage, traditional buildings or conservation. A comparison with the England/Scotland survey results from 2012 reveals that energy efficiency retrofit activities account for a higher proportion of work on traditional buildings by craft businesses in Wales (11%) than was the case in England and Scotland in 2012 (just 3%)."

These figures suggest a significant lack of expertise and capacity which was echoed by respondents. A common theme was that traditional buildings were particularly vulnerable to poor quality work, which itself generated a need for additional repair and re-work; clearly in the context of a Climate Emergency, with severe constraints on the availability of construction workers, this is not cost-effective.

In England, 9% of the workforce working on traditional buildings is female (5% in Scotland, 6% in Wales). This rises to 13% female workforce reported by employers classified as working "exclusively" on traditional (pre-1919) buildings. Development of jobs in the traditional building construction sector, particularly with respect to net-zero

[43] Skills Needs Analysis 2013: Repair, Maintenance and Energy Efficiency Retrofit of Traditional (pre-1919) Buildings in England and Scotland. https://historicengland.org.uk/content/heritage-counts/pub/2013/skills-needs-analysis-2013-repair-maintenance-energy-efficiency-retrofit/

[44] A 'Material' Issue: Understanding and Responding to the Traditional Building Skills Challenge in Wales. Final report, February 2015. CITB

retrofit, should therefore be helpful in expanding the traditional demographic of the sector (see Section 3.1.1).

2.2.2.2 Maintenance and Repair

It is a requirement of PAS 2035 that, before buildings can undergo retrofit, they must be brought up to a reasonable state of repair. Interviewees believe there is a lack of skills in repair and maintenance as well as a lack of skills in adaptation of traditional buildings, which isn't always understood as being part of a retrofit. Demand for training for work on traditional buildings is illustrated by CITB estimates over several years, which consistently forecast that for England, around 7,000 workers (about 500 in Scotland), both new entrants and upskilling existing workers, require training to work on traditional buildings, before net-zero is taken into account[43].

There is a range of specialist skills which are under-represented in the traditional building retrofit industry, for example retrofit design, the repair and draft proofing of sash windows, and maintenance of vapour-open lime mortar walls.

The interviews highlighted the importance of assessing condition first, and then identifying the repairs or retrofit interventions that need to be carried out to get the building to function properly. There were concerns from those interviewed about the role Energy Performance Certificate (EPC) surveys have now taken on, particularly as EPC surveying does not focus on the understanding of systemic and connected effects within buildings (e.g. thermal bridging) and the connection between installation of retrofit measures and ventilation. This mirrored the findings of a scoping study by Sustainable Traditional Buildings Alliance (STBA) on behalf of Historic England and National Trust, "EPCs and the Whole House Approach[45]," which showed that EPCs were originally introduced as a benchmarking and compliance tool but they are now being used in government policy and programmes to drive improvements in the energy efficiency performance of buildings, including the recently introduced minimum energy efficiency standards for the private rented sector. As a result, EPCs are increasingly being used as retrofit design tools: a purpose for which they were not intended and for which they are not suitable. There are particular concerns relating to the use of EPCs in traditionally-constructed dwellings. Alternative approaches, such as Building Passports (see Section5.5.1.4) are better suited to address these requirements.

Repair and maintenance supports a higher proportion of small and medium size businesses.

[45] EPCs and the Whole House Approach: A Scoping Study, Historic England 2015. https://research.historicengland.org.uk/Report.aspx?i=16098

2.2.3 Platform / Off-site Construction

Conventional construction techniques typically use a bespoke design for each project, with components manufactured to specific dimensions, and materials cut, shaped and fitted on site. Platform construction aims to build on the lessons learned in the automotive industry, where a relatively small number of designs is used to manufacture individual components in bulk to consistent specifications, with these components then being installed on a common chassis, to create a (relatively limited) range of vehicles. The same approach in construction would see the development of modular components which can be manufactured in bulk to stringent and consistent specifications, then combined to create design solutions from a more limited palette, but with greater consistency and efficiency. This approach is particularly appropriate for the development of large buildings such as offices and schools, which can be built to standard specifications.

Off-site and modern methods of construction (MMC) are commonly used for smaller buildings, such as housing, as significant elements of each building are still small enough to transport. In off-site construction, components such as floor, wall and roof sections are manufactured in the controlled conditions of a factory, then transferred to site for assembly. The process has now developed to the point where entire sections, including internal and external cladding, services and utilities can be manufactured off site, reducing the time spent on site and the skills required significantly.

As highlighted in the Farmer review[46] and by a number of the interview respondents, one of the key arguments for why we can't use traditional 'business as usual' construction approaches to retrofit is one of labour shortages and potential efficiency gains from MMC; there isn't enough skilled labour to work productively on-site to deliver new-build requirements, along with 27 million housing retrofits and the non-domestic retrofits required in the proposed time frames. MMC therefore has to play a role in delivery. One interview respondent gave an example of six operatives in a factory today being able to deliver about 100 standard retrofits in a year, before the addition of efficiency gains from scale and automation.

Platform and off-site construction present opportunities and challenges for the construction sector. These techniques have been shown to deliver higher quality at lower cost, with greater efficiency; they also provide jobs with consistent location and working conditions, widening the appeal to include a broader demographic, whilst reducing waste and build time[47]. However, the skills they require are quite different to those required for conventional construction: both within the factory and on site, there

[46] The Farmer Review of The UK Construction Labour Model: Modernise or Die, Mark Farmer 2016. https://www.constructionleadershipcouncil.co.uk/wp-content/uploads/2016/10/Farmer-Review.pdf
[47] https://www.offsitehub.co.uk/sustainability/

is less need for specialist trades with clearly marked boundaries, and more for multi-skilled operatives, capable of turning their hand to a broader range of tasks.

These multi-skilled workers are also better suited to cope with the variability in demand required by the net-zero programme for construction more generally. For example, it is likely that an initial focus on improving the energy efficiency of building fabric will gradually be replaced by a focus on energy systems and other interventions. In this context, multi-skilled workers will be better able to adapt.
The recent UK government report on MMC[48] says that respondents reported the following as being among the benefits of a move to these techniques:

- more digital working which will appeal to young workers looking for a modern career, using cutting edge technology;
- factory based jobs in an indoor environment are safer, with less working at height and workers are sheltered from the weather;
- factory based workers are not required to relocate around the county to different building sites;
- off-site methods of construction usually require fewer workers with traditional skills and potentially fewer workers overall in comparison to traditional techniques.
- factories can be strategically placed in areas of the country with higher rates of unemployment to provide local employment opportunities.

The relative novelty of these approaches also means that designers and architects familiar with the techniques are still rare. These techniques are either absent or not well covered in curricula at present, yet there is a recognition from the same report that government house-building targets will not be met without them, and it appears likely that the same is true for net-zero targets. WRAP estimate that modular construction can reduce energy used in the construction process by 67% and waste produced onsite, by 70–90% in comparison with traditional construction methods.[49] James Thomson from Keepmoat Homes told the Parliamentary Committee on Modern Methods of Construction that MMC homes: “take about 20–30% less to heat than a traditionally built new home”[50].
Several interview respondents saw Covid-19 as potentially being a “lightbulb moment” for off-site construction, as it is possible to maintain better social distancing in the factory and during the on-site installation, as well as all the other safety and efficiency

[50] Housing, Communities and Local Government Committee Oral evidence: Modern methods of construction, HC 1831, 18th March 2019
http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/housing-communities-and-local-government-committee/modern-methods-of-construction/oral/98436.pdf

gains. It is hoped that this will provide additional impetus for a faster transition to the widespread deployment of off-site techniques.

2.2.4 Economic environment

CITB maintains the Construction Skills Network (CSN) report, which provides a forecast of sectoral trends for a four-year period. The last report was published in February 2019, when concern was focussed on the effects of Brexit, including resulting economic uncertainty, fears over the availability of migrant workers and other disruption such as import tariffs and logistical delays. These concerns were framed in the context of an orderly exit, or an extension period, and before the coronavirus pandemic, but also before the UK net-zero commitment. The report predicted a growth rate of 1.3% and a need for 168,500 jobs.

Against a background contraction of 20% across the whole economy, construction shrank by 35% in the second quarter of 2020. This contraction has begun to turn around, with a five-year record growth in July, reducing slightly in August, but the sector has been hit hard, with profit warnings and redundancies across the board. What recovery has been seen has been dominated by house building, with commercial activity growing very slightly and civil projects continuing to contract[51]. In context, the net-zero scenario modelled for this report will require an increase in construction sector jobs of a little over 10%.

2.2.5 Devolved nations

The Scottish and Welsh Governments have individual management of many elements of net-zero planning, including training. This has been used to develop specific national programmes, such as:

Scotland:

- Construction Scotland Innovation Centre;
- Apprenticeship programmes with a strong emphasis on net-zero skills;
- Green Jobs match funding
- Climate Emergency Skills Action Plan[52]
- Investment in energy efficient retrofit of the public estate;
- Energy Efficient Scotland Route Map;
- Proposals for new-build to be use zero-carbon heating from 2024;
- Support for hydrogen and off-site construction;
- Ongoing support through the Energy Saving Trust.

[51] https://www.markiteconomics.com/Public/Home/PressRelease/85ddc5d6ae1d4f35a061ce4f5fa669da
[52] Protecting Scotland, Renewing Scotland: The Government's Programme for Scotland 2020-2021. https://www.gov.scot/publications/protecting-scotland-renewing-scotland-governments-programme-scotland-2020-2021/pages/5/

Wales:

- Construction Wales Innovation Centre;
- Three regional Retrofit Skills Academies, primarily aimed at domestic construction and including addressing decarbonisation as a key objective, as part of the ORP (see below).
- Proposals for an upgraded network of construction skills training centres;
- Heat network support in South Wales;
- Nest programme of energy efficiency audits and implementation support

One of the aspects of policy and practice development which differentiates Wales from England, is the process of co-production. In Wales, policy and practice tend to be co-produced, with extensive engagement between government and the construction sector, which in many cases leads to collaboration amongst agencies delivering Welsh Government policy. Three examples of this in the area of decarbonisation are as follows:

- An Optimised Retrofit Programme collaboration between 27 social landlords;
- A collaborative project to develop a standardised system for the delivery of zero carbon timber framed homes. This will see the 11 councils with a retained housing stock working together to appoint a partnership of designers and manufacturers to design, prototype, test and quality-assure a zero-carbon new-build, timber-framed housing system. Once the work of the Innovation Partnership is complete, a contract to supply homes direct to Councils will be let;
- Collaboration between housing associations in the North to work together to build an order book for local MMC suppliers, funded by the Innovative Housing Programme.

Further details on these examples is given below:

Optimised Retrofit (OR) and the Optimised Retrofit Programme (ORP)

This programme will test a new approach to decarbonising Welsh homes, based on the recommendations of 'Better Homes, Better Wales, Better World' (the Jofeh Report) published in July 2019, which has been accepted in principle by the Welsh Government. £19.5m is available in 2020-21 and a further £20m will be available in 2021-22.

The programme trials and tests OR: a pragmatic, whole-house approach to decarbonising existing homes. It is more sophisticated and bespoke than previous retrofitting schemes because it takes into account the materials that homes are made from, the way they store energy and the way energy is supplied to homes. Some of the upgrades that are to be trialled through five projects funded this year will include heat pumps, intelligent energy systems and solar panels.

The intention is not to upgrade all homes to zero carbon in the initial phase but to learn how to upgrade homes well, at an optimised cost, setting the Welsh Government and construction sector on the right path towards the decarbonisation of all homes in Wales. Importantly, the programme also aims to embed, promote and deliver fair and decent work in Wales, provide training in core skills for both suppliers and clients, driving innovation and creating supply chains in line with Cabinet's green economic and

Foundational Economy ambitions. As part of this aspect of the Programme, accreditation is required as a means of embedding quality across the sector.

Also being developed are tools and resources which can be used to roll out the large-scale decarbonisation of all homes across Wales. This includes:

- development of smart systems to streamline retrofit implementation using lessons learned through the Programme,
- post-completion operational performance monitoring to track the real-world effectiveness of designed and implemented measures,
- integrated low-carbon energy systems that consider local infrastructure and intermittent renewable energy supply alongside demand, and
- the creation of open frameworks for the supply of materials and labour which are focused on the development of the Foundational Economy and creation of skills to help meet the challenge of Welsh decarbonisation ambitions.

This programme will give the Welsh Government a much clearer picture of the true costs, while creating the framework for an industry to decarbonise all 1.4 million homes in Wales by 2050. It will set the standard for retrofit schemes in Wales, including existing programmes such as the Welsh Housing Quality Standard (WHQS) with around 300,000 social and fuel-poor homes potentially over the next 10 years. This will open the door for the development of a new long-term Welsh retrofit industry, tackling concerns about quality of work, supporting supply chains, and creating thousands of local jobs and training opportunities in Welsh communities.

Innovative Housing Programme (IHP) – new homes

IHP is an experimental programme, funding innovation to work out how the affordable homes of the future can be produced. The programme is framed closely around the seven well-being goals of the Well-being of Future Generations Act 2015. The programme aims are to:

- increase the supply of affordable housing in Wales;
- work out how to build the homes of the future which are good for tenants, landlords, communities and the planet;
- provide support for those willing to innovate through the use of alternative approaches;
- demonstrate the benefits associated with alternative approaches, to encourage their mainstreaming;
- harness opportunities to deliver jobs, skills training, and develop local industry; and
- publicly disseminate the key findings and maximise learning across private and public sectors.

The expectation is that the homes built with support from IHP will become the norm for homes receiving social housing grant and other sources of government funding in the future. What may have been regarded as novel when the programme first launched will soon be considered mainstream and the programme is succeeding in helping to bring forward and mainstream high quality, near zero carbon, energy efficient homes in

Wales. The challenge now is to ensure the higher costs seen in the first years of the programme are reduced, now that systems have been piloted and are in use across Wales. If costs remain too high, these innovative approaches may face difficulties being mainstreamed across the whole housing sector in Wales.

To support innovation in the construction of new homes, Welsh Government has:

- Committed over £130m of investment in the four years of the Innovative Housing Programme;
- Supported 64 schemes to test and learn new housing solutions;
- Supported the delivery of over 1,900 new homes, of which over 1,400 are additional affordable homes;
- Secured £45m of investment to directly boost the MMC housing sector in Wales;
- Built up an IHP community/network in Wales of over 300 like-minded businesses who share Welsh Governments ambition of positioning Wales at the vanguard of transforming how we build homes in Wales;
- Hosted regular IHP events across Wales to enable the learning from earlier years of the programme to be disseminated and help mainstream practice and approaches.

The IHP programme is being evaluated by a network of ten Universities in the UK, linked to the Active Building Centre Research Programme, to review the homes built. The research considers all aspects of the programme from a technical construction perspective through to a tenant behavioural perspective, to form a holistic view about what has worked, and equally important to this entrepreneurial approach ,what hasn't.

In terms of the remit and findings of this research, there are more similarities than differences. Running the skills model on a regional basis, with different emphasis on the pathways that comprise the net-zero scenario, results in a different profile of skills and training requirements, and these may be delivered in a slightly different way, however there will still be a requirement for retrofit designers, building envelope specialists and heat pump installers. The model has been run to generate these figures for Scotland and Wales; these figures are presented in Appendix A.2.2.

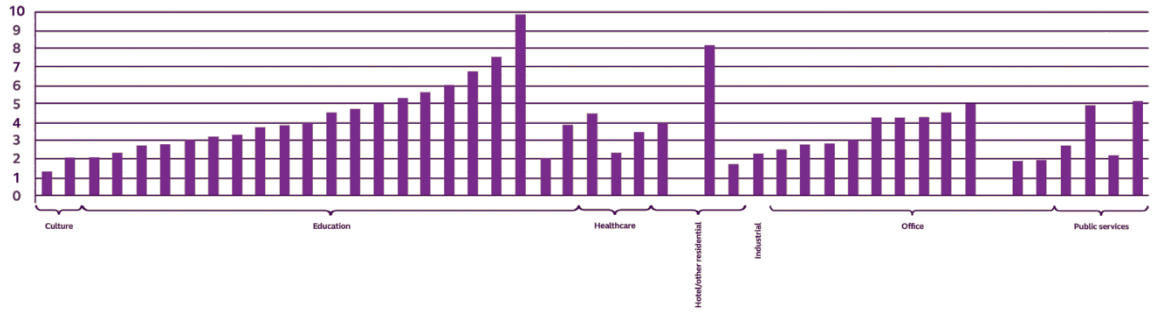
Similarly, the recommendations identified in the qualitative interviews apply across all three countries: new-build is a minor and manageable part of the problem which is, at least in principle more manageable with greater control of building standards. In both Scotland and Wales, there is recognition that encouraging higher standards and modern methods through public procurement is a good way to encourage improvement across the sector. There is also a recognition that holistic retrofit design, bespoke to each particular building (i.e. that PAS 2035, 2038 approach) is essential. Repair, traditional building skills and retrofit are under-represented and seen as a key to decarbonisation. The performance gap is seen as equally important, with similar views provided across countries on the proposed solutions to close it, again with an emphasis on leading by example, rather than using legislation and prosecution.

In terms of the approach to training and upskilling, again similar messages were received. For trades, upskilling and training was largely seen as deliverable through bolt-on training to existing courses and qualifications. When it came to technical, professional supervisory management roles, there were two approaches proposed. One where existing construction courses (which touch on decarbonisation, but aren't very specific) could be adapted at the universities. The other one was that a range of courses should be specifically developed that meet the needs of the new roles. This was largely around advisors, specifiers, inspectors (e.g. PAS2030 and 2035). Whether it's a bolt-on, adaptation or revamp of the qualification would largely depend on the institution and the demand.

2.3 Performance gap

The Innovate UK Building Performance Evaluation (BPE) study in 2016[53] demonstrated a significant performance gap between design and actual carbon emissions for domestic and non-domestic projects. It found that nearly every building had higher carbon emissions than predicted during the design phase. In some cases, total emissions were 10 times the Building Emission Rate calculated for Part L compliance.

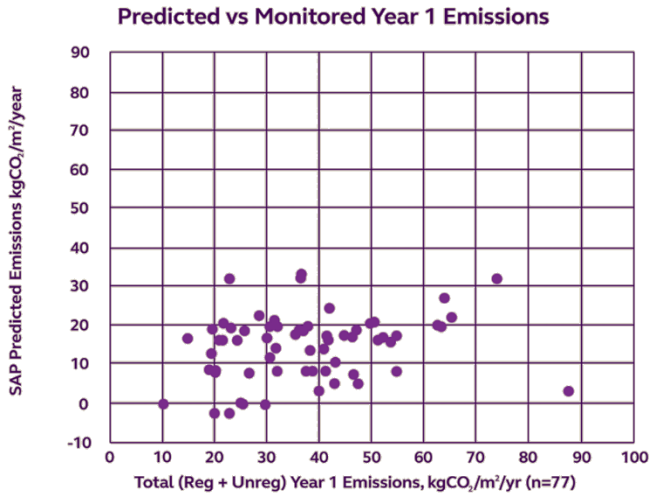
Figure 2.5: Performance gap between design and actual carbon emissions for a number of domestic and non-domestic projects



Source: Innovate UK 2016. For low resolution viewing: categories are Culture, Education, Healthcare, Hotel/other residential, Industrial, Office, Public services.

[53] Building Performance Evaluation Programme: Findings from non-domestic projects, Innovate UK January 2016.
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/497761/Non-Domestic_Building_performance_full_report_2016.pdf

Figure 2.6: Ratio of actual CO_2 emissions to design estimate for non-domestic buildings



Source: Innovate UK 2016

Any proposed route to net-zero will fail if this gap is not addressed, as whatever measures are proposed will not deliver. There has been a great deal of research into the causes of this performance gap (and potential solutions), and most respondents had something to contribute on the subject. The following is a summary of the main points, which are discussed in more detail in the Recommendations section (Section 5.4).

Table 2-2 Performance Gap Causes

Cause	Description
Procurement and contractual	Purchasers of new buildings or retrofit services do not stipulate performance requirements in the procurement process. Particularly in a retrofit context, the complexity of projects, tendency not to complete all measures at the same time, and dependence on occupant behaviour, can make performance requirements difficult (although quality requirements less so). There is (was, before Covid-19) enough work available that it was a seller's market. Builders had no need to take on "difficult" projects or clients.
Skills	Construction workers lack the skills required to build or renovate to the required standard. As well as specific skills (e.g. insulation, heat pump installer), there is a lack of overall awareness of building systems, low-carbon design, and inter-trade issues.

Institutional Competence	Across the procurement supply chain and sub-contractors, there is a lack of agreed standard operating procedures organised into a formal quality management system, including training and competence for staff, communication between parties, oversight, monitoring and continual improvement.
Monitoring and feedback	Outside of studies specifically intended for the purpose, there is little performance monitoring and feedback to identify failure points and implement improvements. This includes monitoring on site (e.g. Clerk of Works) as well as operational performance monitoring.

One interview respondent with considerable experience in retrofit design commented that, while they were fine working with existing contractors that they had come to trust, these were thin on the ground and finding additional contractors to take on this work was a significant bottleneck.

3.0 Supply

This section sets out the study's findings regarding the UK construction sector in 2020, in the specific context of its current ability to achieve net-zero greenhouse gas emissions from the built environment in thirty years or less.

3.1 Training and upskilling

Construction sector workers acquire the training they need to perform the work they do, but according to survey information supplied by industry bodies, the vast majority of the work they are doing now is not what is needed to achieve net-zero. The specific skills required to develop low-carbon retrofit and new-build designs are not (yet) in demand, and the contractual and quality requirements to implement these designs successfully are also rare.

The survey (Appendix A.1.5.1) highlighted that the sector recognises that there is a decarbonisation skills gap and that there is a clear appetite for retraining and upskilling. Over 70% believed that they knew the skills they needed to contribute to the decarbonisation of the built environment, with approximately 90% stating they would be willing to re-train, as demand for new roles and skills' changes in the future. Although a third of those surveyed stated that their business hadn't, to date, provided them with any decarbonisation related training.

The most significant reasons for decarbonisation skills gaps in their professions were seen as lack of training, lack of funding for training, regulation changes and lack of standards. With external funding to cover some or all of the cost of training; and

receiving an accredited qualification being seen as the most important factors when undertaking decarbonisation retraining or upskilling.

Currently, courses are developed to address demand, but the demand for net-zero work and the skills required is not there yet, so in many cases the courses required have not been developed to date. The current system is limited in its ability to look forward to develop in areas seen by survey respondents as important e.g. off-site construction, improved whole building post construction testing, or those where demand is currently low but will have to rise (e.g. retrofit). This is a particular challenge across training and policy: courses can be developed, but they will remain empty until there is demand for the skills they create; demand which must be met rapidly if we are to decarbonise at the pace required.

As well as the structural issues outlined above, there are other issues specific to the construction sector and the net-zero programme that must also be addressed. These are discussed below.

3.1.1 Competition and appeal

Construction is not the only sector with a part to play in achieving net-zero. Over the past few months, other sectors including energy and engineering have published reports (summarised in Appendix A.1.2.2) estimating the additional number of workers, and skills required, and a similar degree and pace of change will be required from manufacturing, transport, agriculture and other sectors. The opportunities presented by careers in these developing sectors are in direct competition to the requirements of the construction sector.

Also, despite recent improvements, compared to other sectors, construction is poorly represented by women[54] and ethnic minorities[55]. Several respondents were unflinching in their criticism of the sector in terms of its appeal generally, as well as specifically to women and anyone from an ethnic minority.

While all prefaced their comments with agreement that there were of course examples of best practice, in general the stereotype of UK construction was considered nearer to the mark: construction is still rarely a career of choice in the UK. The sector therefore has room to improve in gender and racial inclusivity, working conditions, career progression and similar factors which would help to make it an appealing career choice.

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54 https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/articles/womeninthelabourmarket/2013-09-25#women-in-the-labour-market

55 https://www.constructionmanagermagazine.com/ethnic-minorities-construction-pride-prejudice/#:~:text=According%20to%20research%20from%20Business,comes%20from%20ethnic%20minority%20groups.

The level of competition to be expected from other sectors is a problem in itself, but it is also likely to exacerbate the performance gap, as a shortage of available construction workers will only increase the degree to which procurement of construction services is a seller's market. The construction sector will need to improve its image and offer, if it wishes to attract the best talent in this competitive market.

3.1.2 Time and cost

Finally, the willingness and ability of the sector to up-skill is affected by the time and cost of training courses, and lack of earnings whilst on training, particularly in the light of uncertain demand for new skills, and plenty of demand for existing skills. Obviously, these factors will need to be addressed, but even when they are, the time required to complete training and the costs incurred will need to be addressed. Suggestions for how to approach this are presented in Section 5.0.

4.0 Skills requirements

This section identifies the skills and training required to achieve net-zero. These depend on the decarbonisation pathway taken (the pace and choice of measures), which is not prescribed in this report, allowing stakeholders to use the model and this report to assess the implications of different choices. However, to be able to model and comment on the capabilities and capacity required, the following sections assume that a balanced pathway similar to that proposed by CCC will be adopted.

4.1 Pathways

For this section, it is assumed that the pathway chosen will not be any of the extremes (e.g. rapid and complete deployment of cheap renewable hydrogen, or deep retrofit across the whole built environment) but that it will include elements of all the technological solutions discussed throughout the report. The scale and pace of work required to achieve net-zero are such that even a balanced pathway will require an unprecedented increase in the provision of each of its components. While achieving net-zero across the UK built environment will require mobilisation on a scale rarely seen in peacetime, the model output suggests that this balanced approach is within our capability to deliver.

The following sections set out the requirements for delivering this provision, and any barriers identified.

4.1.1 Hydrogen

A high-hydrogen pathway requires that affordable, low-carbon hydrogen can be generated and delivered to households and businesses through the existing gas network. As the scope of the study excludes major infrastructure projects, the remaining upgrades required for the network to be able to distribute and store hydrogen are excluded; only

the implications for switching heating in buildings from natural gas to hydrogen are considered.

Of all the pathways under consideration, converting to hydrogen is the easiest. Reservations about its practicality as a solution are largely confined to the challenges involved in generating enough low-carbon hydrogen, storing it and distributing it, all at a palatable price. Since all these aspects are out of scope, this study is concerned only with the challenges of converting existing heating systems to hydrogen, should it be achieved. However, the technical challenges associated with the infrastructure should not be downplayed just because success would be appealing[56].

As discussed in Section 2.1.3.1, the infrastructure to generate, store and distribute low-carbon hydrogen at scale does not exist, and it is far from certain that low-carbon hydrogen can be delivered through the gas network cost-effectively. Assuming the intention is to generate green hydrogen using renewable energy, what is certain is that it is more efficient to deliver low-carbon heating directly, using electricity, heat pumps and improvements to the building envelope.

Around 85% of heating in the UK is currently powered by natural gas, with about 26 million domestic boilers currently in place. These heating systems are installed (at a rate of 1.7 million a year) and maintained by around 120,000 qualified gas engineers; non-domestic emissions are around one-third those from domestic but as the individual boilers are so much bigger, they tend to be considered in aggregate output, rather than numbers. As discussed in Section 2.1.3.1, several manufacturers have already developed hydrogen-ready boilers. These can run on natural gas until hydrogen arrives, then they are converted in a matter of hours. Whilst the survey showed (unsurprisingly as this is a developing technology) that hydrogen boiler installation was one area where respondents thought they had a lack in the required skills and knowledge to install, this doesn't necessarily pose an insurmountable challenge. All gas installers in the UK are already highly trained and registered with Gas Safe, with the additional training required to work with hydrogen expected to take about one day for those with existing Gas Safe qualifications.

Hydrogen causes embrittlement of pipework and fittings[57], which is already being addressed in anticipation of a general hydrogen roll-out by replacing or lining existing pipes with plastic. From the street to the boiler, most pipework is copper, which is fine to carry hydrogen at the temperatures and pressures required. Nonetheless, for every

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56 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/760508/hydrogen-logistics.pdf

57 https://www.nace.org/resources/general-resources/corrosion-basics/group-3/hydrogen-embrittlement#:~:text=This%20is%20a%20type%20of,corrosion%20and%20corrosion%2Dcontrol%20processes.&text=Hydrogen%20embrittlement%20does%20not%20affect,titanium%20alloys%20and%20aluminum%20alloys.

installation, the pipework must be surveyed, even it if will only rarely need to be replaced. This would create a requirement for additional qualified surveyors, and a smaller number of fitters to replace pipework. The numbers of the latter are expected to be low, as it is thought that most internal pipework is suitable for hydrogen; the numbers of the latter will depend on the rate of deployment, but estimates suggest that around two hours would be required for each property survey, compared to four worker-days for each boiler installation. Assuming these ratios, a maximum of 7,500 additional surveyors would be required, based on the number of existing gas installers.

The size of the workforce needed for the conversion is highly dependent on the required speed of the conversion. The stakeholders highlighted that drastically increasing the size of the workforce for a short period should be avoided, as this would lead to employment concerns following the conversion, and a boom bust cycle. The industry stakeholders suggested that conversion would be carried out regionally as the gas distribution networks are converted. This would also allow existing Gas Safe personnel in an area to become trained as the region they work in is converted. However, they also pointed out that the existing pool of Gas Safe engineers is geographically fragmented and therefore trained staff may need to move around the country to support the local workforce. This mirrors similar experiences in the smart meter roll out.

Despite these complications, the BEIS Logistics of Domestic Hydrogen Conversion 2018 study sets out some simple calculations at a nationwide level that were used to obtain a sense of the scale of workforce required (noting that the data on the number of surveys and properties undertaken per day in this study may be on the high side, based on some of the recent smart meter abort rate for customers of ~25%[58]). These were as follows:

- Initial survey: 3 homes surveyed per day.
- Property updates (pipework): ½ day (but depends on changes required).
- Appliance conversion/installation: Boiler conversion takes 1 day. Hobs, ovens and fires each take 0.5 days.

This corresponds to a total of 52 million worker-days of effort to convert all 23 million houses connected to the gas grid. However, this Section describes a scenario where net-zero is achieved through a balanced mixture of pathways, so the actual requirements would be less. At the current rate of replacement, and using existing installers, if the above assumptions hold true, it would take around 16 years to replace all the gas boilers in the UK with hydrogen-ready alternatives.

Stakeholders reported that there are currently around 100 accredited gas training centres in the UK. Training is commercial and competitive in the UK and the consensus

58

https://www.ofgem.gov.uk/system/files/docs/2020/06/open_letter_2020_smart_rollout_progress_and_forward_look.pdf

https://www.ofgem.gov.uk/system/files/docs/2020/06/beis_open_letter_on_operational_fulfilment.pdf

was that training bodies would develop their facilities to cover hydrogen if a demand for hydrogen training courses develops. Stakeholders advised that typical training courses retail at around £600 per day. In addition to the development of the personnel required to perform the actual hydrogen conversion, stakeholders pointed out that there would be a requirement to either upskill or attract new engineers to the wider gas industry to enable a hydrogen conversion. An example was provided regarding the technicians and engineers required to develop and manufacture new appliances or engineers performing upgrades to the upstream gas network.

It should be noted that 15% of heating in the UK is not powered by natural gas, so is not suitable for replacement with hydrogen, and that almost 4 million houses are not connected to the gas grid[59], with additional properties in the non-domestic sector.

Table 4-1: Hydrogen skills summary

Timeframe	Skills Summary
1-4 years	Existing gas installers will be able to re-train and install hydrogen-ready boilers, with an additional 200 FTE per year on average
5-10 years	Existing gas installers can continue re-fitting with hydrogen-ready boilers and begin conversion as hydrogen becomes available. 1,500 additional FTE per year average.
10 years plus	Continuation of re-fit and conversion programmes until all connected properties are converted. Workers then employed in maintenance. Steady reduction in numbers required - 500 FTE average
Summary	
Any hydrogen pathway could be accommodated within the existing workforce for installation. As part of a balanced pathway, deployment of hydrogen will form only part of the overall solution, so skills and training requirements would be reduced.	

4.1.2 Fabric First

As discussed in Section 2.2.2, significant expertise is required to develop a retrofit programme for a single building. Each such project requires the skills of a surveyor to assess current condition and any requirements for repair, an energy specialist to model current performance and design an upgrade solution, a project manager to supervise the retrofit programme, and various different trades people are required to implement all

[59] https://www.gov.uk/government/statistics/lsoa-estimates-of-households-not-connected-to-the-gas-network

the recommendations. Given this complexity, accurately modelling energy efficiency improvements to the building fabric of all domestic and non-domestic buildings in the UK is difficult. However, taken over the whole country, or even at a regional level, it is possible to model in aggregate how many of which interventions may be required.

Case Study: Renfrewshire Domestic Retrofit Project

Renfrewshire Council, Construction Scotland Innovation Centre and other partners are delivering a £4.5 million retrofit of 75 terraced council houses. The 1960s-built Paisley crosswall construction properties are being given a retrofit to reduce their carbon emissions and improve their energy efficiency. The completed works could enable carbon dioxide emissions to drop by almost 100 tonnes per property over the next 25 years, collectively preventing 7400 tonnes of carbon dioxide entering the environment[60].

Case Study: RINNO Project

RINNO is a Horizon 2020 project that aims to deliver a set of processes that when working together give a system, repository, marketplace, and enabling workflow process for managing deep renovation projects.

The ultimate objective of RINNO is to dramatically accelerate the rate of deep renovation in the EU by reducing the time, effort and cost of deep renovation while improving energy performance and stakeholder satisfaction[61].

Case Study RE:FIT LONDON – London Borough of Hounslow schools retrofit

The London Borough of Hounslow was the first organisation to utilise the fast-track RE:FIT schools programme, targeting energy efficiency in at least 72 of its schools. At the time of the case study the London Borough of Hounslow had installed energy conservation measures across 11 schools, reducing energy use by 1,200,000 kWh per year and saving over £150,000 off their energy bill every year[62].

For this study, the following common energy efficiency interventions were researched and modelled:

- Insulation

[60] https://www.renfrewshire24.co.uk/2020/01/23/renfrewshire-retrofit-housing-project-could-slash-heating-bills-by-90/

[61] https://rinno-h2020.eu/about/

[62] https://www.london.gov.uk/sites/default/files/approved_-_lb_hounslow_-_case_study.pdf

    - Lofts
    - Cavity walls
    - Solid walls
    - Floors
- Airtightness
- Glazing
    - Double, triple
    - Secondary

Of these, cavity wall insulation is the least intrusive, as it is applied externally, without significantly altering the appearance of the building. Loft insulation can be relatively non-disruptive, although this depends on the condition and accessibility of the loft space. Both are limited in the number of buildings that are suitable for their application. Loft insulation can usually be installed by low-skilled workers, but each installation requires a survey to ensure that there are no issues requiring attention, such as frayed wiring, leaks or damp. Cavity wall insulation also requires a survey, and must be installed by qualified operatives (Level 2 NVQ Certificate in Insulation and Building Treatments -Cavity Wall Insulation).

Solid wall insulation can be applied internally or externally, with each having pros and cons. There are also significant differences between installing at street level, compared to high-rise, with the latter requiring significant additional skills such as scaffolding and working at heights.

All forms of insulation require a survey, as they can affect ventilation and they alter the relative humidity profile through the wall, which can lead to condensation and damp.

Following the Grenfell Tower disaster, there is an ongoing programme of replacement of external high-rise cladding across the UK. This has absorbed all current capacity for external wall insulation and has also had a knock-on effect on street-level installations by drawing in qualified installers to the more lucrative high-rise contracts. If significant additional external insulation is required, it should be assumed that existing capacity is negligible.

Fitting internal solid wall insulation is more disruptive than external, in terms of occupants, but can be easier where external walls are inaccessible, listed or otherwise hard to alter. Retrofit insulation to floors can in some cases be carried out relatively quickly using novel techniques but is disruptive.

However, all these forms of insulation upgrade should normally be undertaken only as part of a holistic retrofit design, which would also include primary energy systems, energy distribution, draft stripping, and energy management systems (see below). Glazing upgrades may also be considered as part of such a programme, depending on the condition and effectiveness of existing units. In many cases, the addition of secondary glazing is more cost-effective.

As the combination of building envelope interventions is specific to each building, the model allows them to be apportioned across the building stock, making separate provision for the retrofit design and co-ordinator role.

Table 4-2: Fabric first skills summary

Timeframe	Skills Summary
1-4 years	A very rapid development of training facilities and courses is required, to train around 12,000 people a year.
5-10 years	Continuing growth in training requirement at around 30,000 a year, the balanced scenario has a sharp drop-off in the requirement toward the end of this period, as all opportunities to undertaken certain measures (e.g. cavity wall insulation) are exhausted.
10 years plus	No further training required. A continuing decline in the numbers required, as opportunities for further measures are exhausted.
Summary	
Improving the fabric energy efficiency of every building in the country is a colossal task but it has to be done. Some of the required roles, such as surveying and designing each project, require deep knowledge of building systems, considerable experience and specialised training. Many of the installation tasks can be delivered with lower levels of training but millions of interventions are required every year, for decades. Provided the scale of the response required is recognised and adequate action taken, it is still possible to achieve this task but there is no time to lose in developing the capacity to deliver the training required. A balanced scenario requires in the region of 12,000 new workers to be trained every year for about the next seven years, resulting in an increase over this period of about 100,000 workers. Because this scenario requires the rapid improvement of building envelope energy efficiency across the country, employment builds rapidly, then drops off sharply when all building envelope improvement projects are complete. This boom and bust element will need to be considered, and addressed.	

4.1.3 Heat Pumps

This scenario assumes undertaking a property-by-property heat pump conversion, typically to either an air-source or ground-source heat pump, including initial survey and system specification, and the installation itself. In a commercial context, there are opportunities for other heat sources to be used, such as surface water, marine, mine-water and effluent.

Before the physical installation of the system can begin, an on-site survey is required to identify the best option for the property based on space, heating demand and heat distribution system (wet radiators, underfloor heating etc). Heat pumps must be sized more carefully than traditional boilers according to the heat demand of a building and the capacity of the heat distribution system.

Heat distribution may need to be upgraded to work with lower flow temperatures, and hydraulic balancing is required to ensure that the distribution of water in heating systems is optimised.[63] Hydraulic balancing is always needed to ensure that a heating system is working optimally but traditional heating types (e.g. gas boilers) are less sensitive to this need, so it is often overlooked. The survey will be used to develop a specification and the installation project plan.

This would also be a good opportunity for surveyors to recommend additional retrofit measures which act synergistically to reduce operating costs and emissions by reducing both total energy consumption and flow temperatures; there is therefore a strong argument for considering that heat pump installation design surveyors should be qualified more widely (see Section 4.1.2). There is also significant potential for integrating heat pumps with other technologies, such as on-site generation, thermal storage, smart meters and smart tariff systems, which should be taken into account here. Similarly, clients need training in the idiosyncrasies of heat pump operation, particularly those who are accustomed to the flexibility, responsiveness and power of gas.

In terms of installation times, the HPA's Heat Pump Roadmap assumed that 6 working days would be needed to install a heat pump in a new build that has been constructed to allow 55°C flow temperatures, 8 working days are needed in retrofit homes and 3 working days are needed to replace heat pumps with a new heat pump. Each installer is assumed to work for 200 days per year[63].

The HPA estimated that there were around 900 heat pump installers in the UK in 2019. These installers are skilled in heat loss calculations, hydraulic balancing, flow temperature calculations and heating system sizing. As heat pumps can use HFC refrigerants, a proportion of the installers will be F-Gas qualified. Split systems are charged on-site (monobloc systems are typically charged and sealed at the factory, although repairs may require re-charging on site).

Heat pumps also tend to require 32-amp electrical supplies, and therefore an installation will require someone on site that is Part P (of the Building Regs) qualified to be able to connect the power supply.

Most heating system installers would need to upskill to be able to install heat pumps, which could act as a brake on their uptake as consumers are usually reliant on the knowledge and advice provided by heating installers. The proposed ban on new gas boiler installations only applies to new-build installations, but is currently one of the significant policies (alongside for example, RHI and the Merton Rule) supporting heat pump deployment.

[63] https://www.heatpumps.org.uk/wp-content/uploads/2019/11/A-Roadmap-for-the-Role-of-Heat-Pumps.pdf

Widespread heat pump deployment will require both upskilling of the current workforce and training the next generation of low-carbon heating installers. This will ensure that the quality of heat pump installations is high, the knowledge of the benefits that the technology can bring is commonplace, and there are enough installers to scale up deployment to the levels required.

The training content would need to contain a number of elements:

- A broad renewables heating training course that gives installers an understanding of how a range of renewable heating technologies work, including heat pumps and the basics associated with their design. The qualification outcome of this training would be an Ofqual-accredited Renewables Heating Certificate.
- A general heat pump training course that teaches installers about how a heat pump works (including heat loss calculations, hydraulic balancing, flow temperature calculations and heating system sizing), as well as what installers can and can't do without appropriate certification (e.g. F-gas and Part P). The qualification outcome from this training would be an Ofqual-accredited Heat Pump Certificate and a skills card similar to Gas Safe, with retraining every 5 years.
- Various manufacturer-specific training courses would then follow this. These have already been developed and are provided by the manufacturers to train installers on specific product installation requirements. The qualification outcome from this training is a specific Manufacturer Certificate, with periodic retraining.

Overall, it was estimated that this in total could be a week's worth of training e.g. 40hrs. It would not necessarily need to be undertaken all at once. In addition, some of this could be delivered online. As noted there would need to be a skill card as evidence of competency. During the interviews it was suggested that this could be run by an organisation such as Gas Safe or Microgeneration Certification Scheme (MCS). One way to drive this would be for Building Regulations to stipulate that someone has to be trained and qualified, as there is a safety aspect to this as well as a quality aspect.

The UK heat pump manufacturers have seven training rooms or training schools in the UK. This presents an opportunity for the manufacturers to play an important role in this training delivery. It is worth noting that specific manufacturing training is often a prerequisite for installation of their products

The energy efficiency of some (e.g. traditional, listed and historical) buildings may be effectively impossible to improve through retrofit. In these cases, and potentially more widely, there is an argument for the use of hybrid heat pumps, which can operate in heat pump mode normally, but retain the ability to switch to gas (or hydrogen) when heat demand is beyond the output capacity of the heat pump.

Many decarbonisation specialists have reservations about the deployment of hybrid heat pumps, as they have the potential to operate constantly in gas boiler mode, which makes no contribution to decarbonisation. Conversely, they have the ability to provide

heat not only for the type of buildings that cannot be improved, but also for those that can, while they are; which may well take several years to complete.

From a skills perspective, hybrid heat pump installations require the skills needed to install a gas boiler and those required to install a heat pump.

Table 4-3: Heat pump skills summary

Timeframe	Skills Summary
1-4 years	A rapid increase in training will be required, of around 7,500 installers a year. This is within the capacity of existing training facilities.
5-10 years	An increase in the rate of training, up to a peak of around 15,000 a year. Towards the end of this period, this will exceed existing training capacity but increasing this within this period is manageable.
10 years plus	Ongoing work for the workforce, with a gradual reduction in the requirement for installers, as new installations give way to maintenance work. Limited ongoing training requirement.
Summary	
Heat pumps are almost certain to be a key technology in decarbonising the built environment. The skills required to install them effectively are sophisticated, and quite different from those required to install conventional heating systems. They are also more efficient when installed alongside improved energy efficiency, distribution and management systems, so a familiarity with these disciplines among heat pump installers would be an advantage. A major effort will be required to train enough competent installers but for most pathways, the scale is within the capacity of existing training resources. A balanced scenario would require between 7,500 and 15,000 heat pump installers a year to be trained over the next seven years, resulting in an additional resource of around 60, 000 workers. These workers would then be required for most of the next twenty years, with demand gradually tailing within the range of natural attrition.	

4.1.4 Heat Networks

Most pathways include provision of a proportion of heat through heat networks, which are described in Section 2.1.3.4. Although they are included in the scope of this study, heat networks (including district heating and communal heating) are better considered as infrastructure rather than building energy systems. They can extend to cover entire cities (e.g. Nottingham District Heating Scheme, which is 85km long) and are typically developed at the scale of streets, city blocks or high-rise flats, with their viability depending on the availability of suitable heat sources and dependable high density heat demand.

Research undertaken for this study has corroborated the findings of the recent study[64] undertaken into heat networks for BEIS by IFF and added figures to the qualitative observations of that study, so that quantitative estimates of skills requirements can be derived for different pathways.

The main skills gaps include strategic level project planners, engineers and developers, design engineers and control systems / PLC specialists, and at an installation level, welders and general installers.

This is indicative of the holistic nature and the scale of heat network design, as distinct from individual house-scale interventions. To design and develop an effective low-carbon heat network requires identification of a suitable source of renewable, low-carbon energy (e.g. a river), development of a system to exploit it (e.g. a commercial scale heat pump), sophisticated modelling of supply and demand, negotiation of access, commercial agreements and tariffs, installation and operation. Connection to building heating systems in a new-build scenario can be relatively straightforward, but integrating heat networks with existing building systems in retrofit context can be challenging.

Existing heat networks can be extended and connected to existing buildings, subject to specified constraints on flow and return temperature and flow rate. However, many existing heat networks are powered by gas boilers or CHP, so decarbonisation of the primary energy source for these systems is essential if they are to make any contribution to net-zero. A recent Call for Evidence[65] for the proposed £270m Green Heat Network Fund (GHNF) included questions relating to the decarbonisation of primary energy sources for heat networks.

A wide range of scenarios is captured under a single heading but, taken in aggregate, the deployment of heat networks at a given rate results in predictable requirements for specific skills.

Table 4-4: Heat Network skills summary

Timeframe	Skills Summary
1-4 years	Significant additional training capacity, 9500 average additional FTE per year, including predominantly specialist and technical skills.
5-10 years	Reduction in rate of training to 866 average additional FTE per year
10 years plus	Reduction in numbers required - 1200 FTE per year

[64] https://www.gov.uk/government/publications/heat-network-skills-review
[65] BEIS: Green Heat Network Fund, Call for Evidence. Closed 13th October 2020.

Summary
Significant deployment of heat networks will require a sharp increase in training, as the sector is currently under-staffed and skills required are typically technical, requiring existing experience and long training courses.

4.1.5 On-site energy

This heading includes a wide range of technologies, many of which bring new opportunities for decarbonisation. These include on-site generation, energy storage and smart systems, as well as the interaction between them.

For the purposes of this study, small-scale wind generation has been excluded. Suitable sites for ground-mounted wind installations are rare, and building-mounted systems have never been demonstrated to be effective; mainly because the wind resource is too low, the swept area too small, and the mechanics too unreliable. Combined Heat and Power (CHP) is also not considered, as it contributes little to decarbonisation and locks in greenhouse gas emissions[66], [67].

For on-site generation, the study considers solar photovoltaic panels and solar thermal panels. Photovoltaic panels (known as PV) generate electricity from sunlight. The cost of PV has dropped dramatically in recent years. Panels are now commonly seen mounted on rooftops; they work best when oriented to the south and generate when the sun shines. While PV generation is effective, the match of supply and demand can be poor, particularly in a domestic context, as most consumption is overnight. This can be addressed in a number of ways: by exporting excess electricity to the grid, or by storing it on site, either as electrical energy in batteries, or as thermal energy in a hot water tank of thermal battery. It is beginning to become possible to connect the switching of household appliances to on-site generation output, so that electricity generated is used as much as possible in the home (or building).

Solar thermal panels do not generate electricity (although confusingly, hybrid thermal/PV panels are becoming available), they generate hot water directly from sunlight. This is stored, usually in a conventional hot water tank, and used for showers, baths etc. Solar thermal panels are very efficient and robust and can make a significant contribution to reducing hot water loads, typically providing all hot water requirements over the summer, and around half in the spring and autumn (but very little in winter).

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[66] Does replacing coal with wood lower CO2 emissions? Dynamic lifecycle analysis of wood bioenergy. Stearman et. al. IOP Science 18th January 2018 https://iopscience.iop.org/article/10.1088/1748-9326/aaa512/meta#artAbst

[67] Europe's renewable energy directive poised to harm global forests. Searchinger et al, Nature Communications 9(3741) 2018. https://www.nature.com/articles/s41467-018-06175-4

All of these systems can now be connected together by smart meters and smart systems, allowing for example storage of electricity generated either on site or off-site at cheap or low-carbon times of day, variable tariffs levels based on wholesale cost of electricity, and other means of balancing the grid, allowing greater deployment of renewable generation and other benefits.

From a skills and training perspective, roof-mounted generation systems such as PV and solar panels require similar skills, such as scaffolding and working at heights. PV systems require electrical qualifications, whereas thermal systems require more plumbing-based skills. Thermal storage similarly can require only plumbing skills (in the case of conventional hot water storage) or both plumbing and electrical skills (in the case of heat batteries). Installation of electrical storage batteries requires electrical skills.

Domestic smart systems tend to be very easy to set up, typically being aimed directly at the consumer market (e.g. Apple HomeKit[68], Google Nest[69]). Non-domestic systems are typically wired into existing systems and require electrical installation skills. These systems can provide insights into consumption patterns which can help occupants to reduce consumption significantly, for modest cost and with relative ease. They are relatively new, and there is still significant untapped potential for integrating them with internal and external systems, automating energy saving and exploiting connected services.

Table 4-5: On-site energy skills summary

Timeframe	Skills Summary
1-4 years	Limited additional training required. 5000 average additional FTE per annum
5-10 years	Limited additional training required. 450 additional FTE per annum
10 years plus	Limited additional training required. -750 annual average reduction in numbers required
Summary	
On-site energy systems are often straightforward to install, requiring at most conventional electrical and plumbing skills. Widespread deployment will not present a significant skills challenge.	

[68] https://www.apple.com/uk/shop/accessories/all-accessories/homekit
[69] https://store.google.com/category/connected_home?

4.2 Skills Analysis Model

This section firstly describes the purpose of the model before moving on to describe the mechanics of the modelling tool and finally the outputs of the model in the context of a central input scenario.

Note: the model is built on the framework of the Construction Skills Network survey, so novel roles (e.g. retrofit co-ordinator) have been mapped as closely as possible onto existing roles, but there are some roles (e.g. off-site construction, heat network design) which are not included in CSN, and which are therefore not included in the projections.

4.2.1 Purpose

The model has been developed as an informative scenario planning tool. For any net-zero deployment scenario the model computes the impact on the construction sector workforce both in terms of the numbers of people required to carry out the deployment scenario and the minimum skills those people will require.

The tool has been developed so that a user has the freedom to input any net-zero deployment scenario. This provides the option for not only a predetermined deployment scenario to be input into the model, but also for the model to be used as a goal seeking tool to derive a deployment scenario which is acceptable and deliverable for the construction workforce in terms of both recruitment and training capacity. The model is also supported by relevant guidance which allows users to update all baseline input assumptions if improved data becomes available in the future. This requirement for the tool to be flexible and adaptable is at the core of its development and allows its' use to stay relevant into the future.

4.2.2 Description

The model uses a series of calculations and assumptions to compute the impact of a net-zero deployment scenario on the construction sector. It has been developed in MS excel to help with ease of use, given it is a widely used programme and most have access to it. Ease of use was a key consideration during model development as well as the ability for it to be used by someone without expert knowledge in each of the building types or the interventions. A final key element of the model is adaptability and ensuring the model remains a useful tool for years to come. To this end, all input assumptions are readily updateable, and the model contains guidance listing where these input assumptions can be found throughout the model.

In this section, the major assumptions and steps in the modelling are described. A more detailed explanation of the mechanics of the model is found in Appendix A.1.0.

There are three steps making up the model:

1) **Step 1 - Model inputs** – the first step of the model is an input stage for the model user. A net-zero deployment scenario is input into the model and this forms the basis of all the model outputs. The model has been built so that any possible

deployment scenario can be run through. However, there are some constraints on the input data which the model accepts. These consist of:

a. The model is limited to four different property types: domestic existing, non-domestic existing, domestic new build, non-domestic new build, using an average 3 bed semi-detached house, and a high rise block as the basis for these types, as set out in Appendix A.2.3.1. Although it is recognised that these four standard property types may not reflect the complexity of the building stock in a small geographical area such an approach was considered a good compromise in terms of not requiring a large number of input assumptions, broken down by further property types, and to ensure the model is workable by all users;
b. 18 different types of possible intervention including building fabric, heating systems and technologies such as PV. This list of interventions has been developed in consultation with stakeholders as those most relevant for the transition to net zero. Although it is recognised that each intervention has its own complexity, these categories represent an average for that intervention. It is also possible to input requirements for retrofit co-coordinators; and
c. Pace changes for years 2021 – 2030 can be changed on an annual basis and from 2030 – 2050 this pace change is on a 5-yearly basis. This is a key part of any input assumption as, although only the number of number of installations across property types is needed to understand the total effort required to reach net-zero by 2050, the pacing of these interventions is key to understand the requirements on resources and skills across the 30 year period.

2) **Step 2 - The FTE requirements** – the second step of the model produces the first outputs which consist of heat maps and charts of the additional workforce required to deliver the scenario input in step 1 by CSN Occupational Group. To do this a series of assumptions are used including:

a. CSN Occupational Groups are used throughout the model and the additional jobs required are classified according to the 28 CSN Occupational Groups used as the structure for the Construction Skills Network Forecast[70]. (This approach was chosen so that the model is consistent with other CITB forecasting tools);
b. It is acknowledged that there are some jobs, especially those relevant to heat networks and modern methods of construction, which do not fall in to these CSN Occupational Groups and for the purposes of the modelling, they are considered out of scope;

[70] Construction Skills Network forecasts 2019-2023 – UK, CITB. https://www.citb.co.uk/about-citb/construction-industry-research-reports/search-our-construction-industry-research-reports/forecasts/csn-forecasts-2019-2023-uk/

c. Similarly, new roles such as retrofit advisor, assessor, co-ordinator, designer and evaluator, which are not included in the CSN structure, are mapped as closely as possible to existing roles (e.g. retrofit co-ordinators are included in the Construction Project Manager category);
d. Input data for the 'time taken' to install an intervention per property type and CSN Occupational Group forms the basis of the calculation in this step; and
e. A utilisation rate assumption has been made that 4%[71] of the current construction workforce currently works on net-zero projects and are therefore available to install the input deployment scenario.

3) **Step 3 - The skills and qualification requirements** – this third and final step of the model considers the skills and qualification requirements of the workforce required to deliver the intervention scenario and presents the outputs as heatmaps and graphs. The skills and qualifications are treated slightly differently in the model as outlined below:
    a. Qualification level: 'Qualification level' refers to NVQ levels, degrees, and PhD's. The model uses Labour Force Survey and Construction Skills Network data to understand the spread of these qualification in the current workforce and apportions the same spread of qualifications to the additional workforce; and
    b. Specialist skills: 'Specialist skills' refers to both certified courses such as the 'F-gas' and non-certified courses such as general 'sustainability training'. Input data for the percentages of the workforce required to install an intervention who require the specialist skill is used to calculate the specialist skills requirements of the workforce.

In conclusion, the three steps of the model outlined above form the scenario planning tool and enable a user to input any net-zero deployment scenario and derive the impact on the construction workforce in terms of additional FTE per CSN Occupational Group and the implication on skills and qualifications. Finally, the input data for the model is fully updateable so that the model can be updated alongside technical innovation and data improvement.

It is acknowledged that there are some jobs, especially some aspects of heat networks and modern methods of construction, which do not fall in to the CSN Occupational Groups. The model assigns hours across the CSN Occupational Groups for measures relating to these disciplines, but there are some occupations which are outside the CSN framework, and for the purposes of the modelling, these are considered out of scope.

[71] This figure is taken from a survey of their members conducted by the Federation of Master Builders, which asked what proportion of their time was spent on low-carbon work. The FTE requirement estimate for each CSN Occupational Group has been reduced by this percentage, on the grounds that that amount of work is already being done.

4.2.3 Example scenario

An illustrative net-zero compatible scenario has been used, based on input from the CCC alongside other steering group members. This illustrative scenario is intended to be a balanced scenario, incorporating moderate levels of energy efficiency uptake and a mix of low carbon heat technologies (including some hydrogen as well as electricity). It incorporates an 'energy efficiency first' trajectory, designed to maximise energy efficiency deployment over the coming decade, ahead of wide-scale low-carbon heat deployment. This section presents the results of this deployment scenario and explains the outputs of the model.

The input scenario provided data which related to existing and new-build domestic property and profiled a deployment scenario for most of the interventions included within the model to 2050. Some aggregation of the scenario was required where one of the modelled intervention categories was split into several lines within the data, and some of the interventions included in the model were not considered in the input data, such as estimates for solar thermal panels, so estimates were made for their deployment using similar interventions from the input data.

To run the model completely, estimates were made for non-domestic properties:

- For non-domestic existing properties, a factor of 1/60th of the deployment scenario for the domestic existing property type was input. This factor is based on the standardised energy consumption figures for domestic and non-domestic buildings, which tend to be presented per unit, and per m^2 respectively, so that figures for individual dwellings and flats can be compared; and
- For non-domestic new build, 1/60th of the deployment scenario for domestic new build was input. This assumption is based on relative energy consumption figures of domestic vs non-domestic properties.

The input scenario provided also did not include data for the numbers of retrofit co-ordinators required for domestic and non-domestic existing properties. An assumption has been made that the number of retrofit co-ordinators required in a particular year will equate to the same number as the intervention with the most installations in a particular year, on the basis that those interventions will have been specified by a retrofit co-ordinator.

This net-zero deployment scenario forms the basis of the results presented in Figures 4-1 to 4-6, which illustrate how the model can be used to determine the skills implications of a decarbonisation scenario. Each figure will be discussed in turn alongside a brief analysis of the modelled results.

These figures are based on a static 2019 baseline and are expressed in terms of additional FTE requirement. It is important to note that the modelled requirement will actually be additional to a baseline which starts at around 2.7 million, which varies annually, and which may be expected to vary more than usual in the context of coronavirus, EU exit and other factors.

The model does not include attrition, as that is included in the baseline, and the model derives additional FTE jobs required as a result of net-zero, so overall attrition is not relevant.

As the purpose of the model is to inform requirements for skills and training, it generates figures for additional work generated by the net-zero programme. It does not model the reduction in work that results, for example in the installation and maintenance of fossil-fuel energy systems. This has led to some confusion in interpretation of the figures during the report review process, as they are often read as net additional construction sector jobs, when in fact the model only estimates additional work, taking no account of reductions in existing workload.

This confusion seems to be particularly acute with respect to replacement of equipment: CCC has provided design life estimates for the various measures included, and these have been built into the model at appropriate time-spacing. For example, air-source heat pumps have a design life of 15 years, as do gas boilers. 10,000 ASHP units installed in 2021 will result in an additional 10,000 replacements in 2036. Both the original installations and the replacements will require additional trained staff, and both will displace installation work that would otherwise have gone to fossil-fuel boiler installers. The model only considers the additional skilled staff required, and the implied training requirements; it does not consider reductions in demand as a result of displacement of conventional installations.

The following sections describe the graphs presented below, which are derived from the model. The model itself has been submitted to CITB and forms part of this report; output in any format can be generated from the model.

4.2.3.1 FTE requirement by CSN Occupational Group

The graph of additional FTE requirement above 2019 year baseline CSN workforce per CSN Occupational Group profiled to 2050 (Figure 4.1) displays the output of step 2 of the model. It shows that, with the input deployment scenario there will be a peak in the total number of additional workers required to deliver the scenario in the late 2020's of around 350,000 additional workers. The CSN survey recorded 2.7 million workers in the construction sector in 2019, therefore this scenario requires an increase of around 13% in the current size of the construction sector. The peak in demand for workers in the late 2020s is primarily driven by the 'energy efficiency first' scenario, which requires a major effort to improve building energy efficiency in preparation for the installation of modern, low-carbon heating systems.

For clarity, the chart is presented with the data table, and includes only those occupations where additional FTE are required as a result of implementing the required measures. This does not suggest that those occupations excluded will not be required; it is because the model takes account of existing effort in net-zero activities. Where the required additional effort is less than existing capacity, the model returns a requirement for zero additional effort.

The graph of annual difference in FTE required per CSN Occupational Group (Figure 4.2) builds on Figure 4.1 and shows the difference in FTE requirement per CSN Occupational Groups for adjacent years. The graph shows that 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 (nec) where almost 12,000 additional workers will be required; and
- Building Envelope Specialists where nearly 8,500 additional workers will be required.

Based on the illustrative scenario, in the late 2020's the numbers of additional workforce required on top of the 2019 base construction workforce will decrease rapidly, as energy efficiency work is completed; they will then become broadly stable (still at around 250,000 FTE more than the 2019 baseline) to 2050 as the requirement for maintenance and replacement kicks in. The decrease in workforce mostly affects the 'building envelope specialists,' 'construction project managers' and 'Labourers nec*' CSN Occupational Groups and is on the scale of 20-30,000 people in each of these categories in years 2028 -2029. With foresight these reductions in numbers can be managed, for example for example through structured programmes of re-skilling, particularly as there will be an increase in the requirement for low-carbon energy systems around this time.

4.2.3.2 FTE requirement by qualification level

The graph of FTE requirement, in addition to the 2019 workforce base, per qualification level profiled to 2050 (Figure 4.3) shows the same profile as Figure 4.1 but split into qualification levels, showing the relative distribution of workers required at each skill level. There is a weighting toward NVQ Level 3 and below.

The graph of difference in annual FTE requirements for subsequent years for each qualification label profiled to 2050 (Figure 4.4) shows the per annum variation in requirements, as Figure 4.2 but split by qualification level, as Figure 4.3. It highlights that around year 2030 there will be quite large-scale reduction in numbers required which will fall mainly on less skilled workers. This highlights that under an energy efficiency first deployment scenario, there is a need for careful management of this key transition to ensure that workers are protected and have a just transition to other work.

In this context, it is perhaps worth emphasising that this model is intended to illustrate the consequences of particular decarbonisation pathways, so that those consequences can be considered; it is not an illustration of government policy. Thus, the sharp drop in employment resulting from this analysis should be read as a warning to prompt appropriate action to ensure a just transition, while of course maintaining the net-zero decarbonisation trajectory.

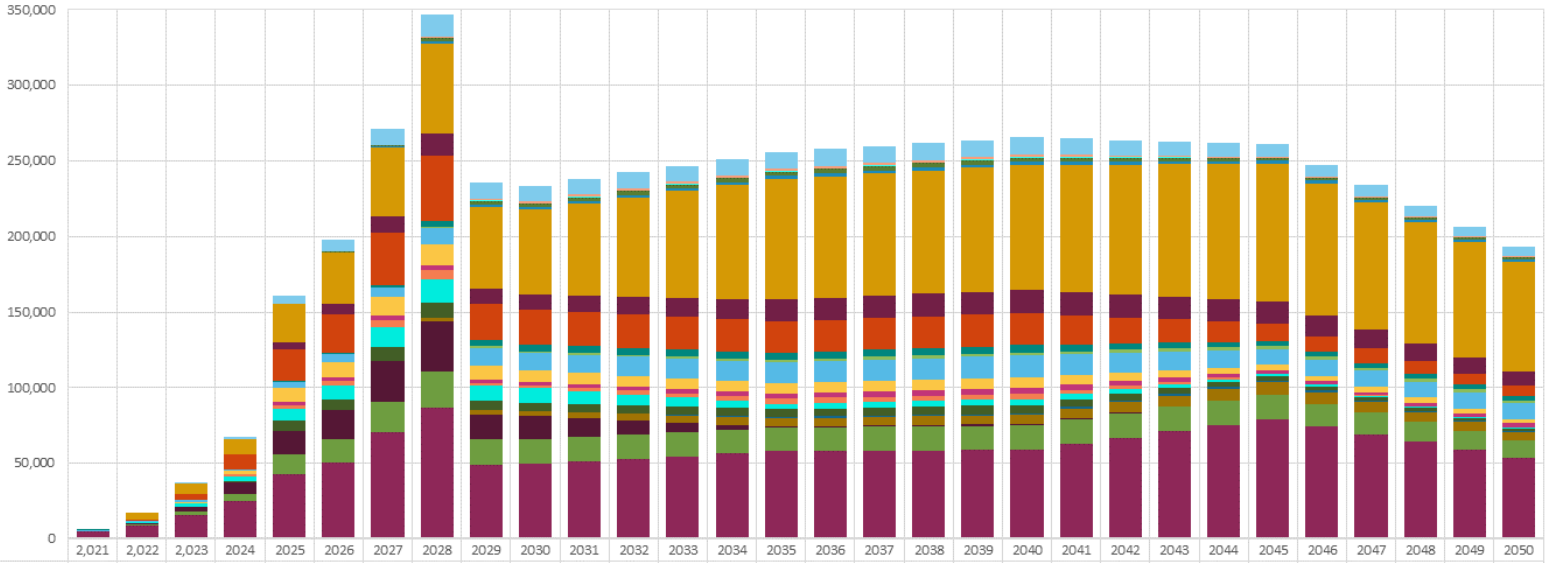
4.2.3.3 FTE requirement by Specialist Skills

The graph of FTE requirement for each Specialist Skill profiled to 2050 (Figure 4.5) and difference in FTE Requirements for subsequent years for specialist skills profiled to 2050 (Figure 4.6) show the requirement for specialist skills such as heat pump installer. Based on the illustrative scenario, these qualifications peak at around 250,000 in the late 2020s, when there is a sharp drop-off, followed by a gradual increase over the next five years or so, back to the peak level of around 250,000, which remains stable until the mid-2040s, when it starts to tail off to around 200,000 in 2050. Figure 4.6 shows the annual variation in training (and reduction in numbers required) by specialist skills. In the late 2020's, in line with the general reduction in additional workforce requirement described above, the need for some specialist skills will also decrease. Those specialist skills most affected include:

- Asbestos Awareness Training (-22%);
- Trustmark Approved Retrofit Co-ordinator (-17%);
- Trustmark Approved Retrofit Designer (-15%).

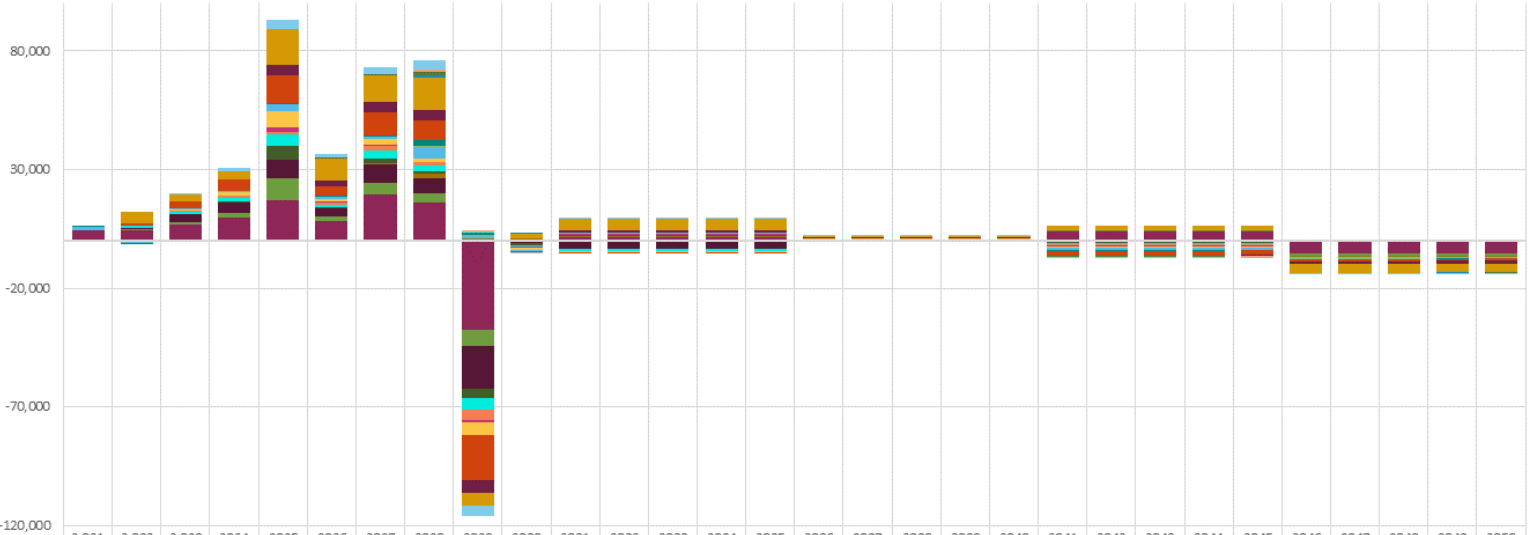
The scale of change implied by the illustrative scenario represents, as a maximum, a decrease in specialist skills of 80,000 courses per year. The impact of this on training colleges would need to be carefully considered and planned.

Figure 4.1: Graph of additional FTE requirement above 2019 year baseline CSN workforce per CSN Occupational Group profiled to 2050



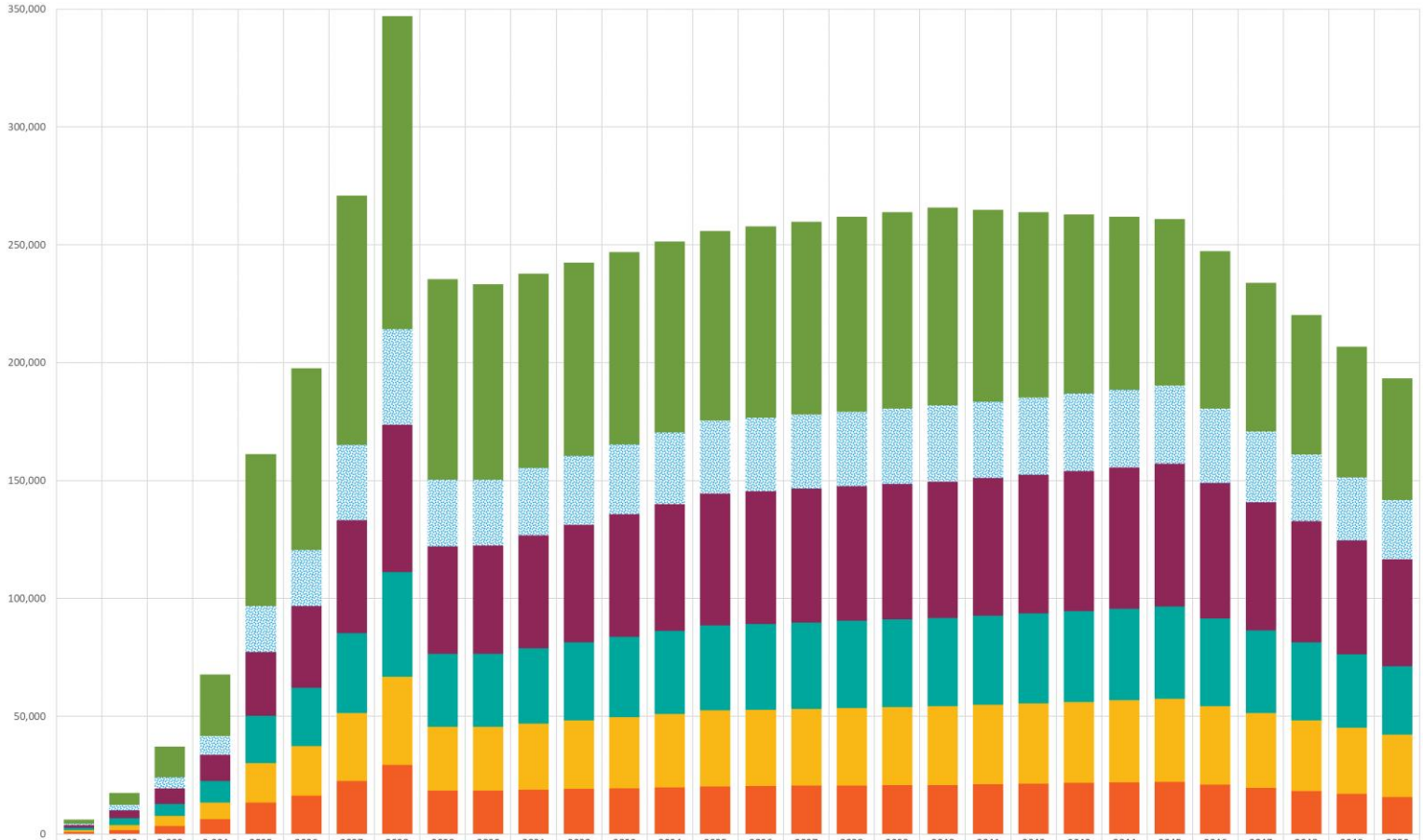
	2,021	2,022	2,023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Surveyors	0	0	419	1,813	5,957	7,553	10,541	14,522	10,146	9,998	10,170	10,342	10,514	10,686	10,858	10,944	11,030	11,116	11,202	11,288	10,671	10,054	9,436	8,819	8,202	7,813	7,425	7,036	6,647	6,258
Civil engineers	0	0	0	0	0	0	0	883	1,253	1,253	1,319	1,386	1,452	1,518	1,585	1,603	1,621	1,640	1,658	1,676	1,467	1,259	1,050	841	632	600	568	536	505	473
Non–construction operatives	0	0	0	0	0	0	0	152	337	337	370	403	436	470	503	512	521	530	539	548	444	340	235	131	27	11	0	0	0	0
Civil engineering operatives nec*	0	0	0	0	101	392	617	2,203	2,574	2,574	2,640	2,706	2,773	2,839	2,906	2,924	2,942	2,960	2,978	2,997	2,788	2,579	2,370	2,162	1,953	1,921	1,889	1,857	1,825	1,793
Logistics	0	0	0	0	0	171	476	1,336	1,416	1,456	1,545	1,635	1,724	1,813	1,902	1,917	1,932	1,947	1,962	1,977	1,964	1,952	1,939	1,926	1,914	1,814	1,715	1,616	1,516	1,417
Plumbing and HVAC Trades	0	4,804	7,351	10,464	25,464	34,407	45,735	59,470	54,056	56,175	60,914	65,653	70,392	75,132	79,871	80,436	81,001	81,567	82,132	82,697	84,475	86,252	88,030	89,807	91,585	87,824	84,063	80,302	76,541	72,780
Electrical trades and installation	0	0	0	0	4,254	6,671	10,626	14,983	9,956	9,959	10,880	11,800	12,720	13,641	14,561	14,692	14,823	14,954	15,084	15,215	15,051	14,887	14,723	14,559	14,395	13,352	12,309	11,266	10,223	9,180
Labourers nec*	0	942	4,074	9,322	21,165	25,161	35,348	43,305	24,057	23,297	22,742	22,187	21,632	21,077	20,522	20,665	20,808	20,951	21,094	21,238	19,243	17,248	15,253	13,258	11,263	10,328	9,394	8,459	7,524	6,590
Steel erectors/structural fabrication	331	0	0	0	526	963	1,299	3,679	4,234	4,234	4,334	4,434	4,533	4,633	4,732	4,760	4,787	4,814	4,842	4,869	4,556	4,243	3,930	3,617	3,303	3,256	3,208	3,160	3,112	3,064
Plant mechanics/fitters	0	0	0	0	0	0	0	738	1,055	1,117	1,273	1,430	1,586	1,742	1,898	1,917	1,936	1,954	1,973	1,992	2,074	2,156	2,238	2,320	2,402	2,258	2,114	1,970	1,826	1,682
Plant operatives	1,335	521	892	1,123	4,018	5,204	6,114	10,856	12,078	11,666	12,089	12,513	12,936	13,360	13,783	13,926	14,069	14,212	14,355	14,498	13,642	12,785	11,929	11,072	10,216	10,340	10,464	10,588	10,713	10,837
Scaffolders	0	281	1,000	2,268	9,227	10,160	12,456	13,890	8,729	7,839	7,590	7,341	7,092	6,843	6,595	6,708	6,822	6,936	7,049	7,163	6,511	5,859	5,208	4,556	3,904	3,699	3,494	3,289	3,084	2,878
Specialist building operatives nec*	0	0	0	0	1,824	2,310	2,954	3,204	2,343	1,826	2,115	2,403	2,692	2,981	3,269	3,373	3,477	3,581	3,685	3,789	3,389	2,989	2,589	2,189	1,788	1,992	2,195	2,399	2,602	2,805
Glaziers	0	0	364	1,445	2,524	3,202	4,956	6,340	1,867	1,870	2,183	2,495	2,808	3,121	3,433	3,433	3,433	3,433	3,433	3,433	2,840	2,247	1,654	1,061	468	327	186	45	0	0
Floorers	0	621	1,713	3,410	7,950	9,030	12,788	15,043	10,092	9,674	8,473	7,271	6,069	4,868	3,666	3,722	3,777	3,832	3,888	3,943	3,458	2,973	2,488	2,004	1,519	1,360	1,201	1,042	883	724
Roofers	0	0	0	441	6,651	7,364	9,097	10,107	6,198	5,380	5,342	5,304	5,266	5,228	5,190	5,294	5,398	5,502	5,607	5,711	5,080	4,449	3,818	3,186	2,555	2,382	2,208	2,034	1,861	1,687
Plasterers	0	0	0	0	0	0	0	0	137	188	314	441	568	695	822	837	852	868	883	898	965	1,031	1,098	1,165	1,231	1,114	997	880	764	647
Painters and decorators	0	0	0	0	0	0	287	2,207	3,075	3,376	3,842	4,308	4,774	5,240	5,706	5,754	5,802	5,850	5,898	5,945	6,387	6,828	7,269	7,711	8,152	7,615	7,078	6,541	6,004	5,467
Building envelope specialists	0	465	3,616	8,084	15,859	19,007	27,234	33,607	15,600	15,033	12,124	9,216	6,308	3,400	492	567	643	718	794	869	664	459	254	49	0	0	0	0	0	0
Wood trades and interior fit-out	0	0	0	0	0	0	0	83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction Trades Supervisers	0	872	2,155	4,085	13,231	15,555	20,158	23,943	17,256	16,689	16,452	16,216	15,979	15,743	15,506	15,673	15,840	16,007	16,174	16,341	16,299	16,257	16,215	16,173	16,130	15,144	14,157	13,171	12,185	11,198
Construction Project Managers	4,640	8,920	15,649	25,337	42,390	50,537	70,175	86,415	48,900	49,410	51,131	52,853	54,574	56,295	58,016	58,156	58,296	58,436	58,577	58,717	62,841	66,965	71,090	75,214	79,338	74,233	69,127	64,022	58,916	53,811

Figure 4.2: Graph of annual difference in FTE required each year per CSN Occupational Group



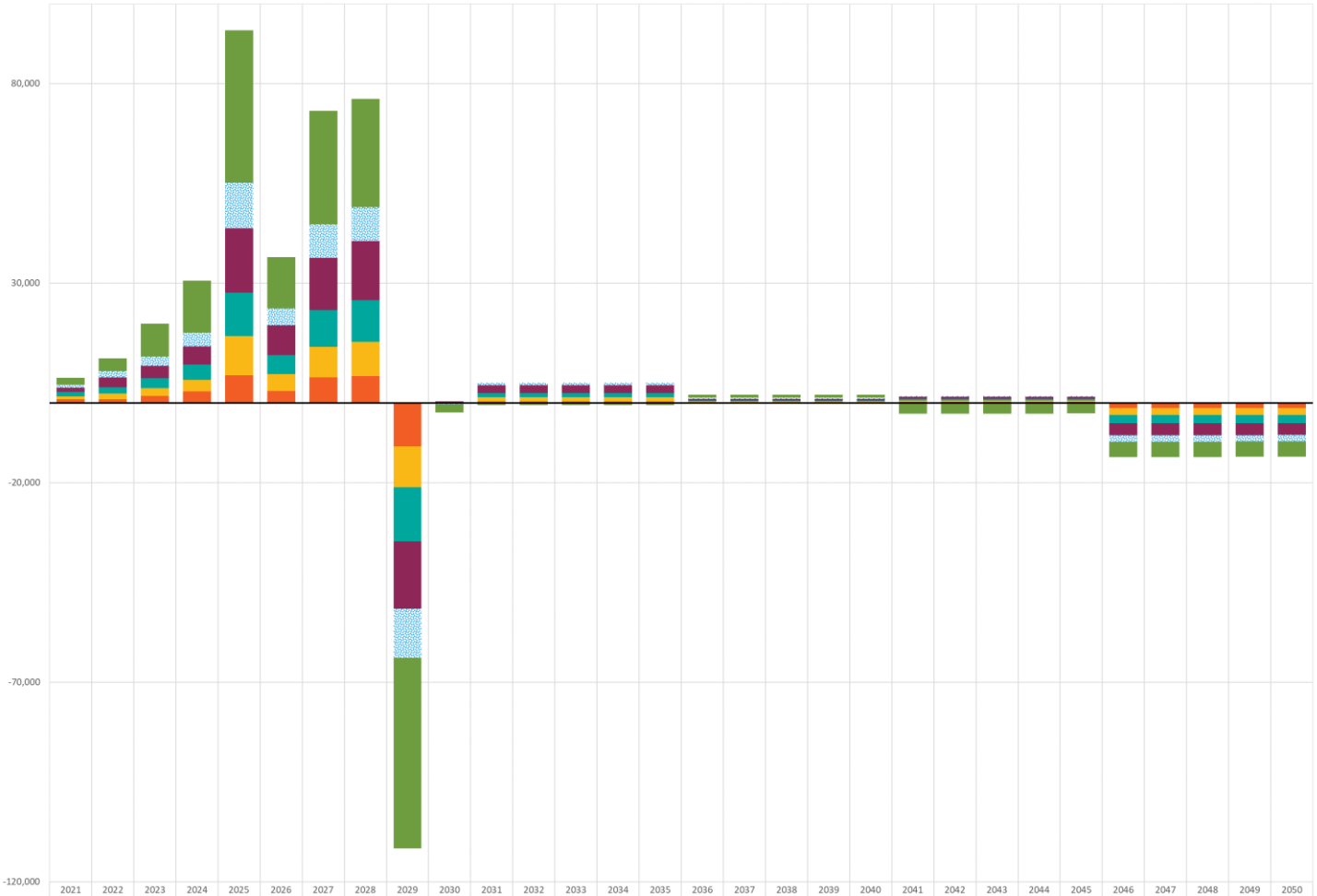
	2,021	2,022	2,023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Surveyors	0	0	419	1,394	4,144	1,596	2,988	3,981	-4,377	-147	172	172	172	172	172	86	86	86	86	86	-617	-617	-617	-617	-617	-389	-389	-389	-389	-389
Civil engineers	0	0	0	0	0	0	0	883	370	0	66	66	66	66	66	18	18	18	18	18	-209	-209	-209	-209	-209	-32	-32	-32	-32	-32
Non–construction operatives	0	0	0	0	0	0	0	152	185	0	33	33	33	33	33	9	9	9	9	9	-104	-104	-104	-104	-104	-16	-11	0	0	0
Civil engineering operatives nec*	0	0	0	0	101	291	224	1,587	370	0	66	66	66	66	66	18	18	18	18	18	-209	-209	-209	-209	-209	-32	-32	-32	-32	-32
Logistics	0	0	0	0	0	171	305	861	80	40	89	89	89	89	89	15	15	15	15	15	-13	-13	-13	-13	-13	-99	-99	-99	-99	-99
Plumbing and HVAC Trades	0	4,804	2,547	3,113	15,000	8,943	11,328	13,735	-5,414	2,119	4,739	4,739	4,739	4,739	4,739	565	565	565	565	565	1,778	1,778	1,778	1,778	1,778	-3,761	-3,761	-3,761	-3,761	-3,761
Electrical trades and installation	0	0	0	0	4,254	2,417	3,955	4,357	-5,028	4	920	920	920	920	920	131	131	131	131	131	-164	-164	-164	-164	-164	-1,043	-1,043	-1,043	-1,043	-1,043
Labourers nec*	0	942	3,133	5,248	11,843	3,996	10,187	7,957	-19,248	-760	-555	-555	-555	-555	-555	143	143	143	143	143	-1,995	-1,995	-1,995	-1,995	-1,995	-935	-935	-935	-935	-935
Steel erectors/structural fabrication	331	-331	0	0	526	437	336	2,380	555	0	100	100	100	100	100	27	27	27	27	27	-313	-313	-313	-313	-313	-48	-48	-48	-48	-48
Plant mechanics/fitters	0	0	0	0	0	0	0	738	317	63	156	156	156	156	156	19	19	19	19	19	82	82	82	82	82	-144	-144	-144	-144	-144
Plant operatives	1,335	-814	372	231	2,895	1,186	910	4,742	1,222	-413	424	424	424	424	424	143	143	143	143	143	-856	-856	-856	-856	-856	124	124	124	124	124
Scaffolders	0	281	719	1,269	6,958	934	2,296	1,434	-5,161	-891	-249	-249	-249	-249	-249	114	114	114	114	114	-652	-652	-652	-652	-652	-205	-205	-205	-205	-205
Specialist building operatives nec*	0	0	0	0	1,824	486	644	250	-861	-517	289	289	289	289	289	104	104	104	104	104	-400	-400	-400	-400	-400	203	203	203	203	203
Glaziers	0	0	364	1,081	1,079	678	1,754	1,384	-4,473	2	313	313	313	313	313	0	0	0	0	0	-593	-593	-593	-593	-593	-141	-141	-141	-45	0
Floorers	0	621	1,092	1,696	4,541	1,080	3,758	2,256	-4,952	-418	-1,202	-1,202	-1,202	-1,202	-1,202	55	55	55	55	55	-485	-485	-485	-485	-485	-159	-159	-159	-159	-159
Roofers	0	0	0	441	6,210	713	1,733	1,009	-3,909	-818	-38	-38	-38	-38	-38	104	104	104	104	104	-631	-631	-631	-631	-631	-174	-174	-174	-174	-174
Plasterers	0	0	0	0	0	0	0	0	137	51	127	127	127	127	127	15	15	15	15	15	67	67	67	67	67	-117	-117	-117	-117	-117
Painters and decorators	0	0	0	0	0	0	287	1,920	868	301	466	466	466	466	466	48	48	48	48	48	441	441	441	441	441	-537	-537	-537	-537	-537
Building envelope specialists	0	465	3,151	4,468	7,775	3,149	8,227	6,373	-18,007	-567	-2,908	-2,908	-2,908	-2,908	-2,908	76	76	76	76	76	-205	-205	-205	-205	-49	0	0	0	0	0
Wood trades and interior fit-out	0	0	0	0	0	0	0	83	-83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction Trades Supervisers	0	872	1,283	1,930	9,146	2,324	4,603	3,786	-6,688	-567	-236	-236	-236	-236	-236	167	167	167	167	167	-42	-42	-42	-42	-42	-986	-986	-986	-986	-986
Construction Project Managers	4,640	4,281	6,729	9,688	17,052	8,147	19,638	16,241	-37,515	510	1,721	1,721	1,721	1,721	1,721	140	140	140	140	140	4,124	4,124	4,124	4,124	4,124	-5,106	-5,106	-5,106	-5,106	-5,106

Figure 4.3: Graph of FTE requirement, in addition to the 2019 workforce base, per qualification level profiled to 2050



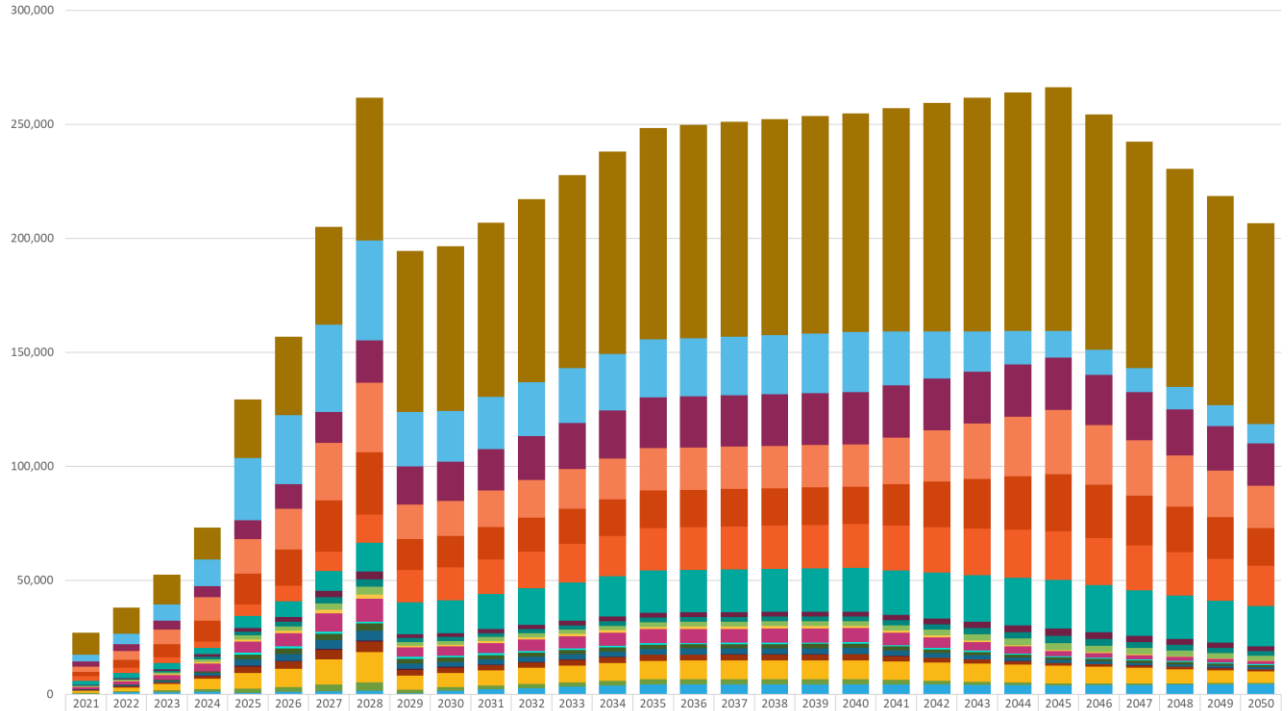
	2,021	2,022	2,023	2,024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Below NVQ level 2, other or no qualifications	1,753	4,962	13,162	26,147	64,318	77,158	105,647	132,760	85,028	82,960	82,458	81,955	81,453	80,950	80,447	81,158	81,869	82,579	83,290	84,001	81,319	78,637	75,955	73,273	70,663	66,834	63,006	59,180	55,392	51,623
NVQ level 2	718	2,285	4,597	8,016	19,431	23,713	32,087	40,493	28,198	27,948	28,535	29,123	29,710	30,297	30,885	31,146	31,408	31,669	31,931	32,192	32,404	32,616	32,829	33,041	33,275	31,623	29,972	28,322	26,683	25,050
NVQ level 3	1,044	3,465	6,586	11,113	27,249	34,736	47,815	62,629	45,706	46,021	47,986	49,951	51,916	53,881	55,846	56,265	56,685	57,105	57,525	57,945	58,437	58,929	59,421	59,913	60,434	57,420	54,408	51,398	48,413	45,441
NVQ level 4	1,141	2,748	5,204	9,037	19,952	24,717	33,901	44,396	30,928	30,945	31,985	33,026	34,067	35,107	36,148	36,390	36,633	36,875	37,118	37,360	37,727	38,094	38,461	38,827	39,204	37,151	35,100	33,051	31,007	28,966
Trade App'ships	762	2,208	4,186	7,071	16,860	21,082	28,761	37,322	26,981	27,064	28,086	29,109	30,131	31,153	32,175	32,418	32,661	32,904	33,147	33,390	33,742	34,094	34,447	34,799	35,167	33,422	31,678	29,935	28,205	26,481
First degree	889	1,757	3,498	6,408	13,330	16,282	22,650	29,369	18,517	18,412	18,793	19,174	19,555	19,935	20,316	20,436	20,556	20,676	20,796	20,916	21,179	21,441	21,703	21,966	22,236	20,932	19,629	18,328	17,029	15,730

Figure 4.4: Difference in FTE requirements for subsequent years for each qualification label profiled to 2050



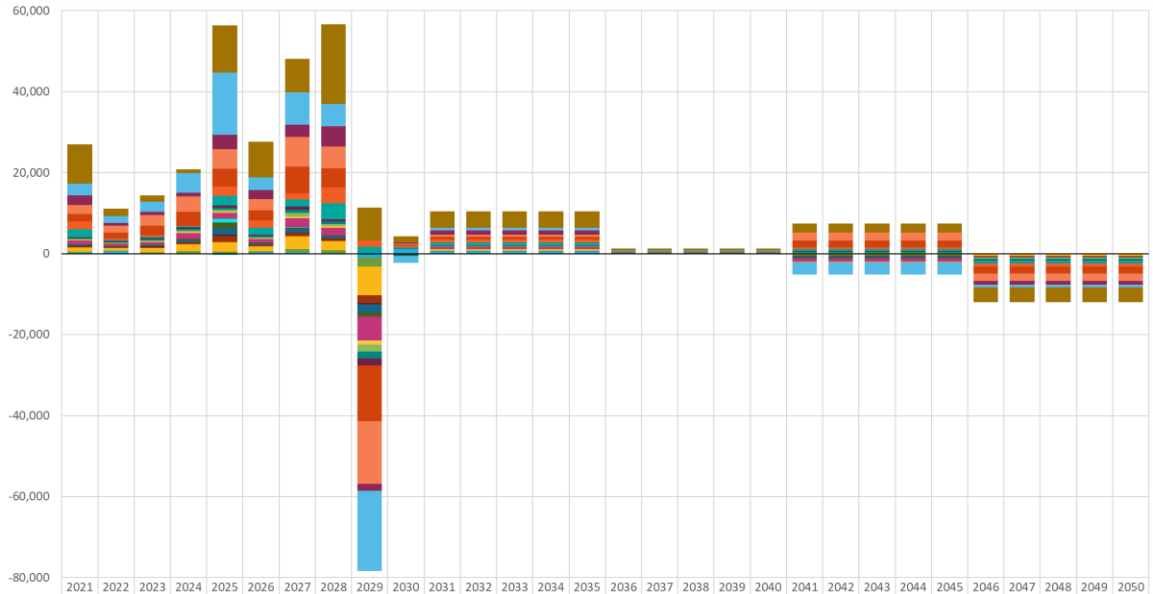
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Below NVQ level 2, other or no qualifications	1,753	3,209	8,200	12,984	38,171	12,840	28,489	27,112	-47,732	-2,067	-503	-503	-503	-503	-503	711	711	711	711	711	-2,682	-2,682	-2,682	-2,682	-2,611	-3,829	-3,828	-3,826	-3,787	-3,769
NVQ level 2	718	1,567	2,312	3,420	11,415	4,282	8,374	8,406	-12,295	-250	587	587	587	587	587	261	261	261	261	261	212	212	212	212	235	-1,652	-1,651	-1,650	-1,639	-1,633
NVQ level 3	1,044	2,421	3,120	4,527	16,136	7,488	13,079	14,814	-16,923	315	1,965	1,965	1,965	1,965	1,965	420	420	420	420	420	492	492	492	492	520	-3,013	-3,012	-3,011	-2,984	-2,972
NVQ level 4	1,141	1,607	2,456	3,833	10,915	4,765	9,184	10,494	-13,468	17	1,041	1,041	1,041	1,041	1,041	242	242	242	242	242	367	367	367	367	377	-2,053	-2,051	-2,049	-2,044	-2,041
Trade App'ships	762	1,447	1,978	2,885	9,789	4,222	7,679	8,561	-10,341	84	1,022	1,022	1,022	1,022	1,022	243	243	243	243	243	352	352	352	352	368	-1,744	-1,744	-1,744	-1,730	-1,723
First degree	889	868	1,741	2,910	6,923	2,952	6,368	6,719	-10,852	-105	381	381	381	381	381	120	120	120	120	120	262	262	262	262	271	-1,304	-1,303	-1,300	-1,299	-1,299

Figure 4.5: FTE requirement for each specialist skill profiled to 2050



	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Heat pump installation course	9,608	11,429	13,040	13,931	25,703	34,520	42,807	62,541	70,616	72,145	76,292	80,440	84,587	88,734	92,882	93,489	94,097	94,704	95,311	95,919	98,107	100,295	102,483	104,671	106,860	103,101	99,342	95,584	91,825	88,066
Asbestos Awareness Training	2,899	4,579	7,061	11,842	27,145	30,283	38,292	43,786	23,944	22,311	22,930	23,549	24,168	24,787	25,405	25,614	25,823	26,032	26,241	26,450	23,510	20,571	17,631	14,691	11,751	11,128	10,504	9,880	9,256	8,632
Electricity for plumbers course	2,416	3,067	3,812	4,805	8,372	10,652	13,642	18,609	16,848	17,094	18,130	19,167	20,203	21,239	22,276	22,405	22,534	22,664	22,793	22,922	22,901	22,879	22,858	22,836	22,814	21,956	21,098	20,240	19,382	18,524
Trustmark Approved Retrofit Coordinator	2,176	3,843	6,496	10,288	15,143	17,898	25,251	30,568	15,120	15,446	16,059	16,671	17,284	17,897	18,510	18,510	18,510	18,510	18,510	18,510	20,451	22,392	24,333	26,274	28,215	26,298	24,381	22,464	20,547	18,630
Trustmark Approved Retrofit Designer	1,934	3,416	5,774	9,145	13,460	15,910	22,445	27,171	13,440	13,729	14,274	14,819	15,364	15,909	16,453	16,453	16,453	16,453	16,453	16,453	18,179	19,904	21,630	23,355	25,080	23,376	21,672	19,968	18,264	16,560
Refrigeration, Heating & Ventilation Qualification	1,922	2,286	2,608	2,786	5,141	6,904	8,561	12,508	14,123	14,429	15,258	16,088	16,917	17,747	18,576	18,698	18,819	18,941	19,062	19,184	19,621	20,059	20,497	20,934	21,372	20,620	19,868	19,117	18,365	17,613
F Gas	1,922	2,286	2,608	2,786	5,141	6,904	8,561	12,508	14,123	14,429	15,258	16,088	16,917	17,747	18,576	18,698	18,819	18,941	19,062	19,184	19,621	20,059	20,497	20,934	21,372	20,620	19,868	19,117	18,365	17,613
Trustmark Approved Retrofit Installer	242	427	722	1,143	1,683	1,989	2,806	3,396	1,680	1,716	1,784	1,852	1,920	1,989	2,057	2,057	2,057	2,057	2,057	2,057	2,272	2,488	2,704	2,919	3,135	2,922	2,709	2,496	2,283	2,070
Trustmark Approved Retrofit Advisor	242	427	722	1,143	1,683	1,989	2,806	3,396	1,680	1,716	1,784	1,852	1,920	1,989	2,057	2,057	2,057	2,057	2,057	2,057	2,272	2,488	2,704	2,919	3,135	2,922	2,709	2,496	2,283	2,070
Trustmark Approved Retrofit Assessor	242	427	722	1,143	1,683	1,989	2,806	3,396	1,680	1,716	1,784	1,852	1,920	1,989	2,057	2,057	2,057	2,057	2,057	2,057	2,272	2,488	2,704	2,919	3,135	2,922	2,709	2,496	2,283	2,070
Pro-Fitter/GGF: Surveyors	153	242	373	626	879	1,037	1,447	1,771	725	725	799	872	945	1,018	1,091	1,091	1,091	1,091	1,091	1,091	952	814	675	536	398	365	332	299	266	233
Pro-Fitter/GGF: Windows and Doors - Novice/GQA Accredited	869	1,372	2,116	3,548	4,978	5,877	8,201	10,035	4,108	4,111	4,525	4,940	5,354	5,769	6,183	6,183	6,183	6,183	6,183	6,183	5,397	4,611	3,825	3,039	2,253	2,066	1,879	1,692	1,505	1,319
BPEC, Solar Thermal Systems NOS Mapped	1	2	2	2	829	851	882	856	878	749	709	668	628	588	548	564	581	597	613	630	618	606	594	581	569	557	544	531	518	506
BPEC, Working at Heights Access Training	145	231	355	594	2,187	2,365	2,797	3,045	2,075	1,865	1,855	1,846	1,837	1,827	1,818	1,845	1,872	1,899	1,926	1,952	1,793	1,634	1,475	1,316	1,157	1,113	1,069	1,025	981	937
BPEC, Award in the Installation and Maintenance of Small Scale Solar Photovoltaic Systems (Level 3)	290	458	706	1,184	2,715	3,028	3,829	4,379	2,394	2,231	2,293	2,355	2,417	2,479	2,541	2,561	2,582	2,603	2,624	2,645	2,351	2,057	1,763	1,469	1,175	1,113	1,050	988	926	863
CITB SMSTS (Site Management Safety Training Scheme)	33	67	114	181	345	393	516	609	335	319	273	227	181	135	89	91	93	95	97	99	95	90	86	81	77	70	63	56	49	42
Gas Smart	299	473	729	1,222	2,802	3,126	3,953	4,520	2,472	2,303	2,367	2,431	2,495	2,559	2,623	2,644	2,666	2,687	2,709	2,730	2,427	2,123	1,820	1,517	1,213	1,149	1,084	1,020	955	891
Diploma in smart metering	1,013	1,691	2,734	4,451	6,801	7,967	11,029	13,305	6,254	6,266	6,626	6,986	7,346	7,706	8,066	8,074	8,082	8,090	8,098	8,106	8,046	7,986	7,925	7,865	7,805	7,265	6,725	6,185	5,645	5,105
Battery Storage Systems Training course	321	507	782	1,311	1,839	2,171	3,030	3,707	1,517	1,519	1,672	1,825	1,978	2,131	2,284	2,284	2,284	2,284	2,284	2,284	1,994	1,703	1,413	1,123	832	763	694	625	556	487
Hyrdrogen boiler conversion courses	198	765	884	971	680	999	1,325	1,467	472	1,585	2,138	2,692	3,245	3,799	4,352	4,352	4,352	4,352	4,352	4,352	4,252	4,152	4,051	3,951	3,851	3,968	4,085	4,203	4,320	4,437

Figure 4.6 Difference in FTE requirements for subsequent years for specialist skills profiled to 2050



	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Heat pump installation course	9,608	1,821	1,611	891	11,772	8,817	8,288	19,734	8,074	1,529	4,147	4,147	4,147	4,147	4,147	607	607	607	607	607	2,188	2,188	2,188	2,188	2,188	-3,759	-3,759	-3,759	-3,759	-3,759
Asbestos Awareness Training	2,899	1,680	2,482	4,781	15,303	3,138	8,008	5,494	-19,841	-1,633	619	619	619	619	619	209	209	209	209	209	-2,940	-2,940	-2,940	-2,940	-2,940	-624	-624	-624	-624	-624
Electricity for plumbers course	2,416	651	745	993	3,567	2,280	2,990	4,967	-1,760	245	1,036	1,036	1,036	1,036	1,036	129	129	129	129	129	-22	-22	-22	-22	-22	-858	-858	-858	-858	-858
Trustmark Approved Retrofit Coordinator	2,176	1,667	2,653	3,792	4,855	2,756	7,353	5,317	-15,448	326	613	613	613	613	613	0	0	0	0	0	1,941	1,941	1,941	1,941	1,941	-1,917	-1,917	-1,917	-1,917	-1,917
Trustmark Approved Retrofit Designer	1,934	1,481	2,359	3,371	4,315	2,449	6,536	4,726	-13,732	290	545	545	545	545	545	0	0	0	0	0	1,725	1,725	1,725	1,725	1,725	-1,704	-1,704	-1,704	-1,704	-1,704
Refrigeration, Heating & Ventilation Qualification	1,922	364	322	178	2,354	1,763	1,658	3,947	1,615	306	829	829	829	829	829	121	121	121	121	121	438	438	438	438	438	-752	-752	-752	-752	-752
F Gas	1,922	364	322	178	2,354	1,763	1,658	3,947	1,615	306	829	829	829	829	829	121	121	121	121	121	438	438	438	438	438	-752	-752	-752	-752	-752
Trustmark Approved Retrofit Installer	242	185	295	421	539	306	817	591	-1,716	36	68	68	68	68	68	0	0	0	0	0	216	216	216	216	216	-213	-213	-213	-213	-213
Trustmark Approved Retrofit Advisor	242	185	295	421	539	306	817	591	-1,716	36	68	68	68	68	68	0	0	0	0	0	216	216	216	216	216	-213	-213	-213	-213	-213
Trustmark Approved Retrofit Assessor	242	185	295	421	539	306	817	591	-1,716	36	68	68	68	68	68	0	0	0	0	0	216	216	216	216	216	-213	-213	-213	-213	-213
Pro-Fitter/GGF: Surveyors	153	89	131	253	252	159	410	324	-1,046	1	73	73	73	73	73	0	0	0	0	0	-139	-139	-139	-139	-139	-33	-33	-33	-33	-33
Pro-Fitter/GGF: Windows and Doors - Novice/GQA Accredited	869	503	744	1,432	1,430	898	2,324	1,834	-5,927	3	414	414	414	414	414	0	0	0	0	0	-786	-786	-786	-786	-786	-187	-187	-187	-187	-187
BPEC, Solar Thermal Systems NOS Mapped	1	2	0	0	827	21	31	-26	22	-129	-40	-40	-40	-40	-40	16	16	16	16	16	-12	-12	-12	-12	-12	-13	-13	-13	-13	-13
BPEC, Working at Heights Access Training	145	86	124	239	1,592	178	432	248	-970	-211	-9	-9	-9	-9	-9	27	27	27	27	27	-159	-159	-159	-159	-159	-44	-44	-44	-44	-44
BPEC, Award in the Installation and Maintenance of Small Scale Solar Photovoltaic Systems (Level 3)	290	168	248	478	1,530	314	801	549	-1,984	-163	62	62	62	62	62	21	21	21	21	21	-294	-294	-294	-294	-294	-62	-62	-62	-62	-62
CITB SMSTS (Site Management Safety Training Scheme)	33	34	47	67	164	48	123	93	-274	-16	-46	-46	-46	-46	-46	2	2	2	2	2	-5	-5	-5	-5	-5	-7	-7	-7	-7	-7
Gas Smart	299	173	256	494	1,580	324	827	567	-2,048	-169	64	64	64	64	64	22	22	22	22	22	-303	-303	-303	-303	-303	-64	-64	-64	-64	-64
Diploma in smart metering	1,013	677	1,043	1,717	2,350	1,166	3,061	2,277	-7,051	12	360	360	360	360	360	8	8	8	8	8	-60	-60	-60	-60	-60	-540	-540	-540	-540	-540
Battery Storage Systems Training course	321	186	275	529	528	332	859	677	-2,190	1	153	153	153	153	153	0	0	0	0	0	-290	-290	-290	-290	-290	-69	-69	-69	-69	-69
Hydrogen boiler conversion courses	198	567	118	87	-290	319	326	142	-994	1,112	554	554	554	554	554	0	0	0	0	0	-100	-100	-100	-100	-100	117	117	117	117	117

5.0 Recommendations

This section sets out the recommendations identified to overcome the barriers identified to achieve net-zero. This report does not recommend any particular scenario or pathway to achieve net-zero. These recommendations are built around the following key outcomes, and led to the development of a route map for their delivery:

- Developing net-zero ready training capability
- Establishing skilled supply chains for retrofit
- New Build/MMC
- Ensuring quality in delivery
- Creating the demand for net-zero skills

This format is used for convenience but should not be taken as recommending a linear progression. The gap between where we are today and net-zero requires the generation of, and ability to meet demand, improvements in the quality of delivery, and development of training resources. Each depends on the others, and all are required.

Anonymous quotes from interviews to substantiate the following recommendations and comments are included in Appendix A.1.4.

5.1 Training supply must be net zero ready

Throughout the research programme which informed this report, specific skills gaps have been identified by respondents and summarised in the route map in Section 5.5. This illustrates a view that was held by several respondents, that a more prescriptive, planned approach to setting the coverage, content and quality of the curriculum is required. Currently, the provision of training is led by demand, which has remained much the same for decades and is based on existing construction techniques and sector priorities.

The rapid shift in the scale and nature of work required to deliver net-zero means that this approach will no longer work: a pathway to net-zero must be mapped out, the training required must be developed, and policy must be implemented to create demand for the skills created. Encouragingly, respondents to the survey indicated that they were very interested in completing training for decarbonisation and felt that they were aware of the skills they would need, and that it would be easy to learn the skills required.

For a number of technologies and approaches there is then a need for specific training and upskilling, e.g. heat networks, heat pumps, hydrogen boilers installation, offsite construction installation or retrofit co-ordinator. New skills being developed through a mix of practical (toolbox talks) and more formalised training (CPD's) modules; with verification that a standard has been met through training centre exams.

For example, a general heat pump training course would focus on the specifics of how a heat pump works (in both a domestic and non-domestic context) including heat loss calculations, hydraulic balancing, flow temperature calculations and heating system

sizing) as well as what installers can and can't do without appropriate certification. E.g. F-Gas qualified. The qualification outcome from this training being an Ofqual-accredited Heat Pump Certificate and a skills card similar to Gas Safe, and a requirement for retraining in 5 years. It would be up to the individual to also then pursue the relevant other specialist skills required e.g. F-Gas qualification.

Where relevant for particular technologies, various manufacturer-specific training courses then follow this, which would be provided by the manufacturer. This trains the installers on the specific configuration and installation requirements of each manufacturer. The qualification outcome from this training is a Specific Manufacturer Certificate, with retraining every 5 years.

Considerable work has already been undertaken across the UK and the devolved nations to review construction qualifications, much of which has involved CITB as a common partner. This approach combines the benefits of the focus of devolved approaches with the benefits of a central hub to disseminate best practice while ensuring conformity and maintaining standards.

Recommendation 1: Addressing Training Gaps

Relevant organisations: Department for Education, Institute for Apprenticeships and Technical Education with input from BEIS, CITB, industry, Welsh Government, Qualifications Wales, Scottish Government, Skills Development Scotland.

Description: Currently, the provision of training is led by demand, which has remained much the same for decades and is based on existing construction techniques and sector priorities. UK Governments should work with training providers to offer training for the key gaps.

5.1.1 Net zero training structure

Many respondents across disciplines and trades discussed low/zero carbon training and upskilling in terms of a series of increasingly more complex and technical curriculum units based on the chosen career path. This is summarised as follows.

5.1.1.1 Introductory net-zero training

The survey and interviews demonstrated strong support for general net-zero, or low-carbon training across the board. It was felt that right across the sector, it would be beneficial for everyone entering or already employed in the construction sector to have a basic understanding of the impacts of buildings on the Climate Emergency, and what measures can be used to reduce energy demand, and the impact of that energy. It would provide an understanding of how the range of low carbon technologies and approaches work and the basics associated with their design. This was seen as module that should be bolted onto all existing training programmes. The qualification outcome being an Ofqual-accredited low carbon building certificate.

Recommendation 2: Net-Zero Training

Relevant organisations: Training providers

Description: Develop a net-zero training course. This could include understanding of the range of low carbon technologies and approaches work and the basics associated with their design. This could be added to existing training programmes.

Although it is out of the scope of this research, this training should include embodied emissions of construction products and activities, without which net-zero cannot be achieved.

5.1.2 Developing new material

The development of new National Vocational Qualifications (NVQs) based on National Occupational Standards (NOS) and the incorporation of new material into existing NVQs was seen by most respondents as the way forward. They were considered still relevant to the sector provided it included a competency test. One respondent noted that in terms of professional degree courses, where they are aligned to the construction industry, many of these courses are accredited by the sector's professional bodies. There is therefore a role for all sector professional bodies to contribute to specifying/ validating the content that is to be covered, and agreeing to only accredit courses which have got the agreed content.

One of the challenges with training is the time taken for new content to be developed and incorporated into curricula; with content often staying relatively static for a period of five years or more. The net-zero training will require an accelerated program in colleges and universities and the private sector as well, to ensure the UK has quality people who can specify, design, monitor, manage, as well as all the installation and maintenance people that go with it. As well as periodic reviews of NOS, there is a mechanism for incremental change. Standards can be amended to reflect changes in current occupational practices, or legislation, as industry requires[72].

There is a vast array of existing courses and it will be important to influencing through organisations (e.g. Qualification Wales) the writers of these qualifications to include decarbonisation within them.

[72] https://www.citb.co.uk/standards-and-delivering-training/training-standards/nvq-svq-standards/construction-contracting-operations/

Recommendation 3: Refreshing Training

Relevant organisations: Training standards and providers

Description: Refresh training material on a more regular basis.

5.1.3 Format of training

A significant proportion of training is provided "on-the-job," either informally or through formal apprenticeships, in a traditional classroom format or through toolbox talks (e.g. BEPIT[73]) on site. It was recognised that there are opportunities for the sector to make better use of modern teaching platforms, such as apps and videos. "Better training" was listed as the best way to attract more people to the sector; in the context of most construction training provided today, this does not necessarily mean more formal class-based training.

CITB's own research into formal on-site training[74] paints a picture of a recognised training route with potential to make a significant contribution to net-zero skills development, given appropriate development support. Meanwhile, developments in e.g. online learning[75] and immersive technologies[76] show the potential for diversifying the way in which these skills are developed.

One respondent commented that:

"if a builder hasn't done a job before, they just look up how to do it on YouTube the night before."

While intended to be flippant, the comment highlights opportunities for platforms such as YouTube to be developed on a more formal basis, to ensure quality-controlled material is developed, and that users' competence can be checked and logged. The factors listed by survey respondents as most important if they were to retrain or up-skill were cost, accreditation and the ability to build on existing skills, all of which could be managed through such an approach. The most popular format for training among respondents was short duration off-site.

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[73] https://bepit.org/

[74] Onsite Assessment: Capacity research and evaluation of the current model for delivery. CITB, November 2016. https://www.citb.co.uk/documents/research/citb_pye_tait_osat_report_nov16.pdf

[75] https://learn.citb.co.uk/courses/course-v1:CIT+CIT001+2017/about

[76] https://www.citb.co.uk/about-citb/construction-industry-research-reports/search-our-construction-industry-research-reports/innovation-technology/a-new-reality-immersive-learning-construction/

Respondents agreed that quality in training was essential, and that there was room for improvement in many existing courses.

Case Study: Train-to-NZEB Project

The "Train-to-NZEB" project aims to provide world-class training on energy efficiency and renewable energy systems in buildings (new and retrofit), based on new training programmes, business plans and up-to-date training equipment for a set of training and consultation centres around Europe.

Its goal is to improve the knowledge and skills in the construction sector and to provide practical trainings, demonstrations and comprehensive consulting services for design and construction of Nearly Zero-Energy Buildings (NZEB) supported by renewable energy systems, based on the Passive House concept.

The training centres (or Building Knowledge Hubs) form an international network, providing training courses on the curricula developed under the European BUILD UP Skills initiative and by project partners, as well as continuous opportunities for exchange, updating and improving of the existing training programmes. The modern training facilities enable the conduction of practical exercises in addition to the theoretical programmes already available in the focus countries.[77]

Case Study: Commercial Retrofit – The Net Zero Plus Electrical Training Institute
The Net Zero Plus (NZP) Electrical Training Institute (ETI) is the USA's largest net zero commercial retrofit training centre. This training facility is a national showcase of excellence for electrical training and innovations in emerging technology testing and demonstration.[78]

Recommendation 4: Format of Training

Relevant organisations: Training providers

Description: Provide training via modern platforms that are outside of the classroom environment.

5.1.4 Cost Barrier

The most important factors when undertaking decarbonisation retraining or upskilling were external funding to cover some or all of the cost of training; and receiving an

[77] http://www.train-to-nzeb.com/

[78] http://totalenergysolution.org/net-zero-plus.html

accredited qualification at the end of the course. With cost generally being seen as more important for smaller businesses, but not exclusively. It was raised as a key issue during the interviews and the survey by respondents with the majority saying funding would incentivise undertaking decarbonisation training. Lost revenue was also seen as an important impact of attending training.

One respondent when discussing heat pump installer training estimated that a four-day course could cost ~£500 to £700. Lost revenue for that period could be ~£1,500 total, so the total training cost the installer ~£2,000. As noted above, if some of this training could be done online, it could help reduce the lost revenue, and that some type of voucher scheme that covers some of the cost would further reduce some of the financial burden on the installer. One respondent also argued that only providing part funding (rather than total funding) for training would be a mechanism of incentivising those attending to make the most of the training being provided. With another arguing that for small companies it was best to do as much of the training at the work place (e.g. building sites), in short dedicated toolbox talk training session to avoid down time to travel to training.

Recommendation 5: Funding for Training

Relevant organisations: UK Government and devolved administrations

Description: Funding should be secured for to help incentivise participation in future training programmes.

5.1.4.1 Inter-trade awareness training

The lack of inter-trade appreciation for the need for quality, and what it affects on the next trade to work on a project, was a common theme in the interviews, e.g. if a trade makes a hole in a wall for a pipe, or a brick layer inadvertently creates a thermal bridge, what impact there may be on other trades, or the buildings performance as a whole. Addressing this issue wasn't seen by respondents to require a fundamental change in the trades, but the need for each trade to have a common understanding of its impact on the overall building. The appreciation of the building systems and structure, their interaction and the need for quality is a common module that should be applied across training for construction trades new build and retrofits.

> *"I think that we've got to accept the fact that trades have got to learn about building science as well. They just haven't got to learn the trade. They got to learn why they're doing what they're doing and the impact of not doing it correctly, what that means."*
>
> ***Interview Quote***

There are parallels between inter-trade awareness training and an increasing requirement for multi-trade competence, which is increasingly required, e.g. for MMC. Competence spanning more than one trade is also valuable in the context of the varying requirements for particular skills suggested by the modelling process. For example, as building envelope interventions become scarcer (essentially because they have all been

completed), the ability to pick up more work in installation of energy systems, or smart systems, will become increasingly valuable. This also links with CITB research showing that, in smaller companies each employee is more likely to take on a wider range of tasks than someone with the same job title in a larger company[79].

Recommendation 6: Intertrade Training

Relevant organisations: Training standards and providers

Description: Develop intertrade training. This could be added to existing training programmes.

5.1.5 Co-operatives

The framework for this report is skills and training in the UK Construction Sector, and because of that the emphasis throughout has been on commercial organisations. However, there is evidence through case studies and interviews that a less commercial approach is effective, and may form an important part of the decarbonisation solution.

Retail sales of DIY supplies in the UK in 2017 were £6.74bn. This includes decoration, repair and extension work, as well as energy efficiency, but it suggests that the DIY approach to renovation and retrofit is not insignificant. There are case studies[80] which demonstrate that providing formal training and support to communities to implement their own projects is an effective way of delivering energy-efficiency improvements. This includes both equipping communities with the knowledge they need to procure and commission work, and to do the work themselves.

The CCC core scenario includes interventions in behaviour change, which might usefully be targeted at initiatives such as this with a demonstrable track record. This approach might not increase the turnover of the sector, or contribute materially to GDP, but it could be effective in delivering decarbonisation.

Case Study: Carbon Co-op/ URBED's People Powered Retrofit

A partnership led by Carbon Co-op and URBED with funding from the Department of Business Energy and Industrial Strategy (BEIS), 'People Powered Retrofit' is a householder-led approach to domestic energy efficiency retrofit in Greater Manchester.

This project is tackling many of the key barriers that homeowners face in commissioning work, including lack of appropriate contractors and concerns around the quality of works

[79] CITB (2017) Faster, Smarter, More Efficient: Building Skills for Offsite.

[80] e.g. https://retrofitworks.co.uk/portfolio_entries/domestic-retrofitworks-case-studies/, https://constructiveindividuals.co.uk/2019/12/16/the-community-self-build-years/

taking a more localised approach to creating a market for energy efficiency.

The new end-to-end retrofit service being piloted includes advice, a My Home Energy Planner assessment and Retrofit Co-ordination to assist householders in procuring contractors and carrying out Quality Assurance.[81]

Recommendation 7: Co-operatives

Relevant organisations: UK Government, devolved administrations and local authorities

Description: The opportunity to leverage co-operative approaches to deliver net zero should be exploited through development and support programmes.

5.1.6 Non-technical and behavioural skills

5.1.6.1 Appeal

As previously highlighted, addressing Net Zero will require a significant increase in workforce numbers to deliver it. It is critical that the appeal of a career in the construction sector is improved. It is not clear whether this problem is unique to the UK, but it is certainly the case that other countries view a career in construction as having higher status, and that they provide greater equality of opportunity.

Given the increase in number of skilled workers that will be required to deliver net-zero, there will be a need to draw in a younger demographic and more women into the workforce. A survey undertaken for BEIS in 2018[82] suggested that two-thirds of 18-24 year olds would prefer to work in the green economy than outside it, so this demographic should be amenable, provided the reputational issues the sector suffers can be addressed. A common theme from the interviews was the need to change the way construction is marketed to new entrants, moving away from a perception of 'building' and placing a much greater emphasis on innovation, net-zero, decarbonisation, modern methods of construction and building engineering.

Communication skills as well as the physical installation was also a theme that was often discussed. As new technologies such as heat interface units, heat pumps, hybrid systems, smart controls are more widely introduced, there will be a need for these systems to be explained to the consumer to a much greater degree than for example a conventional gas boiler. One respondent likened it to those softer customer skills seen in Apple shops.

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[81] https://carbon.coop/

[82] https://www.fenews.co.uk/press-releases/20883-re-article-for-consideration-on-poll-findings-37-million-young-people-would-prefer-a-job-in-the-green-economy-than-one-outside-it

A requirement for these skills, sometimes perceived as "softer" within the sector, will help to broaden the appeal, and demographic available for recruitment. The Skills Needs Analysis research referenced in Section 2.2.2.1 also shows that heritage work attracts females into the construction industry. In England, 9% of the workforce working on traditional buildings is female (5% in Scotland, 6% in Wales). This rises to 13% female workforce reported by employers classified as working "exclusively" on traditional (pre-1919) buildings. This compares with 1% female in manual trades in construction overall. The particular need for skilled workers in traditional and heritage renovation therefore appears to have synergies with the need to broaden the pool of talent by increasing the appeal of the sector.

Off-site construction techniques present the opportunity for a different format of employment, which may appeal to a wider demographic, and the requirement for an unprecedented degree of effort across the sector for the next thirty years should provide security, however there is work to do to improve the reputation and appeal of building work. Given the sheer numbers required to deliver net-zero, the sector cannot afford to restrict the pool of talent it draws from.

Recommendation 8: Improving the Reputation of the Sector

Relevant organisations: Construction industry bodies, teaching organisations

Description: The reputation of the construction sector has to change if there is going to be a big enough pool of talent to draw on to achieve net-zero. Recent developments have the potential to transform the industry but these gains must be advertised, and every opportunity taken to improve the standing of the sector, including curriculum and careers advice.

5.1.6.2 Trust

While there is a wide range in the level of trust the British public places in different building trades[83] , the most trusted (electricians, central heating engineers and plumbers; notably those professions with stringent licensing requirements) enjoy levels of trust shared by the police and judiciary[84]. This puts these professions in an excellent position to be able to influence the pace of decarbonisation by recommending retrofit options to clients, provided everyone is aware of the fundamentals (see Section 5.1.1.1)

[83] https://www.which.co.uk/news/2018/06/builders-and-roofers-the-most-mistrusted-tradespeople-say-which-members/

[84] https://www.ipsos.com/ipsos-mori/en-uk/trust-politicians-falls-sending-them-spiralling-back-bottom-ipsos-mori-veracity-index

This also applies to informing the general public about the Climate Emergency, the impact that their homes and offices have on it, and what they can do about it.

Recommendation 9: Supporting net-zero in Construction

Relevant organisations: Construction industry bodies, colleges

Description: Related to Recommendations 20 and 26, construction sector workers have demonstrated their enthusiasm for playing their part in the net-zero transition. Relevant bodies should ensure that they are supported to do so.

5.2 Establish skilled supply chains for retrofit and manage transitions

Retrofit is the most important and the most challenging part of the UK's net-zero programme for the built environment. Policy to realise this does not yet exist, but some potential options do, and are discussed in Section 5.5.1. Assuming a successful policy is developed, the skills and training requirements will vary, depending on what pathway is adopted. PAS 2035 and PAS 2038 will most likely be the framework (possibly built around a Building Passport approach).

> *"One of our arguments for why we can't use business as usual for retrofit is that there just isn't enough labour. There isn't enough skilled labour to work productively on-site to deliver, for example, 27 million housing retrofits in 10 or 20 years"*
>
> ***Interview Quote***

Irrespective of pathway and approach, several respondents raised concerns about the number of additional individuals that would be needed to deliver the level of retrofit required to deliver 27 million domestic and 2 million non-domestic retrofits in hopefully significantly less than 29 years. Especially when considering that these types of measures will need to be delivered alongside adaptation measures to increase resilience to climate change that has not been within the scope of this study.

5.2.1 Build training capacity to support the delivery of PAS 2035 and PAS 2038

PAS2035 is welcomed across the sector as a marked improvement (PAS 2038 is due for release in 2021), however there are still significant concerns with the system, particularly in the context of its widespread use to underpin the UK's decarbonisation plan. There are currently nowhere near enough retrofit designers or co-ordinators to cope with the demand that will be required. There are many more EPC assessors, but this level of qualification and experience is not sufficient to support retrofit design.

The Green Homes Grant requires tradespeople to be registered with Trustmark[85,86], and Trustmark requires that registered business comply with the requirements of PAS 2035, so it seems likely that there will be an immediate requirement for retrofit professionals to deliver the hundreds of thousands of interventions the Grant hopes to encourage. The Trustmark website includes a listing of all the energy efficiency measures covered by the Grant, and certification bodies that can provide accreditation under PAS 2035 to carry out these measures[87].

There is concern that NVQs do not yet exist for all the roles required to support the standard; developing these would be a no-regrets, low-cost intervention which should be prioritised. CITB is responsible for development of National Occupational Standards for the roles that are within their scope, so are well placed to lead on the development of NVQs to match. Universities and colleges are likely to need considerable support; for example, college lecturers could not teach the Retrofit Co-ordinator course: it would require a training programme for trainers.

The specification currently "expects" but does not require a qualified (e.g. RICS) surveyor to develop the retrofit designs. Given the complexities which are involved, particularly in traditional buildings, there is concern that designers may be expected to work on systems with which they are not familiar.

PAS 2035 is not necessarily aimed at one-off retrofit projects. Particularly in the owner-occupier sector, it is likely that retrofit activities will be implemented over an extended period. This would tie in well with a Building Passport approach. However, in any retrofit project and particularly in those over a longer timescale, there is concern that the retrofit co-ordinator is taking on an unsupportable amount of responsibility, and therefore risk.

[85] https://www.trustmark.org.uk/ourservices/pas-2035
[86] https://www.gov.uk/government/news/quality-assurance-at-heart-of-new-2-billion-green-homes-grants
[87] https://www.trustmark.org.uk/scheme-provider-certification-bodies

Recommendation 10: PAS2035 and 2038 Training

Relevant organisations: Training colleges

Description: Investment should be prioritised to establish sufficient capacity of competency-based qualifications (like NVQ) focussed on the roles required to delivering the PAS 2035 (And forthcoming PAS 2038) specifications.

5.2.2 Off-site retrofit

Energiesprong is an example of one approach to offsite retrofit. It is a 100% publicly-funded organization established to drive a retrofit solution that can deliver net-zero built environment at scale with homes initially, and primarily retrofit, although it is working on new-build projects as well.

This type of approach involves the removal of existing windows and doors and fitting the property with factory-built panels and roof that wrap the property around. These panels have the external final finish, insulation, triple-glazed windows and doors already installed, along with a services module containing, for example, a heat pump. This is achieved through 3D laser measurements of the property, gathering millions of data points, which are plugged into a digitized production line which produces an integrated cassette panel. These are delivered to the site and installed on each property, either hanging off brackets or standing on new footings around the property.

This approach combines the needs of a retrofit with the efficiencies of off-site construction techniques and presents an example of one of the approaches necessary to achieve net-zero in the UK. In the Netherlands, where the Energiesprong model is now mature, it has become financially neutral, with all costs and finance being paid through utility bill savings.

Interview respondents that specialise in offsite retrofit reported particular skills bottlenecks in the deployment of this approach, including:

- architects with experience of designing for manufacturing assembly;
- surveyors familiar with creating the detailed data to go into a design and putting the data in that design together in a factory to deliver a product that is guaranteed in its performance and quality. This not only includes using new technology such laser scanning type approaches to create the design, but also a different set of surveyor skills in terms of more structural assessments - e.g. will the existing wall hold the external envelope;
- installers and project management on site. These types of offsite approaches require a different skillset from traditional construction as the process is more of installation and connection, but across a broader range of trades. It also leads to quick installation times and requires skills around just in time delivery/ sequencing management and quality checking. At present these installers are often trained to install a single manufacturers system, and that as demand increases for off-site installation skills there is a need for on-site assembly

accreditation and training to allow installers to demonstrate competency and more easily move between manufacturers and their systems; and

- technicians to monitoring performance and operating as a service, as part of an integrated operation maintenance and long-term performance guarantee.

Case Study: Energiesprong

Energiesprong is a whole house refurbishment and new build standard and funding approach. It delivers fully integrated refurbishment packages, supported by long term performance guarantees and thus makes the solution commercially financeable and scalable. The retrofit is non-intrusive and can usually be completed within one week, and without the resident needing to move out. The result is a warm, comfortable and affordable home that is modern and attractive with a long-term quality guarantee.

Energiesprong is using the social housing sector in the UK as the launching market for these solutions, with a view to later scale to the private homeowner market. [88]

Case Study: 2nd SKIN

2nd SKIN, developed by TU Delft and implemented by start-up BIK Bouw, is a lightweight façade that acts as a building's second skin. With this low-carbon solution, existing buildings can be easily upgraded, meeting eco-friendly building requirements and significantly reducing energy consumption and CO_2 emissions. The concept includes excellent insulation, a geothermal heat pump system to provide heating, cooling and hot water, and photovoltaic panels to generate electricity.

The façade is installed at minimal disruption to the occupants, helps to create affordable housing and strengthens local economic opportunities, opening up possibilities for local workers and companies to install the technology.[89]

[88] https://www.energiesprong.uk/about
[89] https://www.climate-kic.org/success-stories/2nd-skin/

Recommendation 11: Offsite Skills

Relevant organisations: UK Government and devolved administrations, local authorities

Description: Promote the role of offsite approaches to deliver retrofit and address the skills requirements.

5.2.3 Traditional buildings

There is a severe lack of skills in the repair and maintenance of traditional buildings, never mind the particular requirements of energy efficiency retrofit. The traditional building specialists interviewed provided some examples of traditional building specific issues and the lack of skills to properly address them. For example, traditional buildings primarily have vapour-open walls, where moisture enters a wall through soft brick or stone and then evaporates out, usually through the lime mortar joints. The use of cement mortars for repair, or addition of insulation, to those walls can lead to very different performance and lead to issues such as damp, if not properly designed and specified. Sash windows are another feature of many traditional buildings, and again require specialist skills to repair and maintain them. It was stated that throughout the construction industry there has been a lack of training in the skills required to maintain these older buildings. With most people, the focus of their training has been on new construction and their base education needs to include all types of buildings. As noted elsewhere, however, training is currently demand-led, so this situation requires not only development of the required training and delivery, but also policy to drive demand for traditional repair, maintenance and retrofit.

Resources such as the Understanding Conservation website[90] developed and maintained by the Council on Training in Architectural Conservation[91] (COTAC) provide some instruction in the former, while the whole building retrofit approach as defined by the Sustainable Traditional Buildings Alliance (STBA)[92] not only focuses on improvements in insulation, but also airtightness, thermal coherence of the whole building shell, its services and occupant needs. Additionally, the Home Countries Heritage bodies (Historic England, Cadw and Historic Environment Scotland) have undertaken research and produce comprehensive range of technical advice freely available for both those working in the construction industry and building owners[93], [94]. To cover these other critical

[90] http://www.understandingconservation.org/
[91] https://www.cotac.global/
[92] http://www.sdfoundation.org.uk/downloads/What-is-Whole-House-Retrofit-Dec2016.pdf
[93] https://historicengland.org.uk/advice/technical-advice/energy-efficiency-and-historic-buildings/

[94] https://www.historicenvironment.scot/advice-and-support/your-property/saving-energy-in-traditional-buildings/

factors and prevent unintended consequences will mean investing in additional training for assessors and for all the trades required for traditional retrofit.

This training needs to provide an understanding of the function of traditional buildings in order to make recommendations for them, and to implement these recommendations. For example, the Level 3 Award in Energy Efficiency and retrofit of traditional (pre-1919) buildings and Scottish Level 6 Award in Energy Efficiency Measures for Older and Traditional Buildings are a requirement of PAS 2035 implementation in these buildings (and is being recommended similarly for PAS 2038), and at the very least an energy retrofit survey should be carried out by professional surveyors who have undertaken that course. There are also, for example, teaching resources[95] to introduce these subjects.

It is important to note that there is significant potential to reduce carbon and improve energy efficiency in traditional buildings. There are plenty of examples (e.g. see below), and it is essential to achieve net-zero. However, it requires the development and dissemination of relevant skills, and policy to generate demand for the service.

Case Study – Survey Protocol Development

The Sustainable Traditional Buildings Alliance (STBA) is undertaking a project funded by BEIS working with Melin Homes, which is a social housing provider in South Wales, looking at the practicalities of whole house retrofit and as part of that project training has been developed for surveyors to carry out whole house retrofit survey along with a survey protocol. In addition, the Each Home Counts review[96] recommended improvements to surveying and there is a workstream which is being managed under the Retrofit Standards Task Group, (RSTG), to develop survey protocols. So there is work being done in this area, but has not yet been disseminated to industry.

[95] Understanding Traditional (pre-1919) and Historic Buildings for Construction and Built Environment Courses. July 2019.
[96] http://www.eachhomecounts.com/

Recommendation 12: Traditional Buildings Training

Relevant organisations: Training standards, and providers

Description: Greater emphasis should be placed on the training requirements for traditional buildings, both in mainstream construction education and upskilling. Greater consideration should be given to lessons learnt from investigations in to improved building survey techniques assessment tools and systems.

5.3 New Build Modern Methods of Construction

The recent UK government report on Modern Methods of Construction[97] identified that respondents reported the following as being among the benefits of a move to these techniques:

- more digital working which will appeal to young workers looking for a modern career, using cutting edge technology;
- factory-based jobs in an indoor environment are safer, with less working at height and workers are sheltered from the weather;
- factory-based workers are not required to relocate around the country to different building sites;
- off-site methods of construction usually require fewer workers with traditional skills and potentially fewer workers overall in comparison to traditional techniques; and
- factories can be strategically placed in areas of the country with higher rates of unemployment to provide local employment opportunities.

The relative novelty of these approaches also means that designers and architects familiar with the techniques are still rare. These techniques are either absent or not well covered in curricula at present, yet there is a recognition from the same report that government house-building targets will not be met without them, and it appears likely that the same is true for net-zero targets. Buildoffsite is working with Oxford Brookes University to develop a diploma focussing on off-site design.

WRAP estimate that modular construction can reduce the energy used in the construction process by 67% and waste produced onsite, by 70–90% in comparison with traditional construction methods.[98] James Thomson from Keepmoat Homes told the

[97] https://publications.parliament.uk/pa/cm201719/cmselect/cmcomloc/1831/183102.htm
[98] Current Practices and Future Potential in Modern Methods of Construction, WRAP 2007. http://www.wrap.org.uk/sites/files/wrap/Modern%20Methods%20of%20Construction%20-%20Summmary.pdf

Parliamentary Committee on Modern Methods of Construction that MMC homes: "take about 20–30% less to heat than a traditionally built new home"[99].

Coronavirus may be a "lightbulb moment" for off-site construction, as it is possible to maintain social distancing, as well as all the other safety and efficiency gains. It is hoped that this will provide additional impetus for a faster transition to the widespread deployment of off-site techniques. MMC brings improvements in efficiency, quality and cost, with a shift to a static and more controlled working environment, which improves the appeal of construction jobs and widens the demographic. Respondents agreed that the increase in scale, pace and quality required by the transition to net-zero will not be achieved without significant development of modern methods.

Survey respondents considered that off-site construction, improved surveying technology and improved whole-building post-construction testing were the top three non-traditional methods that could help the transition to decarbonisation of the built environment.

Recommendation 13: New-build MMC training

Relevant organisations: Training providers and trade associations

Description: Greater consideration should be given to the skills needs for modern methods of construction.

5.4 Quality of delivery is assured

The gap between design and operational performance in buildings has been described in Section 2.2.4. This section describes the recommendations suggested to close the gap.

Quality is critical if the net-zero programme is going to be effective and was raised by a significant number of the respondents. All the decarbonisation designs and programmes in the world will achieve nothing if they do not work. The performance gap is usually referred to in the context of new-build but, as regards the net-zero programme, it is of course even more important in retrofit, simply because retrofit itself is so much more important. However, closing the performance gap in a retrofit context is more complex, so there are useful lessons to be learned from the experience of trying to do so in new-build.

Recommendations to close the gap cluster around common themes, with overlap between them:

1) Competence, at the individual and institutional level;
2) Procurement and contractual requirements;

[99] http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/housing-communities-and-local-government-committee/modern-methods-of-construction/oral/98436.pdf

3) Regulation and oversight.

5.4.1 Competence

Respondents commented that there are skills gaps right across the sector, including clients, designers, contractors, installers and building managers, many of whom lack the expertise to make sure buildings are procured, designed, constructed and operated to avoid any gap between design and operational performance. A building once in operation may not perform due to poor quality of design, poor construction or poor operation.

Underlying all these issues is competence, which is built up by various routes, through training, experience, testing and continual professional development.

5.4.1.1 Licensing

In many other countries, operational licensing is mandatory[100], and/or a formal system of vocational education is in place, which builders must complete before they can work. In the UK, any person or company is legally allowed to undertake construction work without having to demonstrate a minimum level of competence. This means that our construction industry is not as safe, professional or productive as it might otherwise be.

Many respondents suggested that it would be beneficial to introduce a system of mandatory operational licensing, incorporating minimum qualifications and experience, demonstrated through examination, with regular checks to ensure skills are up to date. However, these respondents were more representative of industry bodies and multi-national businesses than micro-businesses. The responses to the survey were more balanced, and these suggested continuing professional development and membership of a trade association as useful ways of ensuring required standards are maintained.

Some trade bodies have specific entry requirements but do not require refresher training or continual professional development, so amending membership requirements to include CPD might be a help. There would also need to develop systems to allow experienced builders who may not have any formal qualifications to demonstrate their ability or the application of more stringent standards would have the perverse effect of reducing the overall competence of the sector.

In answer to the question of what would help ensure required standards are met to deliver the decarbonisation of the built environment, most survey respondents said they would like to see a minimum level of qualification for decarbonisation work, continuous updating of skills through regulated certification, and membership of a trade association.

[100] Licensing Domestic Contractors: An International Perspective. Pye Tait August 2013, for BEIS. https://www.pyetait.com/wp-content/uploads/2015/08/licensing-domestic-contractors.pdf

Recommendation 14: Operational Licensing Regime

Relevant organisations: UK Government, devolved administrations

Description: Consideration should be given to the introduction of mandatory operational licensing, incorporating minimum qualifications and experience, demonstrated through examination.

5.4.1.2 Organisational Competence

Another important aspect of the performance gap can best be described with reference to standard practice in other sectors. Repeated examples of poor quality and bad practice would not be tolerated in other industries in the same way that they appear to be in the construction sector. This is related to issues around procurement (see Section 5.4.2), which does not always include snagging and operational performance in contracts, and the bespoke nature of many construction projects, which is addressed by off-site and platform construction techniques.

However, many construction firms do operate externally certified Quality Management Systems (QMS), so it is not apparent why construction does not conform to the same quality standards as other industries. Respondents have suggested that one aspect may be the structure of the industry in the UK, together with the country's population density: land developers and builders are often the same business, with profit deriving principally from the development function; as property is in such high demand in the UK (and fuel costs are so low) there is little incentive to spend more time and money on constructing high quality, low carbon homes[101]. Improvements to procurement and contractual structures can help to drive this, but institutional competence is essential to deliver it.

The economic impact of the Covid-19 pandemic does present an opportunity for the construction sector to make use of competent managers and management systems practitioners being made redundant by aviation, automotive and related industries, where the use of these systems is commonplace.

[101] Independent Review of Build Out: Final Report. Rt. Hon. Sir Oliver Letwin MP. October 2018.

Recommendation 15: Quality Management

Relevant organisations: All businesses engaged in building, and the procurement of buildings and building services

Description: Greater emphasis should be given in procurement and delivery to quality management systems, continual improvement and competence at organisational level.

5.4.2 Procurement

The process of procuring building services, whether new-build or retrofit, is also seen as an area with potential for improvement on both sides: buyer and seller. Standard contract conditions can be set, specifying quality or performance standards. These can include requirements for qualification and experience of workers on site, opportunities to develop local apprenticeships, and stipulations for maximum embodied carbon of components.

Minimum standards to be achieved in post-completion testing are already included in contracts. Subject to caveats regarding occupancy and facilities management competence (or householder behaviour), there is potential for these to be extended to include operational performance.

"Value engineering" reduces capital costs but can increase costs over the buildings lifetime, so competence in designing contracts to take this into account is critical. Collaboration and communication between client, designer and builders is essential, but there are plenty of examples of such collaborative structures being developed by impartial third parties. There is also an opportunity here to access the vast quantities of investment looking for good quality green projects, through linking schemes such as the Climate Bonds Initiative to well-managed, low-risk green building projects.

To address this, several respondents saw a particular need for client-related training in how to procure, specify and ensure delivery of for example, low-carbon and off-site manufactured buildings.

Recommendation 16: Procurement support

Relevant organisations: Building Procurers

Description: There is a need to ensure that organisations and individuals who are responsible for procurement ensure that they understand the technologies and solutions available to them to achieve net-zero. Consideration should be given to the development or adaptation of training courses that are focused on achieving net-zero and on ensuring quality control throughout build projects.

5.4.3 Formal establishment of oversight role (e.g. Clerk of Works)

A number of interviewees noted that for a new build site, the Clerk of Works is a position that helps to ensure the quality is right first time. This is a role that has been eroded over

recent decades, but it was felt that there is a need for it, over and above the retrofit co-ordinator role. While it is the responsibility of each tradesperson to do their own quality assurance at the moment, the Clerk of Works role (competently executed) is responsible for overall quality, and for the interface between trades (see Section5.1.4.1).

A clerk of works oversees the quality and safety of work on a construction site, making sure that building plans and specifications are being followed correctly. Duties include performing regular inspections of the work on site and comparing completed work with drawings and specifications. Following the Grenfell disaster, there is a proposal to introduce a new role of Independent Quality Assessor, which would be an extension of the Clerk of Works role.

One interviewee also discussed the need for returning to a system with Local Authority Building Control officers, that would provide quality assurance on works being undertaken, particularly if they were physical fabric works.

It was clear that these types of roles were about checking to make sure that the contractor is actually implementing quality control processes and evidencing that the work has been done properly, rather than being responsible for quality control themselves. With the option of making their own independent checks if they want to or if they feel the need to.

The existing Construction Site Supervisor Level 4 and Construction Site Manager Level 6 roles have recently undergone development of a new Retrofit Pathway. Recently completed within the CITB Standards development team, it is currently going through the processes of the regulator, credit and levelling before being made available to the Awarding Bodies.

Recommendation 17: Oversight

Relevant organisations: UK Government and devolved administrations

Description: Consideration should be given to the requirement for a Clerk of Works role to be formally established for complex building work.

5.4.4 International models

As discussed in Section 0, the United Kingdom is a world leader in efforts to decarbonise its economy, including the construction sector and built environment. However, this statement should not be interpreted as indicating that our efforts are sufficient, or exemplary; merely that there are few sources of inspiration where other countries have already achieved more.

The report[102] commissioned by BIS in 2013, looks at 12 international schemes for licensing contractors and maintaining standards in building trades, covering schemes from Australia, Europe and the United States and characterising the key characteristics of each. However, it is not able to reach any conclusion on whether such schemes are beneficial. Other countries (Germany is often cited) have what are considered to be better vocational training and apprenticeship systems. This is related to the higher esteem in which construction (and related) jobs are held in these countries, but it is not clear which is cause and which effect, or whether such a distinction makes sense.

Northern European countries are held to have made greater progress with the technical aspects of low-carbon new-build and retrofit, and the development of these aspects has in turn led to proliferation of the skills required. It seems likely that the UK can follow a similar path, where improved new-build standards and policy to stimulate low-carbon retrofit lead to increased demand for the skills required to deliver them.

Recommendation 18:Review of International Models

Relevant organisations: UK Government and devolved administrations

Description: Consideration should be given to a review of international models for schemes for licensing contractors and maintaining standards in building trades.

5.5 Create the demand for skills to deliver net zero

5.5.1 Establish a policy framework that creates demand

The scope of this study is focused on the implications for skills and training of the net-zero commitment. The policy required to achieve net-zero is out of scope: it is assumed that policy will be developed which will lead to the actions required to achieve it. For the purposes of this report, it is assumed that the policy developed will result in the CCC net-zero scenario being implemented, and the requirements for skills and training development recommended result from this assumption. If the policy, and the resulting demand, are different, the skills requirements will also change.

At every stage of the project, this focus has been emphasised to respondents but the vast majority were insistent that the policy detail was material, and they tended to hold strong views about what they would recommend to achieve net-zero. This section therefore seeks to set out these views in context, and to explain their implications for skills development.

[102] https://www.pyetait.com/wp-content/uploads/2015/08/licensing-domestic-contractors.pdf

5.5.1.1 Provide clarity on decarbonisation pathway

The built environment is complex and there are various possible net-zero pathways (e.g. different deployment rates of retrofit energy efficiency, heat pumps, hydrogen etc.), that can be deployed. As explored in this report, each of these pathways will have different implications for skill requirements.

The most consistent theme which came out of all the research and interviews is the importance of consistent and effective policy to drive demand for low carbon technologies. This has also been a key finding of other research into related aspects of the net-zero transition. In plain terms, the absence of policy direction on how our buildings will be heated and insulated will result in a delay in businesses investing in skills and training needed to achieve net-zero. Accordingly, long-term visibility allowing businesses to plan and invest is required.

This principle has been emphasised in other recent pieces of research: there is widespread agreement among respondents to this and other research projects that what is required is a more hands-on, directed form of government than has become the norm.

Recommendation 19: Decarbonisation Pathway

Relevant organisations: UK Government and devolved administrations

Description: Clarity should be provided at the earliest opportunity of the decarbonisation pathway selected, in detail. This will enable businesses to gain long-term visibility of the technologies, skills and training needed - allowing them to plan and invest as required.

5.5.1.2 Tenure

As discussed in Section 2.1.1, two thirds of operational emissions come from residential properties and two thirds of those properties are owner-occupied. Commercial buildings account for 27% of emissions, with 45% owner-occupied. As around 95% of operational emissions come from existing buildings, this means that almost exactly half of all current operational emissions come from existing owner-occupied properties.

The energy efficiency of publicly-owned buildings can be improved through the development and implementation of direct policy requirements. Rented accommodation and commercial space can similarly be subject to minimum energy efficiency (or greenhouse gas emission) requirements, but there is currently no policy to address this half of the problem by requiring or incentivising improvements in owner-occupied property.

The recently announced Green Homes Grant initiative[103] will pay two-thirds of the cost of energy efficiency improvements up to a maximum of £5,000 in England, between September 2020 and March 2021, with an estimated annual cost saving through reduced energy bills of £200[104], giving a payback of 12.5 years on the balance (8% ROI). This is illustrative of the difficulty in developing policy to encourage effective retrofit. Although the rate of moving house in the UK has fallen[105] to 23 years, so most owners will feel the benefit themselves, in simple economic payback terms, retrofit is not cost-effective. It is also not sufficient to require upgrades as part of the buying and selling process; turnover of privately owned housing is not fast enough.

On 30th Sept 2020 (after submission of the first draft of this report), the UK Government launched its funding scheme to help retrofit publicly-controlled buildings[106]. Around £1bn will be channelled into boosting the energy efficiency of public buildings, including schools and hospitals through a Public Sector Decarbonisation Fund. This will help an array of public sector organisations in England, including central government departments, agencies, local authorities, schools and NHS Trusts, to install energy efficiency and low carbon heating measures, reducing energy bills and carbon emissions. An extra £50m will fund social housing through a demonstrator project for the Social Housing Decarbonisation Fund (SHDF). This UK-wide demonstrator scheme will see grants supplied to upgrade the energy efficiency of over 2,000 of the worst-performing social homes.

While of course welcome, achieving net-zero requires consistent policy direction on a far larger scale than these interventions, however they can be useful in kick-starting development of the skills required. Survey respondents gave a clear indication that government (along with trade associations) should take the lead in addressing potential skills gaps related to decarbonisation of the built environment. There is an opportunity for the improvement of publicly controlled buildings to be used to develop the national net-zero capability that will be required to decarbonise owner-occupied buildings. Such an approach could lead to the gathering of data and information of the skills required to undertake such activity.

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https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/906544/ghg-additional-information.pdf

104 https://www.homebuilding.co.uk/advice/green-homes-grant-what-is-it

105 https://www.zoopla.co.uk/discover/property-news/how-often-do-we-move-house-in-britain/

106 Social Housing Decarbonisation Fund Demonstrator. https://www.gov.uk/government/publications/social-housing-decarbonisation-fund-demonstrator

Recommendation 20: Energy efficiency measures within publicly controlled buildings

Relevant organisations: Public bodies

Description: Energy efficiency measures should be immediately prioritised within publicly controlled buildings. The installation of such measures is expected to lead to exemplar projects being developed. These can be evaluated to understand the skills and training needs. Such data can then be used in subsequent policy development.

5.5.1.3 Rented property

In 2016, The Energy Efficiency (Private Rented Property)(England and Wales) Regulations 2015 established the new Minimum Energy Efficiency Standards (MEES) in the residential and commercial private rented sector (similar regulations in Scotland have been delayed by the coronavirus pandemic). From 1st April 2018, phase one of the Regulations made it unlawful to let properties with an Energy Performance Certificate (EPC) rating below an 'E' rating, subject to a spending cap of £3,500 (including VAT) for domestic rental.

While there are recognised limitations to the EPC system (see Appendix A.1.4), and a minimum rating of E will not deliver net-zero, MEES establishes a precedent that minimum efficiency standards are required, and (within limits) landlords are expected to meet the cost. This precedent could be extended by gradually requiring an increase in minimum standards. A long-term programme with clear visibility would allow property owners to plan ahead, minimising shocks to property values. This approach would link to the development of long-term retrofit design programmes through the PAS 2035 and 2038 standards, allowing government to control the rate at which retrofit design and implementation is deployed, and thus the capacity of training required.

It is noted that the BEIS consultation "Improving the Energy Performance of Privately Rented Homes in England and Wales[107]" was launched following the preparation of the first draft of this report. This consultation seeks views on how the energy efficiency of the private rented sector can be improved to comply with the Government's target of all such properties achieving Band C by 2030 (while recognising that the proposals suggested in the consultation will not do so, but might be strengthened in future to catch up).

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107 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/932402/prs-consultation-october-2020.pdf

Recommendation 21: Reform of MEES

Relevant organisations: UK Government and devolved administrations

Description: MEES should be expanded and aligned with the achievement of net-zero. Such an approach would give long term certainty on the demand for energy efficiency measures and provide an incentive for training.

5.5.1.4 Owner-occupied buildings

The consensus among stakeholders is that the cost of retrofit should be considered in the context of the value of the property, rather than the income of the occupants, with the caveat that there are areas where house prices alone are not sufficient to support this approach. The studies discussed in Section 2.1.3.2 demonstrate that the cost of achieving net-zero through energy efficiency improvements could be in the order of tens of thousands of pounds per household (and of course significantly more in a commercial context). This is beyond the means of most, if it has to come out of income, but as a proportion of the value of a property, it is more palatable, and if fairly applied across all property owners, even more so.

The building passport approach starts with a detailed survey, which is used to design a retrofit programme in a logical sequence, avoiding unnecessary costs caused by having to un-do one stage to begin the next. This would typically be undertaken through the PAS 2035 (or 2038, as appropriate) framework, by appropriately qualified retrofit designers. The programme allows owners to plan ahead, and allows potential purchasers to see what work has been done, and what remains.

Building passports allow government to require, for example, that every building has a retrofit design survey, resulting in a costed plan for improvements which will bring the building up to a specified standard in a specified time period. Prospective purchasers will have a clear understanding of future cost requirements, which they will effectively deduct from the value of the property. Owners will then be able to borrow to implement improvements using the security of the property, since the value will increase as a result. One interview respondent saw these as being potentially very beneficial especially where it would be an online passport, where it was possible to see how any building was performing.

A comprehensive review of building passport schemes in place worldwide has recently been completed for Greater London Authority[108], who were kind enough to share a pre-release copy. It is also fundamental to the Welsh Optimised Retrofit Programme, ensuring that each building's optimised retrofit design is implemented as designed,

[108] Building Renovation Passports: A review into how they can help put existing buildings on track to Net Zero Carbon. Julie Godefroy Sustainability and Etude, unpublished.

without necessarily having to be implemented in one go. It demonstrates the power of this approach in addressing hard to reach emissions from existing, owner-occupied properties. If this approach were to become mandatory, the development of financial instruments and economies of scale would likely follow.

The building passport approach not only facilitates the financing and management of retrofit projects, it also presents an opportunity for the details of all work required to complete retrofit programmes for every existing building to be logged and analysed, providing unprecedented accuracy in terms of planning for what skills are needed, and when. From a skills perspective, such a resource would allow training and recruitment to be planned reliably; it would also provide data which could be used to forecast the rate of decarbonisation, which would be useful for tracking progress and planning any additional interventions that may be required.

Recommendation 22: Focus on owner-occupied properties

Relevant organisations: UK Government and devolved administrations

Description: Owner-occupied properties should be subject to minimum energy efficiency (or greenhouse gas emission) requirements. This is expected to enable significant investment in skills and grow the energy efficiency market.

Recommendation 23: Building Passports

Relevant organisations: UK Government, devolved administrations, GLA, LAs

Description: Building passports should be required for buildings in the UK. These should outline out the needs of each building to achieve net-zero. As such they could provide a clearer indication of the labour and skills requirements to achieve net-zero and be used as a tool for future planning.

5.5.1.5 Valuation

Government could simply require the public sector to decarbonise built assets, but as with the private sector, this would lead to budgetary difficulties. It has been noted by respondents that the public sector asset valuation model currently limits assessments to 60% of market value (limiting the public sector's ability to borrow to fund net-zero measures), and that revising this model could release sufficient equity to complete the

modifications required to achieve net-zero, and others[109] have considered different approaches to financing national retrofit.

It is widely held that the best approach to ramping up decarbonisation of the built environment is to start with the public sector, where Government has more direct control. However, the cost of finance to improve publicly owned or controlled buildings will be considerable. Releasing additional equity and leveraging private finance could remove this constraint, allowing government to control the pace of retrofit and to prime the market in anticipation of decarbonisation of privately owned properties. This would facilitate development of a reliable work-stream to encourage investment in training and would allow the management procedures and other techniques to be developed prior to their deployment across the private sector.

Recommendation 24: Reform public sector asset valuation model

Relevant organisations: UK Government and devolved administrations

Description: Public sector asset valuation model currently limits assessments to 60% of market value. Revising this model could release sufficient equity to complete the modifications required to achieve net-zero.

5.5.1.6 ECO reform

Refurbishment programmes for public and private sector residents are currently funded through the Energy Company Obligation (ECO), subject to eligibility requirements[110]. It has been observed that the way this obligation is currently managed, 35-40% of funding never makes it to houses, and that management directly by Local Authorities would be more efficient. Reform of ECO could provide the funds required to allow Local Authorities to invest in the skilled surveyors, retrofit designers and Clerks of Works required to deliver the public sector retrofit programme.

[109] Business models for residential retrofit in the UK: a critical assessment of five key archetypes. Brown D., Energy Efficiency (2018) 11:1497–1517. https://link.springer.com/content/pdf/10.1007/s12053-018-9629-5.pdf

[110] https://www.ofgem.gov.uk/environmental-programmes/eco/support-improving-your-home

Recommendation 25: Reform ECO

Relevant organisations: UK Government and devolved administrations

Description: Consideration should be given to reforms to ECO so to ensure that a greater proportion of the funding is directed towards buildings. This will enable greater investment in skills; boosting the net-zero workforce.

5.5.2 New-build

In terms of the operational emissions that are the concern of this study, new-build is a small and (in principle) easily managed part of the problem. There are no technical or financial barriers to implementing net-zero new-build standards, yet attempts to do so have been repeatedly thwarted. The Government's legal commitment to net-zero emissions may mean that subsequent attempts are more successful. The reality of the legal obligation to achieve net-zero emissions is that any shortfall from zero carbon in new-build standards will have to be made up later, and it is far cheaper, easier and less disruptive to build right first time, than to go back later and retrofit.

As operational energy efficiency is improved across the built environment as a whole, the embodied emissions associated with materials, logistics and construction activities will become more important, and these must be considered in any net-zero pathway, but the operational emissions of new-build are small and manageable. Passivhaus is one example of how new build low energy, design standards can be delivered in practice. Over 65,000 buildings have been designed, built and tested to this standard worldwide[111].

Case Study: Passivhaus Plus - Lark Rise

Passivhaus buildings provide a high level of occupant comfort while using very little energy for heating and cooling. They are built with meticulous attention to detail and rigorous design and construction according to principles developed by the Passivhaus Institute in Germany, and can be certified through an exacting quality assurance process[112].

Passivhaus Plus was introduced as a new certification category that recognises the production of onsite renewable energy by passive buildings. Lark Rise, finished in October 2015, was the first completed Passivhaus Plus scheme in the UK. This pioneering, ultra-low-energy, all-electric contemporary home incorporated a large photovoltaic (PV) array and a powerful battery, making it one of the most advanced, high-performance homes in England at the time. Two years of monitoring showed that

[111] https://www.passivhaustrust.org.uk/

[112] https://www.passivhaustrust.org.uk/

the scheme generated more than twice as much energy as it consumes in a year and exports to the National Grid around 10 times the energy that it imports each year[113].

5.5.2.1 Regulation

Section 2.2.1 describes the current situation in the UK regarding the proposed updates to Part L and Part F of the Building Regulations. Respondents noted that the standards are based on energy efficiency rather than greenhouse gas emissions, and that they are not of themselves sophisticated enough to drive decarbonisation.

The Future Homes Standard will be implemented through Part L and Part F, so through the Standard Assessment Procedure (SAP). This can lead to least first cost solutions which are not optimal in operation. For example, one comment was:

> *"we'll just fit panel heaters and PV."*

Such an approach might technically fulfil the requirements of the standard, and would do so at minimal cost to the developer, but it would not help much to achieve net-zero: PV generates electricity during the day, and predominantly in the summer, when demand is low, whereas panel heaters are an inefficient way of delivering heat when it is needed, typically at night and in the winter. This would result in a mismatch of supply and demand, which is not picked up by SAP.

The current proposals include a maximum design flow temperature of 55°C, so that new homes are ready for heat pumps or low temperature heat networks. This flow temperature will not allow these technologies to work as efficiently as they can, but it is within reach of recent designs. However, there is currently no requirement to fit these low-carbon heating technologies, so developers can still (more cheaply) fit gas boilers with a flow temperature of 55°C, at least until the installation of gas boilers in new-build is banned (under current proposals) in 2025. Gas boilers can modulate their output without loss of efficiency, so little consideration of design is required when they are specified; replacing them with heat pumps will require greater design effort.

There is a widely held view that improvements are required to close the performance gap between design and operational emissions. This is described in more detail in Section 2.2.4.

[113] https://www.cibsejournal.com/case-studies/case-study-lark-rise-the-uks-first-passivhaus-plus/

Recommendation 26: Future Homes Standards and net-zero

Relevant organisations: UK Government and devolved administrations

Description: Consideration should be given to how the Future Homes Standards can be improved to ensure that net-zero can be facilitated from the outset.

5.5.2.2 Planning

Decarbonising new-build is about more than just the design of individual buildings. Planners should have clear sustainability commitments in the planning requirements (and these need to be consistent between authorities). These then need to feed into the design (potentially via a climate change co-coordinator role) and then this needs to feed down to the site manager (who does not currently require any qualifications).

The recently released Planning white paper[114] includes reference to the Future Homes Standard and future improvements to it. These concepts should be included within local plans, where they can be integrated with other aspects of the Planning process, such as transport, waste and public health.

Recommendation 27: Local plans and net-zero

Relevant organisations: Planning Authorities

Description: Integrate net-zero requirements across the development and implementation of local plans.

5.6 Route map

A route map for skills development has been developed, based on the model outputs, and incorporating information from the interviews, survey, literature review, and other sources used to inform this research. This sets out the critical steps required to develop the skills and training needed to deliver the example decarbonisation scenario. As throughout the report, it is assumed that policy is developed to generate the demand for these skills.

It may be worth reiterating that this demand does not currently exist; as discussed in Section 2.1, decarbonisation of the built environment will require changes to the policy, funding and training landscape that are unprecedented. This route map does not address how this will be achieved, only how to ensure that the workforce is available when it is achieved. However, the project has gathered information from a wide range of

[114] Planning for the Future: White Paper August 2020, MHCLG. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/907647/MHCLG-Planning-Consultation.pdf

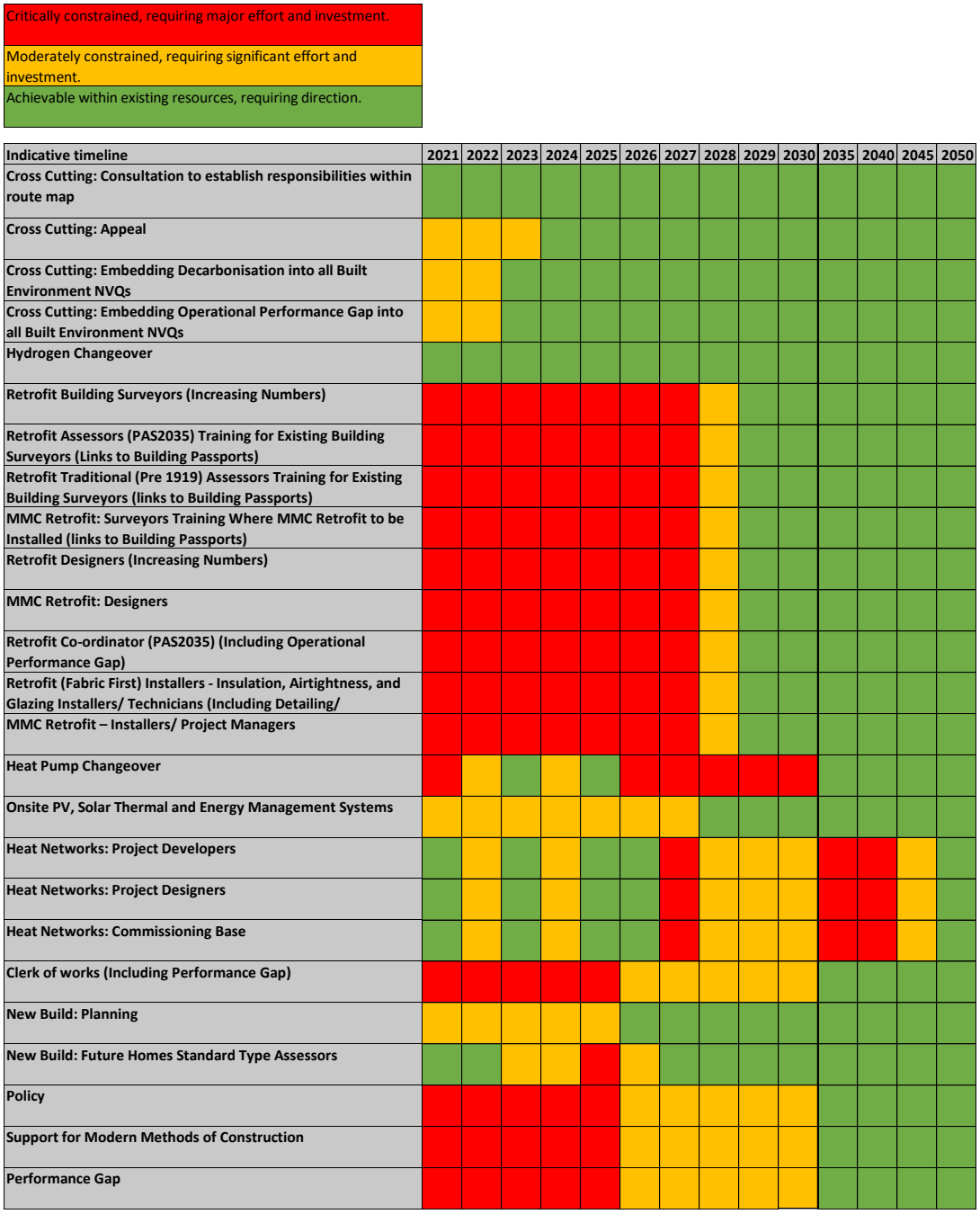
highly experienced respondents representative of the UK construction sector, and most were keen to point out gaps or suggest policy solutions. So as not to lose this information, it is presented in Section 5.5.1. Policy development is included as a part of the route map, but the details of how this might be delivered are outside the scope of this project.

The route map summary presented in actions is based on a condensed summary of the more detailed version in Appendix A.2.2. For each of the skills and training interventions identified, it highlights the constraints on delivery, based on number of workers required with particular skills derived from output from the model running the example scenario, together with data from other sources used in the research. The implications for training interventions are discussed in the sections below.

The route map format is based on a calendar, rather than a flow-chart or other sequential graphic, as it is better suited to the programme required. There is no longer time to build up the net-zero skills programme step-by-step; rather there are several identified gaps, all of which need filling immediately: some are within our current capability, others require some effort and some are critically constrained, requiring a very high level of intervention, as soon as possible. This is illustrated by the red-amber-green coding in Figure 5.1.

Further discussion of the main themes contained in the route map is set out in the sections below.

Figure 5.1: Skills and training actions



5.6.1 Curriculum

Education and training is currently focussed on new-build, using traditional on-site techniques, with little emphasis on low-carbon systems. The net-zero scenario requires a focus on retrofit, modern methods of construction (for both new-build and retrofit) and integration of low-carbon thinking across the board.

Specific low-carbon training is required across all roles, with emphasis on systems design and implementation, on inter-trade issues and on competence and quality. This includes

every part of the construction supply chain, through planners, architects, engineers, construction workers, supervisors and auditors, to occupiers.

Additionally, there are critical gaps in the current curriculum, either in content, emphasis, or both. As discussed above, there is a critical shortage of retrofit designers and co-ordinators, but there is also too little emphasis on retrofit across all training, and on the importance of quality, low-carbon interventions. This reflects current priorities, but the policy being developed will lead very quickly to a major increase in demand for skilled retrofit workers in every discipline, which the current curriculum arrangements are not capable of delivering.

For both retrofit and new-build, modern methods of construction will be critical. The improvements in quality, performance, efficiency and working conditions resulting from these methods are necessary. However, these methods are not covered by the curriculum at the moment. Content and qualifications covering these methods must be developed rapidly, so that they are available to meet the rapid increase in demand. In decarbonisation terms, it is particularly important that training is developed to increase the deployment of MMC in energy-efficiency retrofit. This is currently happening at a very low level in the UK (principally represented by the Energiesprong programme). The pace and scale of decarbonisation required to achieve net-zero, and the importance of retrofit to achieve this, mean that these methods will be of critical importance.

The various industry bodies involved in the development of course content and curriculum requirements should be consulting with urgency to apportion responsibility and to develop these materials. It is suggested that a working group is established across these bodies to co-ordinate this and drive progress.

- Agree responsibility for development of revised and improved course content and new courses required to achieve net-zero;
- Implement course development upgrades across the board, but specifically including:
    - General low-carbon systems training;
    - Retrofit (including non-domestic and traditional buildings);
    - Modern Methods of Construction (including new-build domestic and non-domestic, and retrofit);

5.6.2 Building envelope

The example scenario is based on the premise of tackling energy efficiency first, before addressing decarbonised heating at scale. This approach makes sense, as the design specification for heating systems depends on the energy requirements of the building, which in turn depends on its energy efficiency. Failure to address energy efficiency first results in an incorrectly specified heating system, which is more of a problem with modern heating systems than it was with traditional gas boilers; it would most likely result in inadequate heating until the energy efficiency work is done, and/or inefficient heating afterwards.

However, focussing on energy efficiency first is also not without its difficulties. To ensure that energy efficiency upgrades are carried out effectively and with minimum cost and disruption, whole building approach to design is required (the approach taken by PAS 2030). This approach ensures that interventions are optimised, and that damage and rework are minimised. While this approach is far better than the piecemeal application of individual interventions, there is currently a critical lack of retrofit designers qualified to develop these programmes. Competent retrofit designers require not only training but also experience, and in the case of retrofit designs for non-domestic and traditional buildings, the skills gap is even greater.

PAS 2035 and 2038 require that buildings must be in a good state of repair before undergoing a retrofit programme. There is a critical skills gap in repair skills for traditional buildings, but generally repair skills are among the less critically constrained; the issue here is the sheer numbers required: these are not skills that are typically included in formal training, they are normally picked up through on-the-job training and apprenticeships.

A strict adherence to the energy efficiency first approach generates a training bottleneck which will need to be addressed if it is not to have the effect of slowing down the overall decarbonisation programme. However, there are certain interventions which can be made without fear of interfering with any subsequent retrofit design. Such no-regret interventions include those not directly related to building envelope energy efficiency, such as smart systems and on-site generation, but also some energy efficiency interventions, such as cavity wall and loft insulation; the former being more commonly applicable in non-domestic, and the latter in domestic projects. Many of these interventions also require relatively little training, so the additional workers required to increase their rate of deployment can be skilled up quickly, while longer-term training of retrofit designers is in progress. This will help to start the process of decarbonising quicker, but the retrofit bottleneck is still critical to achieving net-zero emissions across the built environment, and it is therefore of critical importance that it be addressed as a priority.

- Need to continue acceleration of training in retrofit design roles, which require experience and take time to train, with particular gaps in non-domestic and traditional buildings;
- Some no-regrets interventions can be expedited while retrofit designer numbers increase;
- Focus on increasing numbers of specialist building envelope installer roles.

5.6.3 Energy

The list of options for primary energy delivery is quite short. Affordable, low-carbon hydrogen may be developed, but it is unlikely that this will have a significant impact in the next ten years. In skills terms, should the pace of development of hydrogen accelerate, there is enough capacity in the UK's existing gas installation sector to cope, with modest re-training requirements. What should be of more concern is how these installers can be re-trained in the event that demand for their skills drops rapidly. If this

is the case, there will likely be opportunities for gas installers to re-train as heat pump installers.

The rate of development of heat networks can be increased, but these require integrated planning at a large scale, and greater consideration is required of what their primary energy input is, and what it will be. The skills needed for heat network deployment require development. At present, there are skills shortages across all disciplines required, and the pace of deployment is set to increase in the example scenario. The detailed requirements for additional jobs (on the basis of the example decarbonisation scenario) are set out in the model and summarised in Section 4.2, and are also considered in the Heat Network Skills Review[115].

There is a role for on-site renewables, storage and smart systems, but these technologies can only help, they cannot deliver the amount of energy required all the time.

This leaves heat pumps as the principal low-carbon heating system which is ready for deployment now. Training capacity for converting to heat pump installation is likely to be sufficient, with perhaps some additional development depending on the exact pace, and nature of the changeover.

The on-site renewables and heat pump sectors have suffered recently from boom and bust support, which has resulted in significant losses and redundancies, so it is important that whatever support or policy is developed must be implemented for the long term, or there may be reluctance to engage among those best placed to do so. In recent research undertaken by Eunomia for BEIS, the heat pump industry reported a reluctance to invest, due to inconsistent and short-term policy. The UK feed-in tariff was estimated to have been responsible for the development of around 15,000 jobs[116] but the market collapsed[117] when support was withdrawn. This resulted in an estimated contraction of around 94% in the solar industry, and in every small and medium wind turbine manufacturer going out of business.

The three main low-carbon primary energy systems are competitive with each other, which may require intervention to resolve: if hydrogen is deployed through the gas network, (assuming the price and carbon intensity are agreeable) it would require very little additional infrastructure, so it would be cheaper than the alternatives as a drop-in replacement for natural gas, outcompeting heat networks and heat pumps. Where heat networks are planned, deployment of individual heat pumps reduces project viability by reducing the number of properties connecting to the heat network system: the capital outlay for the system remains the same but the income is reduced. It may therefore be

[115] Heat Network Skills Review. BEIS research report no. 2020/020.

[116] Performance and Impact of the Feed-in Tariff Scheme: Review of Evidence. DECC, 2015.

[117] Monthly feed-in tariff commissioned installations. Office for National Statistics.

advantageous to develop zones in which deployment of each technology is promoted, to minimise internal competition.

- Support heat pump training, particularly with respect to whole-system performance and quality of installations;
- Promote heat pump deployment, particularly in areas where low-carbon heat networks and hydrogen deployment are less likely to be competitive;
- Promote heat network development and training, ensuring that primary heat sources are low-carbon;
- If low-carbon, affordable hydrogen deployment becomes competitive, re-train existing gas installers to retrofit hydrogen-ready boilers.

From an integrated energy systems perspective, it should be noted that supplying heat through a combination of renewable electricity generation and heat pumps (either directly or through heat networks) is at least five times[118] as efficient as using renewable energy to generate hydrogen, then burning this hydrogen to generate heat.

5.6.4 Smart systems

This category includes a wide range of technologies, from solar photovoltaics and thermal systems, through battery and thermal storage to smart thermostats, and IoT-connected systems. Some of these are effectively plug-and-play, requiring no specialist skills, while others require detailed knowledge of the inter-relationship of several distinct systems. Currently, these technologies tend to be considered as a stand-alone add-on, typically installed by early-adopters and technology enthusiasts. For them to play the role needed to contribute to the net-zero emissions scenario, these technologies need to be integrated into the whole-system design required for retrofit under PAS 2030, and in new-build installations from the outset.

As discussed, an increase in the number of PAS 2030 retrofit designers is critical, and it is essential that the curriculum for these designers includes smart systems, particularly as these systems, and as opportunities develop for integrating them within and between buildings. For new-build, mechanical and electrical design engineers will need to be familiar with the operation of these systems and their integration into the overall operational design of buildings. This will require updating course content for these disciplines, and the development of inter-disciplinary apprenticeships for systems installers.

There is also a lack of skills in building management, particularly in the non-domestic context. This is anticipated to become increasingly important as building management systems become increasingly complex and sophisticated.

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[118] Liebreich: Separating Hype from Hydrogen – Part Two: The Demand Side. Bloomberg NEF, October 2020.

- Promote deployment of smart metering and BEMS (particularly in a non-domestic context) to target efficiency improvements and modulate demand in periods of high grid carbon intensity;
- Exploit potential for smart systems to mitigate grid upgrade costs, facilitate greater deployment of renewables and electric vehicles.

5.6.5 New-build

Compared to the need to decarbonise existing buildings through retrofit, the reduction of emissions required from new-build is small, and much easier to address, for example through upgrades to Planning requirements and standards applied through Building Control. However, there is still a need for improvements to course content, particularly with regard to integration of systems and low-carbon design. There is also a requirement for standards to be implemented and enforced with greater rigour, for example through the development of specialist roles such as building performance champion, to oversee critical work, testing and training, and a specific insulation role to address quality, thermal bridging etc.

- Implement changes to procurement (e.g. post-completion testing, operational performance standards) to ensure new-build achieves statutory standards.

5.6.6 Performance gap

Improvements are required across the whole building services procurement process, to close the gap between design and operational performance. This includes development of improved contractual structures including post-completion testing and operational performance requirements, minimum training requirements including low-carbon systems for all construction workers, and updated training requirements across all skills.

It is likely that some form of structural improvement in construction sector skills will be required, whether through e.g. mandatory registration, or demonstration of organisational competence through externally certified management systems. The unprecedented surge in construction work required to achieve net-zero, particularly in retrofit, must be delivered with higher quality than is currently prevalent, or it will not be effective; the current performance gap alone is enough to make the net-zero goal unattainable. Even if every building in the country undergoes a complete retrofit, and all new buildings are designed to low-carbon standards, net-zero will not be achieved without a dramatic and consistent improvement in quality. Although this may be an uncomfortable truth for the UK construction sector, it is nonetheless true: business as usual will not deliver net-zero

.

Recommendations to close the performance gap include improvements to contractual and procurement structures, minimum training requirements and upgrades to training courses. They also include improvements to supervision and inspection of construction work, through renewed support for Building Control, and a return to something akin to the Clerk of Works inspection regime.

- Update procurement to make operational performance a condition of contracts;
- Consider implementation of mandatory licensing for construction sector workers;
- Improve institutional competence (e.g. through management systems);
- Implement increased on-site scrutiny (e.g. through Clerk of Works role).

5.7 Summary

The study has collated a very wide range of views and information to identify the skills and training required for the construction sector in the UK to achieve net-zero. The scale of the challenge and limited time remaining mean that the level of commitment and investment required is unprecedented, but achievable.

The study considers only the skills and training requirements, not the policy required to generate demand for these skills. It is assumed that such policy will be implemented; what this report shows is that the sector can be trained up to deliver, and how it can.

There is a requirement for training at a scale which is deliverable, but not within the "business as usual" framework. Achieving net-zero by 2050 requires a thirty-year commitment to a decarbonisation pathway, development of additional training resources and facilities, and deployment at scale. It requires consistent policy and funding to ensure consistent demand for skilled workers.

With these pieces in place, net-zero can be achieved, but there is no time to waste and no slack.

5.8 Further Research

During the study, the following areas were highlighted as offering potential for further research and development:

- **Action plan for stakeholders**. An extensive number of actions and next steps are set out in the route map. These need to be reviewed in collaboration with relevant stakeholders to identify action owners and develop detailed action plans for their delivery. It has been suggested that a working group representing all the relevant parties should be convened to manage this process.
- **Curriculum review and mapping**. This study has identified a wide range of curriculum development needs and stakeholders that are working on developing material. It was not within the scope of the study to develop a map of existing curriculum material, new material in development and gaps that need filling, but this would be a useful output to feed into the action planning described above.
- **Model Development**. The model developed was the first of its kind to assess the potential net zero skills gaps in the construction industry. There is potential to develop the model to provide further insights on the type and location of skills that will be required, for example including a greater number of building types, providing greater granularity in terms of regional data, and improving assumptions for commercial buildings.
- **Embodied Carbon**. As operational emissions come down, the emissions from construction materials and activities will become relatively more important. At

the moment, these are estimated at around a quarter of the total impact from the sector, so halving operational emissions will mean that embodied emissions become relatively more important. Clearly net-zero cannot be achieved without addressing this, however it is outwith the scope of this research. A research project identifying these emissions and looking at plans to manage them is required.

APPENDICES

A.1.0 Methodology

A.1.1 Specification

The purpose of this project was to understand the skills implications for the built environment workforce of the UK Government's commitment to a legally-binding target of net-zero carbon emissions by 2050. The detailed evidence contained in the report covers the following aims:

- Provide clarity on the most significant skills barriers across the contractor and building professional services occupations to the delivery of net-zero and the role that workforce skills development can play as an enabler for the decarbonisation of the built environment;
- Identify tangible opportunities for interventions by governments, industry and CITB to take action to address skills barriers and provide a clear call to action for industry to enable action to respond to clean growth opportunities; and
- Enable industry and government to assess workforce outcomes using labour market forecasting, based on different approaches, sectors and policies. This forecasting model will allow feasibility to be assessed for alternative deployment pathways, in terms of their impact on skills and labour markets.

The research specified the following deliverables to achieve the specified outcomes and ensure representative and robust data collection and analysis:

- Desk-based research
- Interim report on the qualitative findings
- Interim report on the quantitative findings
- Forecasting tool/model
- A presentation to the steering group on the key findings and recommendations
- Submission of full draft report.

A.1.1.1 Research questions

The research questions were mapped to the research tasks, based on the deliverables for the project.

- Task 1 - Desk-based research
- Task 2 - Qualitative research
- Task 3 - Quantitative research
- Task 4 - Tool: Forecast/Scenario Planning/Analysis
- Task 5 - Analysis, Conclusions and Recommendations

Table A1-5-1 - Research Questions

	Task 1	Task 2	Task 3	Task 4	Task 5
RQ 1	Establish a baseline of existing evidence				
a	✓				
b	✓				

	Task 1	Task 2	Task 3	Task 4	Task 5
RQ 2	**Define a range of plausible deployment trajectories**				
a	✓				
b	✓				
RQ 3	**Describe the impact of the transition to net-zero on the composition of the workforce, against the agreed deployment trajectories**				
a	✓				
b	✓	✓	✓	✓	
c					✓
d	✓	✓	✓	✓	✓
e	✓	✓	✓	✓	✓
RQ 4	**Assess workforce capacity and capability against deployment trajectories**				
a		✓	✓		✓
b		✓	✓		✓
c		✓	✓		✓
d		✓	✓		✓
e		✓	✓		✓
f					✓
RQ 5	**Conduct scenario forecasting / analysis**				
a				✓	
b				✓	
c				✓	
RQ 6	**Identify and assess resources (qualifications, training, assurance of competence)**				
a	✓	✓			✓
b	✓	✓			✓
c	✓	✓			✓
RQ 7	**Provide clear, practical and achievable recommendations with clearly identified responsible owners across all recommendations**				
a					✓
b					✓
c					✓
d					✓
e					✓

A.1.1.2 Model capability

Building on the insight obtained from the other phases of the project, a tool was developed using a bottom-up approach to consider the skills demand pathways which could be overlaid and compared with

current supply to present gaps and shortages. The tool allows the user to analyse the skills constraints on the deployment trajectories and explore the implications of accelerating the UK's journey to net-zero.

Based on the various pathways developed in conjunction with CITB and tested with stakeholders in the steering groups, the skills demand pathways include several factors:

- Existing BEIS modelling, reflecting the array of policy options currently on the table (e.g. a full electrification pathway, a hydrogen pathway, a hybrid pathway).
- The deployment pathways (e.g. number of retrofits needed to achieve net-zero, number of heat pumps installed to comply with Future Home Standard).

Each policy option and deployment scenario has a baseline timeline for delivery, but also includes the flexibility to change the delivery timings. This allows policy makers to plan for a significant ramp-up in skills needs and potential bottlenecks in demand. The tool informs advice around qualifications and training, and demonstrates possible alternative outcomes based on policies (base scenario, best case, worst case). The structure of the model is explained in greater detail in section 4.2 of the report.

A.1.2 Literature Review

A.1.2.1 Rapid Evidence Assessment

A Rapid Evidence Assessment (REA) was carried out to identify immediate issues (skills gaps and shortages), find evidence of challenges businesses and individuals face achieving current levels of compliance and to identify and qualify industry stakeholder organisations and individuals who could provide insight relevant to the project. The data found was mapped against the research questions outlined in the specification in order to:

- Identify those areas where the evidence base is robust;
- Identify key gaps in information;
- Assess whether other parallel studies are expected to be able to fill those gaps; and
- Direct the qualitative and quantitative research to those gaps that need filling.

The REA was conducted in alignment with the guidance provided by the steering group and drew upon Eunomia's broader experience of similar exercises. The following information sources were utilised: internet and electronic journals; grey literature; media articles; opinion pieces or blog articles; and other sources, independent reviews, from previous research projects, recommendations from CITB, BEIS and from the stakeholder interviews.

The sources were searched using keywords[119] and the results were assessed for relevance using an iterative approach. Abstracts and executive summaries were reviewed to eliminate sources that were not relevant to the net-zero skills context.

In total, over 98 sources were identified and analysed including academic papers, survey results, government-commissioned research, policy evaluations, industry reports and grey literature. The split of

[119] Keywords used to search included "low carbon heat," "skills," "workforce," "demand," "train," "re-train," "jobs," "retrofit," "staff," "building skin," "shortage," "barriers," "training," "gap," "heat pump," "heat network," "hydrogen," "transition," "accreditation," "installers," and "qualifications." These words were used alone or were combined.

these sources was roughly 56% industry or government reports, 12% articles, 6% grey literature, plus 26% other remaining sources.

Findings from the REA were used to inform the interview questions and to help develop a robust set of interview and survey questions.

Table A1-1-2 - REA sources

Title	Author	Publish date
Zero carbon Britain Rising to the climate emergency	Centre for Alternative Energy Canolfan y Dechnoleg Amgen	2019
Wates sets five-year Zero Carbon target	The construction index	2020
Bringing embodied carbon upfront Coordinated action for the building and construction sector to tackle embodied carbon	World green building council / Ramboll	2019
Raising ambition **Zero Carbon Scenarios from across the globe**	Centre for Alternative Energy Canolfan y Dechnoleg Amgen	2018
Deliverable Proof – Reports resulting from the finalisation of a project task, work package, project stage, project as a whole	EIT Climate-KIC	2018
Skanska UK **Net-zero 2045** **Special report on** **cutting carbon**	Skanska	2019
Net Zero **The UK's contribution to** **stopping global warming**	CCC	2019
Net Zero Carbon Buildings: A Framework Definition	UKGBC	2019
Ofgem decarbonisation action plan	OFGEM	2020
Mission Possible - Achieving net-zero carbon in Construction	EDIE	01/12/2019
Emerging findings: New roles in construction	ICF	2019
Structural Change & Industry Dynamics	CITB	2020
National Grid - skills required for net-zero energy	National Grid	2020
Japanese to build UK's biggest offsite village construction	Construction Engineer	01/02/2020
Drivers of structural change and industry dynamics	ICF	2019
Reinventing retrofit **How to scale up home energy efficiency in the UK**	Zero Energy Buildings Catalyst (ZEBCat) project	2020
House of Commons Legislating for net-zero	House of Commons Library	2019

Buildings Energy Mission 2030: Background Report to Recommendations from the UK Green Construction Board in response to the 2030 Newbuild Challenge.	The Green Construction Board	2019
By popular demand: What people want from a resource efficient economy	Green Alliance	2018
Zero Carbon Britain: Rising to the Climate Emergency models	CAT	01/11/2019
Carbon Emissions in the UK Built Environment Achieving 80% Reduction by 2050	ARUP	Unknown
Energy Innovation Needs Assessment	Vivideconomics	2019
Creating Zero Carbon Communities: The Role of Digital Twins	Commissioned by Integrated Environmental Solutions (IES)	2019
Zero Carbon Compendium The future of low energy cities and communities	Zero Carbon Hub	2015
Construction professions team up for climate change pledge	The construction news index	Unknown
Whole supply chain is key to achieving net-zero	Construction news	13/02/2020
Work Package 2: Productivity Mapping & Literature Review	Innovate UK	30/08/2019
Building Skills for Net Zero Emissions	Green Construction Board Meeting	03/12/2019
Carbon Sequestration by buildings	The alliance for sustainable building products	Unknown
No more baby steps' says sustainable construction expert	Scottish construction now	02/12/2019
Integrated retrofit design methodology	newTREND	01/08/2017
Installer survey results	Charter Institute of plumbing and heating engineering	01/10/2019
Step by Step retrofits with passive house components	Passive house institute	2016
Plan of Work 2020 Overview	RIBA	2020
UK housing: Fit for the future?	Committee on Climate Change	01/02/2019
Sustainable outcomes guide	RIBA	Dec-19
The decarbonisation of heat	regen	Unknown
English housing survey Energy report 2017 - 2018	Ministry of Housing, Communities & Local Government	2018
Heat Pumps Integrating technologies to decarbonise heating and cooling	European Copper Institute	2018
The clean growth strategy	HM Government	2008

ENERGY CONSERVATION, ENGLAND AND WALES The Energy Efficiency (Private Rented Property) (England and Wales) Regulations 2015	UK government	26/03/2015
ENERGY CONSERVATION, ENGLAND AND WALES The Energy Efficiency (Private Rented Property) (England and Wales) (Amendment) Regulations 2016	UK government	21/06/2016
ENERGY CONSERVATION, ENGLAND AND WALES The Energy Efficiency (Private Rented Property) (England and Wales) (Amendment) Regulations 2019	UK government	01/03/2019
The Future Homes Standard 2019 Consultation on changes to Part L (conservation of fuel and power) and Part F (ventilation) of the Building Regulations for new dwellings	Ministry of Housing, Communities & Local Government	Oct-19
Climate Change (Emissions Reduction Targets) (Scotland) Act 2019	Scottish government	31/10/2019
The Future of Skills: Trends impacting on UK employment in 2030	Nesta	Unknown
Climate change, innovation and jobs	London school of Economics	Unknown
REPORT TO THE COMMITTEE ON CLIMATE CHANGE OF THE ADVISORY GROUP ON COSTS AND BENEFITS OF NET ZERO	Advisory Group on the Costs and Benefits of Net Zero	Unknown
Greening Jobs and Skills LABOUR MARKET IMPLICATIONS OF ADDRESSING CLIMATE CHANGE	OECD	Unknown
Reducing UK emissions 2019 Progress Report to Parliament	Committee on Climate Change	Jul-19
Warmer & greener: A guide to the future of domestic energy efficiency policy	Westminster sustainable business forum	Unknown
Construction skills network 2019 - 2023	CITB	Feb-19
Construction skills network - 2020 - 2024	CITB	To be released
SOLID WALL INSULATION Unlocking Demand and Driving Up Standards	Chief Construction Adviser	Nov-15
Solid wall heat losses and the potential for energy saving	BRE	02/03/2016
Route map 2020	BRE	Unknown
Closing the gap between design & as-built performance	Zero Carbon Hub	Mar-14
Residential heat pump installations: the role of vocational education and training	University of Westminster	Sep-15
Heating engineers, skills and heat decarbonisation	UKERC	Sep-19
Heat Pump Market Analysis by Growth Application and Forecast to 2025	Market watch	Apr-19
The future role of heat pumps in the domestic sector	University of Oxford	Unknown
Public acceptability of the use of hydrogen for heating and cooking in the home	CCC	Nov-18

Will we heat our future homes with hydrogen?	ARUP	Unknown
Role of hydrogen in UK energy system	Energy research project	Unknown
“We need to retrain boiler engineers in low carbon heat skills”	networks.online	Unknown
UK’s first National District Heat Skills Academy	Heat Networks Sustainability by Sweden	Unknown
Delivering net-zero: A roadmap for the role of heat pumps	Heat pump association	2019
District Heating - Delivering affordable and sustainable energy	Changeworks	Apr-17
Leti Climate Emergency Design Guide 2020	LETI	2020
Trust and Certainty October 2015	Skyblue	2015
Shifting the focus: energy demand in a net-zero carbon UK	CREDS	2019
Construction and built environment Skills transferability in the UK	CITB	2018
Career and Training Progression Routes in the Construction Industry Final Report	CITB	2013
Transitioning to Hydrogen - Assessing the engineering risks and uncertainties	Institute of Engineering and Technology	2019
Hydrogen in a low carbon economy	CCC	2018
Analysis on abating direct emissions from "hard to decarbonise" homes, with a view to informing the UK's long term targets	CCC	01/08/2019
The remaining potential for energy savings in UK households	Researchgate	2018
Workforce Mobility and Skills in the UK Construction Sector 2018/19	CITB	2019
UNLOCKING CONSTRUCTION’S DIGITAL FUTURE:A skills plan for industry	CITB	2018
MIGRATION AND CONSTRUCTION: The view from employers, recruiters and non-UK workers in 2019 Full Report – October 2019	CITB	2019
Skills and Training in the Construction Industry 2018	CITB	2018
THE IMPACT OF MODERN METHODS OF CONSTRUCTION ON SKILLS REQUIREMENTS FOR HOUSING	CITB	2019
PATHWAYS INTO CONSTRUCTION Employers: improve routes into construction with CITB’s biggest fund	CITB	2019
Skills and training to decarbonise heating	Off Gas Grid	2020

Evolution or Revolution	CITB	2020
BUSUK Final Report 2012	Build Up Skills	2012
What is whole house retrofit	STBA	2016
Each Home Counts	BEIS	2016
Achieving net-zero: Regulating the Decarbonisation of Heat	SEA	01/01/2020
UK Construction Online 2020: The Year of Net Zero	UK Construction Online	01/01/2020
Housebuilders hold summit to take carbon emissions down to zero	Showhouse	Unknown
Nottingham council unveils 2028 target to become UK's first carbon neutral city	PSE	01/01/2019
11 office buildings become first to accomplish net-zero carbon status	PBC Today	01/01/2020
Environmental Innovation in the construction sector	PBC Today	01/01/2020
TOWARDS NET ZERO: The implications of the transition to net-zero emissions for the Engineering Construction Industry	ECITB	01/01/2020
Skills and training to decarbonise heating	Sustainable Energy Association, CIPHE, OFTEC, GSHPAA, HPA	Unknown
Skills Needs Analysis 2013Repair, Maintenance and Energy Efficiency Retrofit of Traditional (pre-1919) Buildings in England and Scotland	English Heritage, CITB, Historic Scotland	01 January 2013
Behaviours, Cultures and Performance in the Construction Industry	Skyblue Research Ltd	2019

A.1.2.3 Additional reports

Following the REA, additional documentation was identified as being relevant to the study. This was supplemented by recommendations of literature gleaned from the qualitative interviewees and the steering group workshops. The sources were reviewed using the same methodology and any relevant data was added to the REA matrix.

Table A1-3 - Additional REA sources

Title	Author	Publish date	Summary
Eight policy packages for Scotland's Green Recovery	Climate Emergency Response Group	01/07/2020	Climate Emergency Response Group report focussed on delivering practical, workable, solutions that the Scottish Government should be implementing now, in order to move Scotland towards a net-zero economy, while recovering from the COVID-19crisis. Of the 8 packages one is Retrofit buildings for a net-zero Scotland. Within this it sets our proposals for Tackle Fuel Poverty Support households Support businesses and public sector estate Strategic approach Limited details on the skills needs and gaps to deliver net-zero
A Green Stimulus for Housing	New Economics Foundation	01/07/2020	Focused on implications of wide scale whole house retrofit programme of 9m houses in the parliament period, saving around 15% of total domestic energy demand Some useful analysis on jobs implications – Looking to follow up with Parity Projects and CROHM model used Emissions savings of approximately 19.23MtCO2/year by 2023/24, or 21% of 2019 emissions from the UK's homes. This is a cumulative 40.9 MtCO2 by 2023/24, meaning this policy proposal alone could surpass the UK's fourth carbon budget targets. Would generate 117,811 new jobs in Year 1, rising to 382,885 per year by Year 4. It recommends: a National Retrofit Taskforce Public capital investment and tax changes Strengthen Building Regs Area Based Delivery (Local authority driven)

Retrofitting to decarbonise UK existing housing stock	RICS	April 2020	Broad reaching paper explores: current landscape of retrofitting policy drivers, regulations, technical processes and fiscal levers, gaps and opportunities and where industry standards and tools can overcome barriers In terms of skills its recommendations focus on: Apprentice training and assessment Public awareness of standards and professional competency-based advice and training in regard to energy efficiency retrofits and wider home improvement works
Net Zero – the Road to Low Carbon Heat	CBI	22/07/2020	Report outlines the challenges and opportunities of decarbonising the heat in our homes and buildings around the UK A key recommendation is that the Government should include 'low-carbon skills' in the national retraining scheme. This focuses on: There needs to be a national plan to train and reskill a workforce. National apprenticeships and a CPD programme needs to be developed in collaboration with industry. A national low-carbon skills programme, which will create the skills for the installation and retrofit work that then transitions to maintenance and customer service. Skills around low-carbon solutions installations, collecting and managing consumers energy data should be included.
Energy Efficiency's offer for net-zero compatible stimulus and recovery	EEIG	June 2020	The EEIG report focuses on net-zero in a post Covid 19 economic recovery and recommends a comprehensive government-led programme that: Treats energy efficiency as a national infrastructure investment priority, with EPC target for all homes Provides additional public capital investment of £1.8 billion per year to 2030, Establishes adequate incentives for 'able to pay' homeowners and landlords, Sets out robust regulation, that requires some homeowners to take action Supports a long-term approach to delivery in which local authorities play a core role Ensures strong advice provision, quality assurance and safety standards. Limited details on skills needs and gaps

Building the Net Zero Energy Workforce	National Grid	January 2020	Increase low carbon electricity generation by about 50% to ensure we can meet demand whether in homes or transport from sources such as wind and solar. Reduce the carbon impacts of heating by installing low carbon heating systems in about 2.8 million homes. Develop CCUS technology to reduce emissions particularly from gas powered electricity generation and industry and develop hydrogen networks Power about 11 million EV's by installing about 60,000 EV charging points across the country. 2030 117,000 new jobs 2040 152,000 new jobs 2050 131,000 new jobs Total 400,000 new jobs

A.1.3 Interviews

In addition to the primary evidence and to enable the mapping of required skills against the pathways, the qualitative interviews were used to gather data from key stakeholders. The interviews focused on their views, perceptions and attitudes towards the net-zero skills requirement, barriers to growth, and what policy interventions might support this growth.

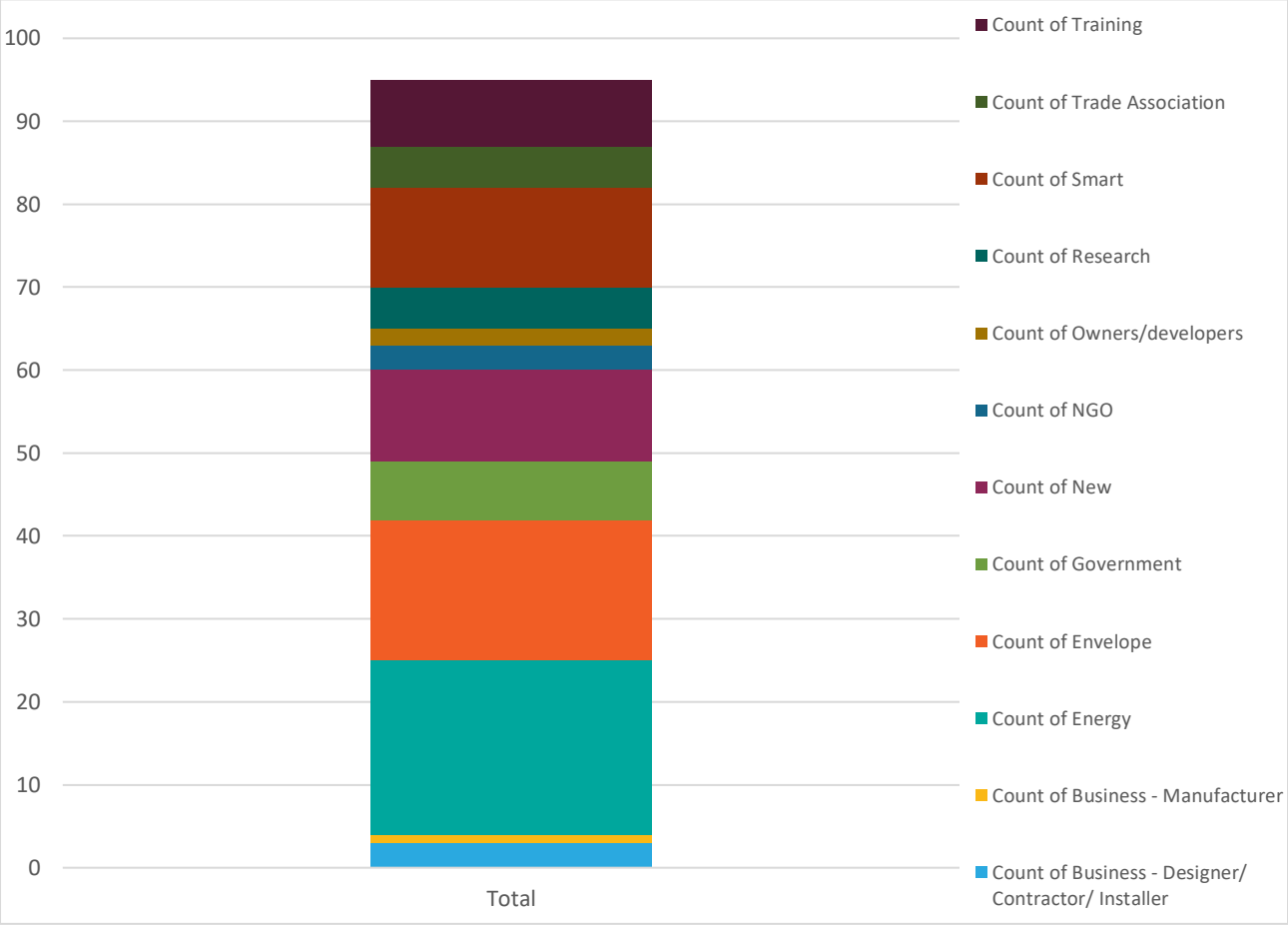
Recruitment of research subjects either involved contacting subjects which had already engaged in previous projects and contacting relevant trade associations. The spread of the backgrounds of the interviewees was tracked in a spreadsheet and shared with CITB through the research phase. Appendix A.1.3.2 shows the spread across the two interview tranches.

45 anonymous interviews were held remotely using an open format, but were structured around the topic guide in Appendix A.1.3.2. The interviews were recorded and transcribed with permission from the participants, to facilitate the analysis.

To ensure comparability of findings, topic guides for each research component were developed in consultation with CITB. Each theme within the guide was closely aligned to the project objectives to ensure the study remained relevant and focused and also focused on the identification of case study examples to illustrate skills needs, regional delivery of net-zero and existing training. Appendix A.1.3.2 contains the key questions, probes and prompts used during the interviews

A.1.3.1 Sample frame

Figure A 1.1 - Interview sample frame



A.1.3.2 Topic Guide

Participation - Introduction

Please use this script in a responsive and discursive way for each individual.

- Verify company name
- Ask for named contact [if available]
- Email address
- Confirm contact name

Organisation:
Named contact:
Tel number:
Date of first contact:
Date of interview:
Interviewer:

- My name is [AS APPROPRIATE], and I am a researcher from Eunomia Research & Consulting. We are UK-based company and have **been commissioned by** the Construction Industry Training Board (**CITB**) in association with the UK Government Department for Business, Energy and Industrial Strategy (**BEIS**) to carry out an independent study on the **skills required in the construction sector to deliver the government's commitment to achieve net-zero emissions by 2050** (2045 in Scotland, 95% net-zero in Wales).

Amongst other things, the study aims to identify:

- **Establish a baseline of existing evidence**;
- Define a range of **plausible deployment trajectories**;
- **Describe the impact of the transition to net-zero on the composition of the workforce**, against the agreed deployment trajectories;
- **Assess workforce capacity and capability against deployment trajectories**
- Identify and assess resources (qualifications, training, assurance of competence)

- IF PUBLICATION QUERIED: The findings will inform a report to CITB, which will inform a white paper feeding into the UK Government Heat Strategy. All commercially sensitive data will be anonymised.
- Offer to send letter from CITB if they want more details.

Participation - Request

- Are you happy to participate in the interview now or at a later date? Secondly, are you able to comment on your organisation's views on;
  - The skills required to achieve net-zero greenhouse gas emissions from the built environment;
  - The number of trained individuals currently working with these skills, and the number required to achieve net-zero;
  - The training resources required to achieve the required growth in skilled workers.
- IF YES, CONTINUE AND SIGN SEPERATE INTERVIEW WRITTEN CONSENT FORM (RUN THROUGH THIS)
- IF NO, END AND ARRANGE ALTERNATIVE TIME, OR INTERVIEW WITH ALTERNATIVE CONTACT.

We acknowledge that some of the information you provide may be commercially sensitive. We can reassure you any information you provide will be treated as confidential and anonymous. We will not name organisations taking part in the project, nor will we allow the identification of organisations by proxy. If you share any supplementary documentation it will be stored securely with access restricted to those on the project team. To alleviate any concerns, we can offer you a review of the interview transcriptions before it is used as part of the research. We are also very happy to sign a non-disclosure agreement if required.

Interview – Recording request

With your permission we would like to **record the interview** so that we gather an accurate record of your views. The data will be stored securely in accordance with the Data Protection Act and GDPR. We will not share the recordings or transcriptions with anyone other than our immediate research team and transcribers. Are you happy for the interview to be recorded?

- If YES record the interview and have the participant sign the correct section on consent form to confirm in writing that the interviewee is happy to be recorded.
- If NO proceed without recording and have the participant sign the correct section on consent form, confirming in writing that the participant is happy to be interviewed, but not recorded.

Interview - Background

In this interview we are looking for your organisation's views on the following:

1. Organisation background;
2. Choice and pace of decarbonisation pathways;
3. Existing skills in the construction sector;
4. Scale and pace of training required;

5. Training requirements and timescales.

- We may be in touch following the interview to ask further questions with regards to Future Policy Pathways.

1. Background Questions			
1.1	**Participant's role in the organisation?**	Probe: What department do you work in? What are your responsibilities?	
1.2	**Nature of Organisation**	Probe: Briefly describe your business? What sector or sub-sector do you cover? What is the main product or service you provide?	
1.3	What geographical locations do you cover?	Probe: Local, regional, national, international	
1.4	Size of organisation	How many employees? How many members? How many employees represented by all members?	

Interview background questions

Our model uses five maximum pathways to establish a space within which all potential pathways for decarbonisation can be modelled, so that the skills and training requirement required can be established. These are:

Scenario	Description
Hydrogen led	• Generation, transmission and distribution of affordable hydrogen at scale. • Hydrogen boilers etc. deployed on replacement and in new-build at all buildings on gas main.
Heat pump led	• Natural gas phased out • Negligible contribution from hydrogen • Almost all heating and hot water supplied by heat pumps
Heat networks	• Up to 20% of all heating is provided by heat networks • Heat sourced renewably; remaining 80% delivered direct

Renovation	• Requirement for all existing buildings to improve EPC rating
	• Primarily through improvements to:
	  ○ Insulation
	  ○ Airtightness
	  ○ Glazing
	  ○ Heat recovery

On-site energy	• Rapid deployment of:
	  ○ On-site renewables generation
	  ○ Smart meters
	  ○ Smart storage
	  ○ Smart tariffs
	  ○ Heat as a service
	  ○ Demand management

These pathways encompass:

- new-build
- retrofit
- different rates of decarbonisation
- existing skills
- size of current and future workforce
- just transition

We are looking for any information you can provide on the types of skill, and the number of people with those skills that will be required to deliver these pathways, taking into account the scale of the challenge and the pace of change required, the size and skill-set of the existing workforce, potential for transfer of skills, up-skilling, training requirements and time-scales.

Within the context of decarbonisation of the built environment, which of the following interventions does your organisation cover?

[The following tables set out the structure of the main questions (columns) for each topic (rows). Cells contain example probing questions. The question structure is set out in greater detail at the end of the document.]

2. Building envelope						
Intervention	Y/N	What skills do we already have? Skills / competency verification methods	What new and additional skills are required? Modern Methods of Construction (MMC)	How can we develop the skills required? Preferred approach	What are the barriers to developing these skills? Just transition Upskilling Bottlenecks	What is the role of government? Training Standards Accreditation
Retrofit projects			Retrofit co-ordinator PAS 2035 Energy modelling	How many required?	Co-ordination Competition	
Insulation Lofts Cavity walls Solid walls Floors					Finance	
Airtightness			Testing			
Glazing *Double, triple* *Secondary*						
Heat recovery						

3. Energy sources						
Intervention	Y/N	What skills do we already have? Skills / competency verification methods	What new and additional skills are required?	How can we develop the skills required? Preferred approach	What are the barriers to developing these skills? Just transition Upskilling Bottlenecks	What is the role of government? Training Standards Accreditation
Hydrogen		Gas Safe			Competition	Standardised training programme?
Heat pumps		Plumbers Electricians	Holistic design Retrofit vs. New-build	Quality Assurance Timescale	Brexit Barriers to new entrants? Transfer from e.g. gas	Standardised training programme?
Direct electric heating			Plumbers Electricians			
Solar thermal			Working at heights System integration			
Biogas			Gas Safe			
Heat networks		Current capability Transition to lower-T	Whole system design System integration Civil engineering		Risks from skills gaps Competition	

4. On-site management						
Intervention	Y/N	What new and additional skills are required?	What skills do we already have?	How can we develop the skills required? Preferred approach	What are the barriers to developing these skills? Just transition Upskilling Bottlenecks	What is the role of government? Training Standards Accreditation
Thermal storage Hot water Phase change		System integration				
Heat distribution *Radiators* *Underfloor* *Warm air*		Energy modelling				
On-site generation		Electricians Site design				
Energy management *Smart meters* *BEMS* *Monitoring* *Connectivity*						

Interview - Basic Questions

Aide memoire for each Intervention:

- What skills already exist?
- How many people are currently employed?
- What skills are required?
    - ISCED 2011 education level
- How many more people will be required?
    - Estimate of worker-days per intervention.
- What is needed to develop:
    - Existing skills?
    - New skills?
- How long does it take to train?
    - Retraining cycle
- How are skills currently developed and verified?
    - current role of qualifications, apprenticeships, manufacturers training and competency schemes
    - What resources are available? Are they used?
- What training format is appropriate (preferred method):
    - Manufacturers?
    - Training college?
        - Class size?
    - On the job?
    - Different model?
- What barriers are there to training and deploying enough people?
    - Competition within Construction
    - Competition outside Construction
    - Size of available workforce
        - Trained up through education system
        - Imported
        - Retention, churn, flow of labour
    - Quality of available workforce
    - Appeal of a career in construction
        - Gender
        - Diversity
- Are there sectors with complimentary skills?
- What can government do to help?
    - Policy (education, business, building)
    - Standards
    - Accreditation
    - Support
- What other organisations could be involved?
    - Public procurement (LAs, NHS)
- What can CITB do specifically?
- Reflecting on your answers, what impact do you anticipate CV19 having, specifically on skills development for decarbonisation of the built environment?

Interview - Close

- Ask if respondent has anything else to add.
- Stop recording.
- Thank participant.
- Reassure about confidentiality.
- Explain next steps of project.
- Check whether participant has questions about the project.
- Check okay to follow up.

Qualitative Data Analysis

Once the interviews were complete, the data was processed into a format from which patterns and findings started to emerge. This "thematic analysis" looked across all the interviews to identify the common issues and identify the main themes that summarise the views collected. The transcribed interview scripts, along with interviewee notes, formed the basis of an 'interview matrix'. The data was reorganised and summarised under key headings developed in advance and emerging from fieldwork. The key headings under which data was sorted were:

- Baseline – What skills and capacity already exist?
- Skills and Training – What additional skills and capacity are required?
- Gaps – Where are the gaps in the existing provision?
- Government Support – Current and suggested
- Barriers – New entrants and transferable skills

A.1.4 Interview quotes

This section sets out some representative comments from respondents:

Subject	Quotes
Policy	*"What has hindered retrofit and energy efficiency and all that kind of stuff for ages is inconsistent policy. Previous funding streams have been stopped, they've been started, they've been designed around funding criteria rather than what's required for the building and it's led to a host of horrible installations of stuff that are been rectified now using public cash.."*
	"Even with a policy direction that's very, very clear, I think industry has had its fingers burnt in the past. There would need to be a mechanism, a very real thing that encourages them to do so whether that's the Clean Heat Grant or A. N. Other. The policy needs to be supported by another mechanism and then a pipeline of work. No one's going to go out and spend the time to get trained up if-- I've got two lads that can do this, but nobody's asking for that. "Oh, that was a waste of time."
Retrofit	*"Incentives and a passport system - I think something like that is a really good idea, but also having the visibility of an online passport. That anybody can see, anybody can go on, and see how well performing your home is. There's a ranking system that is really visible as well."*

	"Gap between EPC and net-zero - That's the way the EPC is driving it, though, because it's carbon, it's not fabric. There's a difference, and the government needs to see that. They need to see that there's a difference between the two. Then we've also got health issues in the UK because our homes are too cold or too hot. It's not just about carbon"
	"We need 50,000 people to do the Housing Association, four million stock. I think we need another 50,000 to do the Local Authority stock which is the same. That's 100,000 jobs before we turn to the private sector. I think we need 300,000 to join the private sector. There's 400,000 jobs here, legitimate jobs and that doesn't include the supervision and the monitoring and making sure that performance is right. There is maybe a half a million jobs that we could create, legitimate jobs to add to the current workforce, because we can't afford to take many people from the current workforce that we've got doing repairs and maintenance. That's an ongoing thing forever, because of the stock being so poor."
	"One of our arguments about why we can't use business as usual for retrofit is that there just isn't enough labour. There isn't enough skilled labour to work productively on-site to deliver 27 million housing retrofits in 10 or 20 years"
	"We should bear in mind that most people's base education doesn't really include much work to existing buildings, does it really in terms of the professions, and people work on technical issues behind the desk, or laptop, or whatever. They're not trained much on existing buildings. They're certainly not trained on all the buildings. Most people, the focus of their training is on new construction and of course, new construction is probably just over 50% of work activity. Work for existing buildings isn't too far behind. Everybody will probably end up working on existing buildings and even traditional buildings. Their base education needs to include those types of buildings."
	"On the design side: specialist input to evaluate thermal bridging, buildings services (smart grids, battery storage, PV and ventilation) , overheating assessment, monitoring"
	"That basic knowledge needs to be instilled in virtually every bit of Construction Industry Training. If that isn't done, there's going to be an awful lot of money and carbon wasted on retrofit measures"
	"There is a need for a consistent qualification that applies UK-wide that could then be tailored for local building traditions."
New-build	*"For new build it all needs to come from the top. Planners need to have clear sustainability commitments in the planning requirements (and these need to be the same between authorities). These then need to feed into design where there is a possibility for a climate change co-coordinator role and then this needs to feed down into the site manager."*

Performance gap	*"You wouldn't fly in an aircraft built by the UK Construction Industry."* *"Policy and funding will drive demand, but without reform of the sector, the result will be poor quality interventions which will not be effective."* *"Post-Grenfell, industry has begun to see quality as a benefit rather than a cost, however the "value engineering" approach still means that all possible corners are cut, resulting in least first cost buildings with poor performance and higher operating costs."* *"We've been lobbying for the introduction of a mandatory licensing scheme for construction firms, because they have that in Germany, and in some states in the US...Perhaps then within that, you could write into a CPD requirements or mechanisms to ensure competency. If you said, "Okay, I want to get a license, and I'm the plumber. That means I need to fulfil this competency scheme, which is attached to the license to get it"* *"We need a proper builders' licensing scheme I would say. It's a no brainer in my experience, it's a no brainer. I did some research for the FMB on this a few years ago. You definitely need to bring in licensing. Licensing needs to be backed up by competency testing of a certain kind. That has to be proportionate. In terms of the apprenticeships, then we've continually reduced the number of years somebody has to train as an apprentice. We're down to a level now that people have been taught tasks rather than being educated. We need to extend the duration of apprenticeships so that we are actually properly training people. That's within the government's power. Scotland's apprenticeships are longer than they are in England and Wales, aren't they? Why can't they be the same then across England and Wales in the same way?"* *That's why I believe in licensing to be honest for everybody, because if it's a proper licensing scheme, then it sure could sort all that stuff out."* *"Site managers currently do not require any qualifications so the best way to train them will be to highlight how important it is and then they will incentivised to learn. site managers either come from university or from a trade."*
Oversight	*"An energy assessor, a qualified DEA, it is perfectly possible for some with no professional background in the built environment to do a single week's course and some fairly light touch assessments, then they're a qualified DEA. Unfortunately, I think there's 36,000 qualified DEAs in the country. A huge proportion of those people are fairly low skilled. There are really, really good ones too. I'm not trying to rubbish the profession."* *"historically, Local Authority Building Control officers would provide quality assurance on works being undertaken, particularly if they were physical fabric works. They acted as the QA function in some ways. Every builder, if he was taking a wall down or putting up steelwork, they would come and quality assure that. This quality function has disappeared. It's down to the individual builder now with their liability insurance behind them to deliver to the required quality. In many cases, they have, but in some, they just don't appreciate what they've done. We've lost the Clerk of Works QA function at all levels. On a large building site, maybe that company employees a Clerk of Works, that's fairly easy to address. The retrofit scenario where every home is a site in itself. Wales alone, we'd have one and a half million customers. You can't have one and a half million Clerks of Works. That used to be the council's function in building control, but that's gone. There's a need to bring back some sort of control function. Some of that I guess is through PAS. If we insist, and we use PAS 2035, for example, for retrofit."*

Training	*“Independent Quality Assessor. IQA but that basically is a very, very beefed up Clerk of Works role. We call that the planning supervisor that works on behalf of the client in terms of monitoring the work. But there has been a problem in the past where you've even got Clerk of Works on-site, that the contractor will actually leave all the quality control to the Clerk of Works, whereas the contractor is responsible for quality control.* *That's why it's not just a question of bringing in the Clerk of Works back, you need proper quality management processes. It’s in the way I've described you earlier whereby the Clerk of Works or the Independent Quality Assessor will have a role to play but basically, that role is about checking to make sure that the contractor is actually implementing quality control processes and the contractor is evidencing that the work has been done properly, but also having the option of making their own independent checks if they want to or if they feel the need to.* *That would be a proper quality management system rather than just keeping the system as it is now but sending a Clerk of Works to actually look at the work because some Clerk of Works are not very good to be honest, come across a few who are not that good. We got to bear in mind that there are good and bad in all professions. Some people will take on work because it's work regardless of whether they’re used to that type of work or that type of building, so you got to be mindful of that.* *“On the delivery side: an airtightness or building performance champion that oversees critical work, coordinates testing and training, reactively, to achieve set standards.”* *“I think we're going to have to develop new training courses, we're going to have to develop new NVQs. NVQs are the way. No, don't introduce anything else. National Vocational Qualifications are still relevant in our sector providing that you put that proviso on that you've got to have competency as part of that process. The NVQ without a competency test is useless.”* *“Heat pumps - Training curriculum to upskill installers in heat loss calculations, hydraulic balancing, flow temperature calculations and heating system sizing;”* *“In terms of professional degree courses, et cetera, when they were lined to the construction industry, many of these courses would be accredited by the professional bodies. If the professional bodies got themselves together, and said, these are the areas we want covered, we'll all agree that we'll only accredit courses which have got this sort of content. That's one way in which we can improve the situation because the present situation is just ridiculous. It was often said to me that colleges, universities they're providing- and CITB have always said, we have to listen to what the construction industry says it wants.”* *“Develop skills through a mix of practical (toolbox talks) and more formalised training (CPD’s) models. Verify standards through training centre exams – for skill to be added to CSCS card as extra qualification (badge)? Every site worker has to have a health and safety card, easy to add questions to training exams.”* *"On the job? Yes, critical for subcontractors – imported labour"* *“Who could validate course content? Industry bodies”* *The costs will go up, of course, because they have to be members, but it will become a much more respected trade. It will also instil a sense of quality, "I want to achieve this quality," and being a part of a community that is trying to*

be better, rather than everyone out there for themselves."

"Manufacturer specific training courses – on particular HP installation"

"The apprenticeships had been dumbed down over the last 30 or 40 years to almost meaningless standards. We'd gone from four or five-year apprenticeships down to one-year apprenticeships"

"How are current skills developed? NOS developed, put out to training bodies to develop qualifications – too weak, some training bodies will cut costs and reduce content, deliver online – basic level. If NOS is the skeleton, the industry with support needs to supply the minimum muscles and tissue to ensure a consistent bar is met when training providers provide content, or NOS need to be far more prescriptive."

"I think that we've got to accept the fact that they've got to learn about building science as well. They just haven't got to learn the trade. They got to learn why they're doing what they're doing and the impact of not doing it correctly, what that means."

"Updates every 12 months to maintain designation – encompassing changes to regulations, standards, and any new work in specific field"
"In Wales for example, [there is a] vast array of existing courses and it's about influencing through Qualification Wales, influencing the writers of these qualifications to include decarbonization within them.

The problem often is that qualifications are written and they remain static for years, five years or more. University typically five years before they are rewritten. Things can change a lot in five years. What you find is that they do review the qualifications and they do upgrade them. However it needs more than that. It needs an acceleration program in colleges and universities and the private sector as well, to ensure we have quality people who can specify, design, monitor, manage, as well as all the installation and maintenance people that go with it. Then you have this program on educating the users. It's a huge remit. It really has a huge remit.

Construction Wales Innovation Centre has applied to the Welsh Assembly Government for four low carbon retrofit training centres, as well as wider support to embed decarbonisation technology upskilling into existing Welsh construction training activities (e.g. college/ universities, apprenticeship schemes, and as an additional qualification for the existing trained workforce. These training centres would maximise their impact by focussing on training trainers.

For the Welsh training centres, train the trainer schemes will be important to train people who would then train within that centre, and to cascade it that way. We want all the educators to have gone through train the trainer, and that train the trainers would be different depending on what it is. So rather than an individual super trainer, it will be more about groups of people who are specialists in their own fields. This is seen as a relatively quick model put a train the trainer program in using experts."

"NVQs for various roles don't exist yet. Could be a no-regrets, low-cost intervention "

"A tradesman may build some excellent brickwork, and from the outside, his view of quality is a nice brickwork. What he's missed is on the inside that he's

	bridged a gap. He doesn't appreciate the real impact of that bridging, not just possibly a bit of damp, it's actually a significant thermal bridge problem. An example was quoted during the interviews from a Welsh Government and BRE study on the performance gap of new build, in many cases was 20% of the quoted energy efficiency. In theory, that was an A-rated home, in reality, it was down as a C-rated home. It was due to the quality of the build. The tradesman may be a very good bricklayer or a very good plasterer but, had inadvertently done something that had affected the building itself." *"Perhaps, what often gets forgotten is the interaction of the different measures. We tend to concentrate a lot on the individual skill sets needed for insulation or for heating. Actually, what's important and where we've had problems is quite often a lack of knowledge of the building structure or systems and a lack of knowledge of how they all fit together, where the problems lie, so some form of training around the interaction of all of those. The other thing that I think we always make the mistake of doing is developing energy policy skills, totally in isolation from construction."* *"Covering cost to installer - voucher scheme to help people, installers, get through them. Part of that voucher scheme could be that the installer needs to pay for part of the course to show that they're interested."* *"you need to get trained and have really snappy courses that they don't have to pay for because how on earth are they supposed to afford it"* *"Costs [are] typically ~£500 to £700 for a four-day course. If we can get that whole package down to around about £500 for the week, that would seem workable. Say lost revenue for that week is ~£1,500 total. The total training has cost the installer £2,000. If some of this training could be done online, this could help reduce the lost revenue say if 3 days was in your own time, online and then you're only two days of lost income, that would be a better solution."* *"Small companies do not have the time to send their staff to training sessions when they have delivery pressures and need all hands on deck. When work is down, time is available but money not always. A lot of workers are self-employed, when work is there they are flat out working all hours of the day. Best to do as much of the training at the work place (building sites), in short dedicated toolbox talk training session to avoid down time to travel to training."* *Need to incentives and certifications – "You've got to incentivize it though, that's the thing. The reason they are most trusted is because they have a really good certification body and solid training behind them. If you have that with other builders, a certification. I guess that's where the retrofit coordinator comes in, isn't it? You are then Trustmark approved."*
Pace	*"A 2050 target means that the process needs to be complete by then, at full speed by 2040, and well on the way by 2030, so we have maybe five years to get underway, and we're only just starting to talk about it."*
Finance	*"The current eco funding, which was developed out of consultation protests, works, developed five years ago now wasn't developed that way and it's sort of been retrofitted into it, which is less than ideal. There is a policy, it's not really my job, policy. I don't know what the answers are and we thought Green Deal was an answer or there were lots of-- I don't know the answer to that, but what*

	I do know is that it needs to be consistent and long term. You haven't got the time anymore, if you want to deliver net-zero by 2050, you don't get a chance to cop the policy. You have to get it right this time, and then it has to be consistent. I know the challenges of that with governments changing and thinking of changing, but the mindset of BEIS in particular, is swung wholly around and behind the Whole House Retrofit." *"35-40% of ECO funding never makes it to houses, should be managed by Local Authorities"* *"Remove Energy suppliers from the delivery or influence of the supply chain. They [could] continue to collect the revenue and ALL of this is given back to the government at year end. This is given directly to the LA, HA's who can use 10% of the money to employ skilled surveyors, Clerk of Works to oversee local programmes. This way 90% of the money is used in actual energy efficient measures and 10% upskilling local workers and adding a much needed "on the ground" quality check element in Clerk of the Works. This also puts back around 25% more of the money into measure delivery. Give companies that sponsor apprentice's priority in LA bids, Gov work. Make it a mandatory requirement to take on trainees and train smaller start-ups in larger projects."* *"I'll tell you the biggest thing, the biggest thing you could do for humankind in relation to this is to persuade the government to change the funding model, the valuation model of social housing, because that's the big rub here. That is the thing that makes it very difficult for social housing landlords to get this whole thing to stack up, because social housing is valued at about 60% of market value in terms of the banks, the building societies. Now, it's nonsense. A house is a house. They value it at that because of the tenure that there is, "We've got to fix 10 years for people living in them," but to have a discrepancy of 40% of the value is nonsense… You need to be putting pressure on the banks to start valuing that property at 85% of market value, because at a stroke that would fund the entire retrofit program."*
Procurement	*Clients need training in how to procure off-site manufactured buildings, and how to specify low-carbon and ensure that it is delivered."* *"Procurement should insist of qualified people, minimum % as per PAS 2035, new or refurbishment. Local business's, taking on staff and training should score well. To help smaller business with experience, make the larger projects have a clause to use them as subcontractors managed by the larger company, the larger company then provide the learning / quality control for the smaller businesses, giving them work and the valuable experience at the same time."*
MMC	*"It's not changed since the Egyptians, has it? We put one brick on top of another. Except we do it in the rain."* *"Deskilling for MMC - The thing that enables that is actually because you are deskilling the specific elements of plumbing and electrical wiring…., they moved away from the need for a specific trade specialist like a plumber or electrician and it becomes process-orientated……. make it simple, efficient. and easy to do, so that anyone can do it. That's a key element of how the manufacturing sector actually has moved in the last 40 years in the UK, which is what the construction industry now needs to do as well."*

	"I think there's a multi-tiered approach to how transitional, if that's the right word, how you can transition from trade working into more manufacture led working, what the attributes are you're looking for in people and the aptitude to be able to have that fluid thinking to think differently about what we might need in the future."
Appeal	*"there needs to be a customer (face to face engagement) as a critical part of (the installation) role. There's a communication skills component and then there's the physical install, which is actually making sure it all goes together and it's a high quality and it's commissioned and it works. It creates a really interesting spectrum of different skills that, bearing in mind the nature of the UK building stock, is massive. That role at scale is something which is a huge opportunity for either existing people in the industry or a whole new wave of people that want to get into the industry and do something completely different"*
	"There will be a need to draw in a younger demographic into the workforce"
	"if you look at your heating side of things, you've already got gas installers out there, oil-based system installers, they're already there. That market is aging anyway, so there's something that needs to be done to bring young people into the sector, really appealing to youngsters in getting T-levels, apprenticeships, all of those schemes"
	With a huge imported sub-contractor base as a % of overall workforce, diversity id fit and well as choice based on ability to do the job. When there is a shortage of skilled labour, companies have no interest at all in background, religion, gender, or any other choice an individual makes, it is all about, can he/she do the job."
Coronavirus	*"Companies that were hanging on before Covid will disappear as the outlook was bleak before – no incentive to take a risk. The Gov needs to ramp up the measure delivery, spelling this out ASAP so businesses can take that risk, start up once again and take on and train the resources I needs for the long term. Without an initial, immediate, positive message we could lose 40% + of the industry to other sectors requiring a significant hook to get them back."*

A.1.5 Survey

A small-scale quantitative study was developed through close collaboration with CITB and BEIS to examine the readiness of businesses within the sector to respond to the net-zero challenge.

The principal aim of this task was to help verify the information gathering from the qualitative research, and to verify the extent to which organisations agree with the findings from the interviews.

- Survey questions were developed and fell under the following themes:
- Awareness of net-zero issue
- Decarbonisation training status
- Propensity towards re-training and/or acquiring new skills
- Barriers and gaps – potential solutions
- Path to Net Zero – format of training, accreditation, qualifications levels

The survey was delivered electronically and distributed via the CITB newsletter, website, relevant trade organisations and interviewees who were happy to share the survey.

The survey contained routing to collect data from either self-employed tradespeople or those answering on behalf of an organisation. The data points collected from both sets of questions were the same, to allow cross tabulation upon analysis.

In total, there were 281 responses. Findings from the survey were used throughout the report and a summary of the respondent analytics can be found in Appendix A.1.5.

A.1.5.1 Headline findings of the survey

As with any such survey, the results should be treated with some caution, as surveys tend to be answered by the sort of people who answer surveys; in this case, this may have biased the results towards those that were more engaged and enthusiastic about net.-zero.

The survey highlighted both an interest in decarbonisation and appetite for retraining and upskilling in the field. It was clear that the sector believes it has a good understanding of the importance of decarbonisation and how it will need to change with:

- 75% believing that decarbonisation of the built environment was either very important or important to the company that they worked for, or to themselves when self-employed;
- 70% saying they had a good or very good understanding of how they will need to change as the result of the need to decarbonise the built environment; and
- 78% believing that there is a skills gap in their occupation/profession for decarbonisation work.

The most significant reasons for decarbonisation skills gaps in their professions were listed as lack of training, lack of funding for training, regulation changes and lack of standards.

A high percentage (73%) also believed that they knew the skills they needed to contribute to the decarbonisation of the built environment. Approximately 90% stating they would be willing to re-train, as demand for new roles and skills' changes in the future. A similar percentage were willing to diversify their business offer or profession, for example, changing from a plumber to an electrician. External funding to cover some or all of the cost of training; and receiving an accredited qualification were seen as the most important factors when undertaking decarbonisation retraining or upskill. 40% believing that off-site short duration training was the preferred method of training

delivery, followed by vocational training (27%), online (18%) and apprentice-based learning (15%).

A third of those interviewed stated that their business hasn't to date provided them with any decarbonisation related training. Where training was being provided by their company the most regularly reported areas were in: domestic energy efficiency retrofit; low/zero energy new build, e.g. Passivhaus; and clean heat design, installation or maintenance (e.g. air source heat pumps, biomass). The most common barriers that prevented them from getting training on decarbonisation were: cost of training; lack of time; lack of government funding; and lack of understanding of what net-zero was.

When asked if they had the required skills and knowledge to install, the following measures were the most commonly identified by the respondents: loft, cavity wall, external solid wall, internal wall and floor insulation (solid and suspended), heat pumps and solar thermal. The lowest responses being for hydrogen/ biogas, and heat networks.

Offsite construction and improved whole building post construction testing were seen as the most important non-traditional methods to assist with the transition to decarbonisation of the built environment. With changes to building standards and competency of installers being the key areas to ensure buildings perform to the required standard.

In terms of the best way to address the increased demand for skilled labour in decarbonisation of the built environment the top three areas to target were: existing employees; school leaver/apprenticeships; and female talent. With better training and clearer career progression as the two most significant approaches required to attract more people to address the net-zero skills shortage.

The government and industry association/bodies were clearly identified as those needing to take the lead in addressing any potential skills gaps related to decarbonisation of the built environment.

A.1.5.2 Full survey response

The survey structure asked questions of respondents in their capacity as individuals or on behalf of a business. In the following table the left side contains responses from individuals, with business responses on the right. As the set of questions is otherwise similar, the responses are presented side by side.

Self-employed				Employer		
Q1. Please select the UK Region where you work most of the time.						
Answer Choices	Responses					
East	7.47%	21				
East Midlands	4.63%	13				
London	23.49%	66				
North East	2.14%	6				
North West	11.74%	33				
Northern Ireland	3.20%	9				
Scotland	12.81%	36				
South East	9.25%	26				
South West	9.96%	28				
Wales	6.05%	17				
West Midlands	2.85%	8				
Yorkshire And The Humber	6.41%	18				
	Answered	**281**				
Q2. Please select the category that best describes how you will be answering this questionnaire. If you are currently out of work, please select whichever best describes your normal working status.						
Answer Choices	Responses					
As a self employed tradesperson, or person employed by a company	31.67%	89				
On behalf of a company which employs others in the Construction industry	68.33%	192				
	Answered	**281**				
Q3. What is your occupation/profession?				**Q47. Which of the following occupations/professions are employed by your company? Please select all that apply.**		
Answer Choices	Responses			**Answer Choices**	Responses	
Architect	20.00%	15		**Architect**	27.74%	43
Bricklayer	0.00%	0		**Bricklayer**	21.29%	33
Building envelope specialist	4.00%	3		**Building envelope specialist**	18.06%	28
Civil engineer	2.67%	2		**Civil engineer**	27.10%	42
Construction project manager	6.67%	5		**Construction project manager**	41.29%	64
Construction trades supervisor	1.33%	1		**Construction trades supervisor**	32.26%	50
Electrical trade and installation	0.00%	0		**Electrical trade and installation**	20.65%	32
Floorer	0.00%	0		**Floorer**	8.39%	13
Glazier	1.33%	1		**Glazier**	9.03%	14
Other Labourer	2.67%	2		**Other Labourer**	30.97%	48
Logistics	0.00%	0		**Logistics**	9.68%	15

Self-employed				Employer		
Other Civil engineering operative e.g. road and rail construction operatives, quarry workers	0.00%	0		Non-construction operative e.g. metal working, assemblers, street cleaners, cleaners and domestics.	10.32%	16
Non-construction operative e.g. metal working, assemblers, street cleaners, cleaners and domestics.	0.00%	0		Non-construction professional, technical, IT and other office-based staff e.g. IT technicians, Human Resources personnel, Administrators, Finance and Accounts, Legal	47.10%	73
Non-construction professional, technical, IT and other office-based staff e.g. IT technicians, Human Resources personnel, Administrators, Finance and Accounts, Legal	16.00%	12		Other Civil engineering operative e.g. road and rail construction operatives, quarry workers	8.39%	13
Other Civil engineering operative e.g. road and rail construction operatives, quarry workers	1.33%	1		Other construction process manager e.g. production managers and directors, health and safety officers	32.90%	51
Other construction process manager e.g. production managers and directors, health and safety officers	4.00%	3		Other construction professional and technical staff e.g. mechanical and electrical engineers, engineering technicians, architectural and town planning technicians	32.90%	51
Other construction professional and technical staff e.g. mechanical and electrical engineers, engineering technicians, architectural and town planning technicians	16.00%	12		Other specialist building operative e.g. industrial cleaning processes, construction operatives and skilled trades not already listed	20.65%	32
Other specialist building operative e.g. industrial cleaning processes, construction operatives and skilled trades not already listed	0.00%	0		Painter and decorator	17.42%	27
Painter and decorator	1.33%	1		Plant mechanic/fitter	12.26%	19
Plant mechanic/fitter	0.00%	0		Plant operative	17.42%	27
Plant operative	1.33%	1		Plasterer	18.71%	29
Plasterer	0.00%	0		Plumbing and HVAC Trades	14.19%	22
Plumbing and HVAC Trades	0.00%	0		Roofer	13.55%	21
Roofer	0.00%	0		Scaffolder	9.03%	14
Scaffolder	0.00%	0		Senior, executive, and business process manager	29.03%	45
Senior, executive, and business process manager	6.67%	5		Steel erector/structural fabrication	8.39%	13
Steel erector/structural fabrication	0.00%	0		Surveyor	30.97%	48
Surveyor	8.00%	6		Wood trades and interior fit-out	21.29%	33
Wood trades and interior fit-out	6.67%	5			Answered	155
	Answered	75				

Self-employed				Employer		
Q4. What is your highest level of education?						
Answer Choices	Responses					
Manufacturer training	1.33%	1				
Short duration course	0.00%	0				
NVQ Level 1 equivalent e.g. 3/4 GCSE grades D-G	0.00%	0				
NVQ Level 2 equivalent e.g. 4-5 GCSE grades A*-C	4.00%	3				
NVQ Level 3 equivalent e.g. A Levels, AVCE, BTEC National, Certificate/Diploma, Vocational A-Levels, An ONC (Ordinary National Certificate) and OND (Ordinary National Diploma)	1.33%	1				
NVQ Level 4 equivalent e.g. Higher Education Certificate/BTEC. Full technical certificate, BTEC, HND/HNC	9.33%	7				
NVQ Level 5 equivalent e.g. Higher Education Diploma/Foundation Degree, Level 5 vocational awards, IVQ Advanced Technician Diploma	6.67%	5				
NVQ Level 6 or above	5.33%	4				
Bachelors	29.33%	22				
Masters	28.00%	21				
Doctorate	6.67%	5				
None of the above	1.33%	1				
Other (please specify)	6.67%	5				
	Answered	**75**				
Q5. How many people are employed in company that you work for?				**Q48. How many people are employed at your company?**		
Answer Choices	Responses			**Answer Choices**	Responses	
Self-employed	53.33%	40		**1-9**	23.23%	36
2-9	13.33%	10		**10-24**	16.13%	25
10-24	5.33%	4		**25-49**	12.90%	20
25-49	4.00%	3		**50-99**	8.39%	13
50-99	2.67%	2		**100-249**	12.90%	20
100-249	2.67%	2		**250+**	26.45%	41
250+	18.67%	14			**Answered**	**155**
	Answered	**75**				

Self-employed				Employer		
Q6. What was the annual revenue of the company you work for, or your own self employed revenue, last year?				**Q49. What was the annual revenue for your company last year?**		
Answer Choices	Responses			**Answer Choices**	Responses	
Less than £50K	37.33%	28		**Less than £50K**	3.23%	5
£50K - £99K	18.67%	14		**£50K - £99K**	2.58%	4
£100K - 199K	6.67%	5		**£100K - 199K**	4.52%	7
£200K - £499K	4.00%	3		**£200K - £499K**	8.39%	13
£500 - £999	2.67%	2		**£500 - £999**	7.10%	11
£1M - £1.9M	1.33%	1		**£1M - £1.9M**	9.68%	15
£2M - £4.9M	2.67%	2		**£2M - £4.9M**	10.32%	16
£5M - £9.9M	0.00%	0		**£5M - £9.9M**	10.32%	16
£10M or more	13.33%	10		**£10M or more**	32.26%	50
Unsure	13.33%	10		**Unsure**	11.61%	18
Other (please specify)	0.00%	0			**Answered**	**155**
	Answered	**75**				
Q7. What is the main activity of your company?				**Q46. What is the main activity of your company?**		
Answer Choices	Responses			**Answer Choices**	Responses	
Building completion and finishing	2.67%	2		**Building completion and finishing**	8.39%	13
Specialised construction activities	6.67%	5		**Specialised construction activities**	9.03%	14
Electrical, plumbing and other construction installation activities	1.33%	1		**Electrical, plumbing and other construction installation activities**	3.23%	5
Construction of residential and non-residential buildings	9.33%	7		**Construction of residential and non-residential buildings**	16.77%	26
Construction of roads and railways (and airport runways)	2.67%	2		**Construction of roads and railways (and airport runways)**	2.58%	4
Construction of utility projects	2.67%	2		**Construction of utility projects**	2.58%	4
Construction of other civil engineering projects	0.00%	0		**Construction of other civil engineering projects**	5.16%	8
Demolition and site preparation	0.00%	0		**Demolition and site preparation**	1.94%	3
Development of building projects	4.00%	3		**Development of building projects**	3.23%	5
Retail / hire of construction materials	0.00%	0		**Retail / hire of construction materials**	1.94%	3
Architecture, Planning or Surveying	22.67%	17		**Architecture, Planning or Surveying**	12.26%	19
Engineering or technical consultancy	14.67%	11		**Engineering or technical consultancy**	6.45%	10
Project management	6.67%	5		**Project management**	3.23%	5
None of the above	0.00%	0		**None of the above**	0.00%	0

Self-employed				Employer		
Other (please specify)	26.67%	20		Other (please specify)	23.23%	36
	Answered	75			Answered	155
Q8. In which one of the following disciplines has most of your work been in the last 12 months?				Q50. In which one of the following disciplines has most of your business been in the last 12 months?		
Answer Choices	Responses			Answer Choices	Responses	
Construction - New house building	12.00%	9		Construction - New house building	14.19%	22
Construction - Housing repair, maintenance and improvement, including extensions and loft conversions	14.67%	11		Construction - Housing repair, maintenance and improvement, including extensions and loft conversions	14.19%	22
Construction - Commercial and retail work such as shops, offices and leisure facilities	4.00%	3		Construction - Commercial and retail work such as shops, offices and leisure facilities	10.97%	17
Construction - Industrial work such as factories and warehouses	0.00%	0		Construction - Industrial work such as factories and warehouses	1.94%	3
Construction - Civil engineering and infrastructure projects such as roads, bridges, airports, stadiums etc	5.33%	4		Construction - Civil engineering and infrastructure projects such as roads, bridges, airports, stadiums etc	10.32%	16
Construction - Public sector work specifically health and education facilities	1.33%	1		Construction - Public sector work specifically health and education facilities	4.52%	7
Construction - Historic Buildings (pre 1919)	2.67%	2		Construction - Historic Buildings (pre 1919)	5.81%	9
Construction - Energy efficiency retrofit	10.67%	8		Construction - Energy efficiency retrofit	9.68%	15
Professional - Architects	12.00%	9		Professional - Architects	5.16%	8
Professional - Quantity Surveyors	0.00%	0		Professional - Quantity Surveyors	0.00%	0
Professional - Other surveying	5.33%	4		Professional - Other surveying	1.29%	2
Professional - Building service engineers	1.33%	1		Professional - Building service engineers	0.00%	0
Professional - Planners/town planners	2.67%	2		Professional - Planners/town planners	0.65%	1
Professional - Project Managers	5.33%	4		Professional - Project Managers	0.00%	0
Professional - Multi disciplinary practices	10.67%	8		Professional - Multi disciplinary practices	9.03%	14
Unsure	0.00%	0		Unsure	2.58%	4
Other (please specify)	12.00%	9		Other (please specify)	9.68%	15
	Answered	75			Answered	155
Q9. Are you involved in the following areas of importance for delivering built environment decarbonisation? Please select all that apply.				Q51. Is your company involved in any of the following areas of importance to delivering built environment decarbonisation? Please select all the apply.		
Answer Choices	Responses			Answer Choices	Responses	

Self-employed				Employer		
Domestic energy efficiency retrofit	47.95%	35		Domestic energy efficiency retrofit	41.55%	59
Non-domestic energy efficiency retrofit	34.25%	25		Non-domestic energy efficiency retrofit	35.92%	51
Clean heat design, installation or maintenance (e.g. air source heat pumps, biomass)	21.92%	16		Clean heat design, installation or maintenance (e.g. air source heat pumps, biomass)	28.17%	40
Low/Zero energy new build, e.g. Passivhaus	46.58%	34		Low/Zero energy new build, e.g. Passivhaus	33.10%	47
Heat network design and installation	10.96%	8		Heat network design and installation	15.49%	22
Energy monitoring	26.03%	19		Energy monitoring	26.06%	37
Offsite construction	20.55%	15		Offsite construction	30.99%	44
No, I do not work in any of the above	19.18%	14		No, I do not work in any of the above	20.42%	29
Other. Please provide details of the work that you do.	10.96%	8		Other. Please provide details of the work that you do.	13.38%	19
	Answered	73			Answered	142
Q10. How would you rate your understanding of how you will need to change as the result of the need to decarbonise the built environment?				Q52. How would you rate your understanding of how your business will change as the result of the need to decarbonise the built environment?		
Poor	2.74%	2		Poor	2.11%	3
Deficient	4.11%	3		Deficient	7.75%	11
Fair	23.29%	17		Fair	29.58%	42
Good	32.88%	24		Good	38.03%	54
Very Good	36.99%	27		Very Good	22.54%	32
Total		73		Total	142	
	Answered	73			Answered	142
Q11. How important is decarbonisation of the built environment to the company that you work for, or to yourself as a self employed tradesperson?				Q53. How important is decarbonisation of the built environment to the company that you work for, or to yourself as a self employed tradesperson?		
Not important at all	2.74%	2		Not important at all	2.11%	3
Slightly important	2.74%	2		Slightly important	4.93%	7
Moderately important	19.18%	14		Moderately important	17.61%	25
Important	19.18%	14		Important	23.94%	34
Very important	56.16%	41		Very important	51.41%	73
Total		73		Total		142
	Answered	73			Answered	142

Self-employed			Employer		
Q12. Are you aware of what skills you will need to help you contribute to the decarbonisation of the built environment?			**Q54. Are you aware of what skills your business will need to help you contribute to the decarbonisation of the built environment?**		
Answer Choices	Responses		**Answer Choices**	Responses	
Yes	79.45%	58	**Yes**	69.72%	99
No	20.55%	15	**No**	30.28%	43
	Answered	**73**		**Answered**	**142**
Q13. Have you received training in any areas of decarbonisation? Please select the area(s) of training that you have completed.			**Q55. Does the company you work for provide training on any areas of decarbonisation? Please select the area(s) of training that you have provided.**		
Answer Choices	Responses		**Answer Choices**	Responses	
Domestic energy efficiency retrofit	50.68%	37	**Domestic energy efficiency retrofit**	33.10%	47
Non-domestic energy efficiency retrofit	24.66%	18	**Non-domestic energy efficiency retrofit**	21.83%	31
Clean heat design, installation or maintenance (e.g. air source heat pumps, biomass)	21.92%	16	**Clean heat design, installation or maintenance (e.g. air source heat pumps, biomass)**	19.01%	27
Low/Zero energy new build, e.g. Passivhaus	41.10%	30	**Low/Zero energy new build, e.g. Passivhaus**	22.54%	32
Heat network design and installation	8.22%	6	**Heat network design and installation**	7.04%	10
Energy monitoring	17.81%	13	**Energy monitoring**	14.08%	20
Offsite construction	20.55%	15	**Offsite construction**	15.49%	22
I have not received any training	21.92%	16	**We do not provide any training**	40.85%	58
Other (please specify)	16.44%	12	**Other (please specify)**	15.49%	22
	Answered	**73**		**Answered**	**142**
Q14. What factors influenced your decision to get training for decarbonisation? Please select all that apply.			**Q56. What influenced your decision provide training for decarbonisation to your employees? Please select all that apply.**		
Answer Choices	Responses		**Answer Choices**	Responses	
Increasing demand from employees	1.75%	1	**Increasing demand from employees**	24.14%	21
Increasing demand from customers	19.30%	11	**Increasing demand from customers**	43.68%	38
Awareness of climate change and its impacts	71.93%	41	**Awareness of climate change and its impacts**	67.82%	59
Government funding	12.28%	7	**Government funding**	12.64%	11
Recognise a market opportunity	42.11%	24	**Recognise a market opportunity**	45.98%	40

Self-employed				Employer		
Identified skills gaps	38.60%	22		Identified skills gaps	42.53%	37
Changing building standards or regulations	38.60%	22		Changing building standards or regulations	41.38%	36
Other (please specify)	12.28%	7		Other (please specify)	9.20%	8
	Answered	57			Answered	87
Q15. Were there any barriers that prevented you from getting training for decarbonisation? Please select all that apply.				Q57. Were there any barriers that prevented you from providing training for decarbonisation? Please select all that apply.		
Answer Choices	Responses			Answer Choices	Responses	
Cost of training	35.71%	5		Cost of training	35.29%	6
Lack of time	57.14%	8		Lack of time	41.18%	7
Lack of government funding	21.43%	3		Lack of government funding	41.18%	7
Lack of interest	7.14%	1		Lack of interest	5.88%	1
Don't see any potential for improvement to salary	7.14%	1		Don't see any potential for improvement to salary	5.88%	1
Don't see any potential for improvement to career opportunities	7.14%	1		Don't see any potential for improvement to career opportunities	5.88%	1
Lack of status in industry	14.29%	2		Lack of status in industry	17.65%	3
Lack of accreditation	0.00%	0		Lack of accreditation	5.88%	1
Lack of understanding of what net-zero is	21.43%	3		Lack of understanding of what net-zero is	47.06%	8
	Answered	14			Answered	17
Q16. Have you needed to reskill/retrain in the last 5 years (with regard to all training, not specific to decarbonisation)?				Q58. Have you needed to reskill/retrain your employees within the last 5 years (with regard to all training, not specific to decarbonisation)?		
Answer Choices	Responses			Answer Choices	Responses	
Yes	49.30%	35		Yes	73.79%	76
No	50.70%	36		No	26.21%	27
	Answered	71			Answered	103
Q17. What type of training did you complete to reskill/retrain? Please select all that apply.				Q59. What type of training did they complete to reskill/retrain? Please select all that apply.		
Answer Choices	Responses			Answer Choices	Responses	
Manufacturer training	14.29%	5		Manufacturer training	24.00%	18
Short duration course	42.86%	15		Short duration course	72.00%	54
NVQ Level 1 equivalent e.g. 3/4 GCSE grades D-G	0.00%	0		NVQ Level 1 equivalent e.g. 3/4 GCSE grades D-G	8.00%	6
NVQ Level 2 equivalent e.g. 4-5 GCSE grades A*-C	2.86%	1		NVQ Level 2 equivalent e.g. 4-5 GCSE grades A*-C	24.00%	18

Self-employed				Employer		
NVQ Level 3 equivalent e.g. A Levels, AVCE, BTEC National, Certificate/Diploma, Vocational A-Levels, An ONC (Ordinary National Certificate) and OND (Ordinary National Diploma)	2.86%	1		NVQ Level 3 equivalent e.g. A Levels, AVCE, BTEC National, Certificate/Diploma, Vocational A-Levels, An ONC (Ordinary National Certificate) and OND (Ordinary National Diploma)	22.67%	17
NVQ Level 4 equivalent e.g. Higher Education Certificate/BTEC. Full technical certificate, BTEC, HND/HNC	0.00%	0		NVQ Level 4 equivalent e.g. Higher Education Certificate/BTEC. Full technical certificate, BTEC, HND/HNC	18.67%	14
NVQ Level 5 equivalent e.g. Higher Education Diploma/Foundation Degree, Level 5 vocational awards, IVQ Advanced Technician Diploma	20.00%	7		NVQ Level 5 equivalent e.g. Higher Education Diploma/Foundation Degree, Level 5 vocational awards, IVQ Advanced Technician Diploma	16.00%	12
NVQ Level 6 or above	11.43%	4		NVQ Level 6 or above	9.33%	7
Bachelors	5.71%	2		Bachelors	10.67%	8
Masters	8.57%	3		Masters	13.33%	10
Doctorate	2.86%	1		Doctorate	5.33%	4
Other (please specify)	25.71%	9		None of the above	5.33%	4
	Answered	35		Other (please specify)	16.00%	12
					Answered	75
Q18. Through which training provider was the course delivered?				Q60. Through which training provider was the course delivered?		
Answer Choices	Responses			Answer Choices	Responses	
Work based/In-house course	25.71%	9		Work based/In-house course	30.67%	23
College	22.86%	8		College	13.33%	10
Private provider	42.86%	15		Private provider	33.33%	25
Manufacturer	8.57%	3		Manufacturer	4.00%	3
	Answered	35		Other (please specify)	18.67%	14
					Answered	75
Q19. Would you be willing to re-train, as demand for new roles and skills changes in the future?				Q61. Would you be willing to re-train your employees, as demand for new roles and skills changes in the future?		
Answer Choices	Responses			Answer Choices	Responses	
Yes	86.67%	52		Yes	96.70%	88
No, please provide details why not	13.33%	8		No, please provide details why not	3.30%	3
	Answered	60			Answered	91

Self-employed				Employer		
Q20. Would you be willing to diversify your business offer or profession, as demand for new roles and skills changes in the future? For example, changing from a plumber to an electrician.				**Q62. Would you be willing to diversify your business offer, as demand for new roles and skills changes in the future?**		
Answer Choices	Responses			**Answer Choices**	Responses	
Yes	81.67%	49		**Yes**	93.41%	85
No, please provide details why not	18.33%	11		**No, please provide details why not**	6.59%	6
	Answered	**60**			**Answered**	**91**
Q21. Which of the following measures do you feel you currently have the required skills and knowledge to install? Please select all that apply.				**Q63. Which of the following measures do you feel your employees have the required skills and knowledge to install? Please select all that apply.**		
Answer Choices	Responses			**Answer Choices**	Responses	
Loft insulation	48.33%	29		**Loft insulation**	42.86%	39
Cavity wall insulation	25.00%	15		**Cavity wall insulation**	28.57%	26
External Solid wall insulation	31.67%	19		**External Solid wall insulation**	41.76%	38
High-rise cladding	8.33%	5		**High-rise cladding**	16.48%	15
Internal wall insulation	33.33%	20		**Internal wall insulation**	45.05%	41
Floor insulation (solid and suspended)	38.33%	23		**Floor insulation (solid and suspended)**	41.76%	38
Glazing	21.67%	13		**Glazing**	28.57%	26
Hydrogen, biogas	1.67%	1		**Hydrogen, biogas**	5.49%	5
Direct electric heating	5.00%	3		**Direct electric heating**	18.68%	17
Heat pumps	18.33%	11		**Heat pumps**	30.77%	28
Heat networks	6.67%	4		**Heat networks**	14.29%	13
Thermal storage	16.67%	10		**Thermal storage**	18.68%	17
Heat distribution	8.33%	5		**Heat distribution**	15.38%	14
On-site generation	10.00%	6		**On-site generation**	17.58%	16
Smart systems	13.33%	8		**Smart systems**	16.48%	15
Solar thermal	23.33%	14		**Solar thermal**	25.27%	23
Airtightness and heat recovery	33.33%	20		**Airtightness and heat recovery**	30.77%	28
Other (please specify)	45.00%	27		**Other (please specify)**	38.46%	35
	Answered	**60**			**Answered**	**91**

Self-employed				Employer		
Q22. What factors would be important to you, if you were to retrain or upskill to a install a new measure in the future? Please select all that apply.				**Q64. What factors would be important to you, if you were to retrain or upskill employees to install a new measure in the future? Please select all that apply.**		
Answer Choices	Responses			**Answer Choices**	Responses	
Cost of training	71.67%	43		**Cost of training**	62.64%	57
Builds on existing skills	58.33%	35		**Builds on existing skills**	53.85%	49
Within the local area geographically	40.00%	24		**Within the local area geographically**	45.05%	41
Availability of online training	55.00%	33		**Availability of online training**	47.25%	43
Duration of training	40.00%	24		**Duration of training**	48.35%	44
Accredited qualification	65.00%	39		**Accredited qualification**	63.74%	58
Other (please specify)	10.00%	6		**Other (please specify)**	15.38%	14
	Answered	**60**			**Answered**	**91**
Q23. How interested would you be in completing training for decarbonisation?				**Q65. How interested would you be in offering training for decarbonisation to your employees?**		
Not at all interested	3.33%	2		**Not at all interested**	1.10%	1
Not really interested	3.33%	2		**Not really interested**	3.30%	3
Neutral	15.00%	9		**Neutral**	10.99%	10
Somewhat interested	26.67%	16		**Somewhat interested**	32.97%	30
Very interested	51.67%	31		**Very interested**	51.65%	47
Total		60		**Total**		91
	Answered	**60**			**Answered**	**91**
Q24. How easy or difficult do you think it would be to learn the skills needed for decarbonisation?				**Q66. How easy or difficult do you think it would be for your employees to take on the skills needed for decarbonisation?**		
Very difficult	3.33%	2		**Very difficult**	2.20%	2
Quite difficult	15.00%	9		**Quite difficult**	10.99%	10
Neutral	31.67%	19		**Neutral**	32.97%	30
Quite easy	30.00%	18		**Quite easy**	37.36%	34
Very easy	20.00%	12		**Very easy**	16.48%	15
Total		60		**Total**		91
	Answered	**60**			**Answered**	**91**
Q25. Who do you think should be responsible for keeping skills updated?				**Q67. Who do you think should be responsible for keeping skills updated?**		
Answer Choices	Responses			**Answer Choices**	Responses	
Self-employed				**Employer**		
Individual workers	33.33%	20		**Individual workers**	18.68%	17

Employers	30.00%	18		**Employers**	67.03%	61
Government	25.00%	15		**Government**	7.69%	7
Other (please specify)	11.67%	7		**Other (please specify)**	6.59%	6
	Answered	**60**			**Answered**	**91**
Q26. In addition to your technical skills, what are the top 3 soft skills that are needed to work in your profession?				**Q68. In addition to the technical skills, what are the top 3 soft skills that are needed to work in the area in which your company operates?**		
Answer Choices	Responses			**Answer Choices**	Responses	
Problem-solving	71.67%	43		**Problem-solving**	56.04%	51
Communication skills	58.33%	35		**Communication skills**	54.95%	50
Building relationships and a reputation in a team environment	25.00%	15		**Building relationships and a reputation in a team environment**	30.77%	28
Influencing skills	8.33%	5		**Influencing skills**	16.48%	15
Commercial awareness	23.33%	14		**Commercial awareness**	24.18%	22
Organisation and time management	26.67%	16		**Organisation and time management**	26.37%	24
Adaptability and flexibility	36.67%	22		**Adaptability and flexibility**	34.07%	31
Creativity and innovation	30.00%	18		**Creativity and innovation**	31.87%	29
Digital skills	11.67%	7		**Digital skills**	16.48%	15
Entrepreneurial skills	3.33%	2		**Entrepreneurial skills**	3.30%	3
Conflict management	5.00%	3		**Conflict management**	5.49%	5
	Answered	**60**			**Answered**	**91**
Q27. To help deliver decarbonisation work, what are the top 3 soft skills that you think you would need to develop/improve in your profession?				**Q69. To help deliver decarbonisation of the built environment, what are the top 3 soft skills that you think you would need to develop/improve in your profession?**		
Answer Choices	Responses			**Answer Choices**	Responses	
Problem-solving	41.67%	25		**Problem-solving**	40.66%	37
Communication skills	36.67%	22		**Communication skills**	38.46%	35
Building relationships and a reputation in a team environment	18.33%	11		**Building relationships and a reputation in a team environment**	28.57%	26
Influencing skills	36.67%	22		**Influencing skills**	32.97%	30
Commercial awareness	41.67%	25		**Commercial awareness**	25.27%	23
Organisation and time management	16.67%	10		**Organisation and time management**	15.38%	14
Adaptability and flexibility	43.33%	26		**Adaptability and flexibility**	40.66%	37
Creativity and innovation	35.00%	21		**Creativity and innovation**	40.66%	37
Digital skills	13.33%	8		**Digital skills**	19.78%	18
Self-employed				**Employer**		
Entrepreneurial skills	11.67%	7		**Entrepreneurial skills**	8.79%	8

Conflict management	5.00%	3		**Conflict management**	8.79%	8
	Answered	**60**			**Answered**	**91**
Q28. Do you believe there is a skills gap in your occupation/profession for decarbonisation work?				**Q70. Do you believe there is a skills gap in your occupation/profession for decarbonisation work?**		
Answer Choices	Responses			**Answer Choices**	Responses	
No	20.34%	12		**No**	23.33%	21
Yes, please specify the occupation and the skills that are missing.	79.66%	47		**Yes, please specify the occupation and the skills that are missing.**	76.67%	69
	Answered	**59**			**Answered**	**90**
Q29. What do you feel are the main reasons for any decarbonisation skills gaps in your profession? Please select all that apply.				**Q71. What do you feel are the main reasons for any decarbonisation skills gaps in your sector? Please select all that apply.**		
Answer Choices	Responses			**Answer Choices**	Responses	
Ageing and retiring workforce	21.28%	10		**Ageing and retiring workforce**	30.00%	27
Lack of apprenticeship opportunities	27.66%	13		**Lack of apprenticeship opportunities**	24.44%	22
Lack of talent familiar with new automation and digitalisation technology	8.51%	4		**Lack of talent familiar with new automation and digitalisation technology**	15.56%	14
Lack of long term career stability	23.40%	11		**Lack of long term career stability**	22.22%	20
Lack of accreditations	19.15%	9		**Lack of accreditations**	18.89%	17
Lack of standards	38.30%	18		**Lack of standards**	34.44%	31
Lack of training	51.06%	24		**Lack of training**	37.78%	34
Lack of career path	10.64%	5		**Lack of career path**	20.00%	18
Regulation changes	29.79%	14		**Regulation changes**	25.56%	23
Lack of funding for training	57.45%	27		**Lack of funding for training**	34.44%	31
Existing prejudice within the industry makes it unappealing	34.04%	16		**Existing prejudice within the industry makes it unappealing**	17.78%	16
Lack of interest in adapting to new technologies or methods of working	57.45%	27		**Lack of interest in adapting to new technologies or methods of working**	30.00%	27
Lack of demand for net-zero skills	42.55%	20		**Lack of demand for net-zero skills**	32.22%	29
Other (please specify)	23.40%	11		**Other (please specify)**	16.67%	15
	Answered	**47**			**Answered**	**90**

Self-employed				Employer		
Q30. How would you best resolve any potential skills gaps related to decarbonisation of the built environment?				**Q72. How would your company best resolve any potential skills gaps related to decarbonisation of the built environment?**		
Only by retraining	10.64%	5		**Only by retraining**	7.78%	7
Mainly by retraining	40.43%	19		**Mainly by retraining**	37.78%	34
Equal mix hiring and retraining	46.81%	22		**Equal mix hiring and retraining**	47.78%	43
Mainly by hiring	2.13%	1		**Mainly by hiring**	5.56%	5
Only by hiring	0.00%	0		**Only by hiring**	1.11%	1
Total		47		**Total**		90
	Answered	**47**			**Answered**	**91**
Q31. Which of the following would be the best way to address the increased demand for skilled labour in decarbonisation of the built environment? Please select all that apply.				**Q73. Which of the following would be the best way to address the increased demand for skilled labour in decarbonisation of the built environment? Please select all that apply.**		
Answer Choices	Responses			**Answer Choices**	Responses	
Artificial Intelligence and automation	17.86%	10		**Artificial Intelligence and automation**	13.48%	12
School leavers - apprenticeships	69.64%	39		**School leavers - apprenticeships**	60.67%	54
Female talent	53.57%	30		**Female talent**	37.08%	33
Graduates	48.21%	27		**Graduates**	35.96%	32
Recruit from other sectors	46.43%	26		**Recruit from other sectors**	37.08%	33
Overseas talent	7.14%	4		**Overseas talent**	11.24%	10
Existing employees	64.29%	36		**Existing employees**	64.04%	57
Sub-contractors	23.21%	13		**Sub-contractors**	38.20%	34
Other (please specify)	19.64%	11		**Other (please specify)**	14.61%	13
	Answered	**56**			**Answered**	**89**
Q32. How would you attract more people to address the net-zero skills shortage? Please select all that apply.				**Q74. How would you attract more people to address the net-zero skills shortage? Please select all that apply.**		
Answer Choices	Responses			**Answer Choices**	Responses	
Better training	78.57%	44		**Better training**	69.66%	62
Clearer career progression	53.57%	30		**Clearer career progression**	55.06%	49
Introduce Diversity policies	19.64%	11		**Introduce Diversity policies**	14.61%	13
Increase renumeration and benefits packages	37.50%	21		**Increase renumeration and benefits packages**	23.60%	21
Mentorship schemes	44.64%	25		**Mentorship schemes**	33.71%	30
More efficient working practices	48.21%	27		**More efficient working practices**	33.71%	30
Self-employed				Employer		
Partnerships with trainers	46.43%	26		**Partnerships with trainers**	26.97%	24

Improve working conditions by using Modern Methods of Construction (MMC)	44.64%	25	**Improve working conditions by using Modern Methods of Construction (MMC)**	19.10%	17
Other (please specify)	21.43%	12	**Other (please specify)**	15.73%	14
	Answered	**56**		**Answered**	**89**
Q33. Who do you think should take the lead in addressing any potential skills gaps related to decarbonisation of the built environment?			**Q75. Which of the following groups or institutions should take the lead in addressing any potential skills gaps related to decarbonisation of the built environment?**		
Answer Choices	Responses		**Answer Choices**	Responses	
Government	50.00%	28	**Government**	52.81%	47
Industry associations and bodies	26.79%	15	**Industry associations and bodies**	26.97%	24
Individual workers	3.57%	2	**Individual workers**	2.25%	2
Individual businesses	7.14%	4	**Individual businesses**	8.99%	8
Higher Education	7.14%	4	**Higher Education**	4.49%	4
Secondary schools	0.00%	0	**Secondary schools**	3.37%	3
Further education colleges	5.36%	3	**Further education colleges**	1.12%	1
	Answered	**56**		**Answered**	**89**
Q34. What level of training would you expect to be required to work in decarbonisation measures?			**Q76. What level of training would you expect to be required to work in decarbonisation measures?**		
Answer Choices	Responses		**Answer Choices**	Responses	
Manufacturer training	5.66%	3	**Manufacturer training**	6.41%	5
Short duration course	9.43%	5	**Short duration course**	19.23%	15
NVQ Level 1 equivalent e.g. 3/4 GCSE grades D-G	3.77%	2	**NVQ Level 1 equivalent e.g. 3/4 GCSE grades D-G**	3.85%	3
NVQ Level 2 equivalent e.g. 4-5 GCSE grades A*-C	5.66%	3	**NVQ Level 2 equivalent e.g. 4-5 GCSE grades A*-C**	16.67%	13
NVQ Level 3 equivalent e.g. A Levels, AVCE, BTEC National, Certificate/Diploma, Vocational A-Levels, An ONC (Ordinary National Certificate) and OND (Ordinary National Diploma)	15.09%	8	**NVQ Level 3 equivalent e.g. A Levels, AVCE, BTEC National, Certificate/Diploma, Vocational A-Levels, An ONC (Ordinary National Certificate) and OND (Ordinary National Diploma)**	15.38%	12
NVQ Level 4 equivalent e.g. Higher Education Certificate/BTEC. Full technical certificate, BTEC, HND/HNC	9.43%	5	**NVQ Level 4 equivalent e.g. Higher Education Certificate/BTEC. Full technical certificate, BTEC, HND/HNC**	5.13%	4

Self-employed				Employer		
NVQ Level 5 equivalent e.g. Higher Education Diploma/Foundation Degree, Level 5 vocational awards, IVQ Advanced Technician Diploma	7.55%	4		NVQ Level 5 equivalent e.g. Higher Education Diploma/Foundation Degree, Level 5 vocational awards, IVQ Advanced Technician Diploma	3.85%	3
NVQ Level 6 or above	3.77%	2		NVQ Level 6 or above	1.28%	1
Bachelors	5.66%	3		Bachelors	6.41%	5
Masters	3.77%	2		Masters	0.00%	0
Doctorate	0.00%	0		Doctorate	0.00%	0
None of the above	5.66%	3		None of the above	0.00%	0
Other (please specify)	24.53%	13		Other (please specify)	21.79%	17
	Answered	53			Answered	78
Q35. In addition to training, what else would help ensure required standards are met to deliver the decarbonisation of the built environment? Please select all that apply.				Q77. In addition to training, what else would help ensure required standards are met to deliver the decarbonisation of the built environment? Please select all that apply.		
Answer Choices	Responses			Answer Choices	Responses	
Membership of a trade association	43.40%	23		Membership of a trade association	29.49%	23
Continuous updating of skills through regulated certification e.g. Wiring Regulations	60.38%	32		Continuous updating of skills through regulated certification e.g. Wiring Regulations	44.87%	35
Industry-set base level of qualification required for decarbonisation work	62.26%	33		Industry-set base level of qualification required for decarbonisation work	66.67%	52
Previous experience of working in the field.	26.42%	14		Previous experience of working in the field	25.64%	20
Other (please specify)	22.64%	12		Other (please specify)	11.54%	9
	Answered	53			Answered	78
Q36. What would incentivise you to receive further training on decarbonisation? Please select all that apply.				Q78. What would incentivise you to provide further training on decarbonisation to your employees? Please select all that apply.		
Answer Choices	Responses			Answer Choices	Responses	
Financial compensation for loss of earnings	30.19%	16		Financial compensation for loss of earnings	24.36%	19
Funding from external source to contribute towards training cost (in part)	56.60%	30		Funding from external source to contribute towards training cost (in part)	42.31%	33
Funding from external source to pay for training (in full)	58.49%	31		Funding from external source to pay for training (in full)	58.97%	46
Formally recognised qualification	77.36%	41		Formally recognised qualification	55.13%	43
Other (please specify)	15.09%	8		Other (please specify)	7.69%	6
	Answered	53			Answered	78

Self-employed				Employer		
Q37. From which provider would you prefer to receive any decarbonisation training in the future?				**Q79. From which provider do you think decarbonisation training in the future should be delivered?**		
Answer Choices	Responses			**Answer Choices**	Responses	
In-house	5.66%	3		**In-house**	11.54%	9
Manufacturer based	7.55%	4		**Manufacturer based**	19.23%	15
Private training provider	30.19%	16		**Private training provider**	25.64%	20
Colleges	13.21%	7		**Colleges**	19.23%	15
Further education colleges	16.98%	9		**Further education colleges**	24.36%	19
Other (please specify)	26.42%	14			**Answered**	**78**
	Answered	**53**				
Q38. In which format would you prefer to receive training?				**Q80. In which format would you prefer to deliver training?**		
Answer Choices	Responses			**Answer Choices**	Responses	
Apprentice-based learning	5.66%	3		**Apprentice-based learning**	20.51%	16
Off-site short duration training	43.40%	23		**Off-site short duration training**	38.46%	30
Vocational learning	22.64%	12		**Vocational learning**	29.49%	23
Online	28.30%	15		**Online**	11.54%	9
	Answered	**53**			**Answered**	**78**
Q39. Why would this training format be preferable to you?				**Q81. Why would this training format be preferable to you?**		
Answered	**53**			**Answered**	**78**	
Q40. How important to you is accreditation from a recognised provider when considering training options?				**Q82. How important to you is accreditation from a recognised provider when considering training options?**		
Not important at all	1.89%	1		**Not important at all**	3.85%	3
Slightly important	3.77%	2		**Slightly important**	2.56%	2
Moderately important	24.53%	13		**Moderately important**	17.95%	14
Important	39.62%	21		**Important**	52.56%	41
Very important	30.19%	16		**Very important**	23.08%	18
Total		53		**Total**		78
	Answered	**53**			**Answered**	**78**

Self-employed				Employer		
Q41. What is the maximum amount (£'s) you would spend on retraining, if you knew there was a demand for such skills within your sector?				**Q83. What is the maximum amount (£'s) you would spend on retraining per employee, if you knew there was a demand for such skills within your sector?**		
Answered	**53**			**Answered**	**78**	
Average	**£596.13**			**Average**	**£1,019.25**	
Q42. How long would you be willing to spend retraining to deliver decarbonisation of the built environment?				**Q84. How long would you be willing to spend retraining to deliver decarbonisation of the built environment?**		
Answer Choices	Responses			**Answer Choices**	Responses	
A couple of days	1.89%	1		**A couple of days**	16.67%	13
Up to a week	16.98%	9		**Up to a week**	16.67%	13
1-2 weeks	18.87%	10		**1-2 weeks**	16.67%	13
Up to 1 month	13.21%	7		**Up to 1 month**	7.69%	6
Longer than 1 month	26.42%	14		**Longer than 1 month**	23.08%	18
Other (please specify)	22.64%	12		**Other (please specify)**	19.23%	15
	Answered	**53**			**Answered**	**78**
Q43. Which would be the best way to develop training for decarbonisation of the built environment?				**Q85. Which would be the best way to develop training for decarbonisation of the built environment?**		
Answer Choices	Responses			**Answer Choices**	Responses	
Design an entirely new course	62.26%	33		**Design an entirely new course**	60.26%	47
Update existing training. Please specify which occupation this applies to.	37.74%	20		**Update existing training. Please specify which occupation this applies to.**	39.74%	31
	Answered	**53**			**Answered**	**78**
Q44. Which of the following non-traditional methods do you think could assist with the transition to decarbonisation of the built environment? Please select all that apply.				**Q86. Which of the following non-traditional methods do you think could assist with the transition to decarbonisation of the built environment? Please select all that apply.**		
Answer Choices	Responses			**Answer Choices**	Responses	
Offsite construction	66.04%	35		**Offsite construction**	61.54%	48
Improved surveying technology	45.28%	24		**Improved surveying technology**	28.21%	22
Improved whole building post construction testing	81.13%	43		**Improved whole building post construction testing**	64.10%	50
Digital twins/BIM	30.19%	16		**Digital twins/BIM**	32.05%	25
Platform construction	16.98%	9		**Platform construction**	14.10%	11
Other (please specify)	26.42%	14		**Other (please specify)**	17.95%	14
	Answered	**53**			**Answered**	**78**

Self-employed				Employer		
Q45. If a property were to get a full retrofit, or there was a new build construction built to net-zero standards, what is the main change you would make to the way things are done today to ensure buildings perform to the required standard?				**Q87. If a property were to get a full retrofit, or there was a new build construction built to net-zero standards, what is the main change you would make to the way things are done today to ensure buildings perform to the required standard?**		
Answer Choices	Responses			**Answer Choices**	Responses	
Changes to contract	3.77%	2		**Changes to contract**	17.95%	14
Changes to oversight	3.77%	2		**Changes to oversight**	2.56%	2
Competency of installers	18.87%	10		**Competency of installers**	25.64%	20
Changes to business models	5.66%	3		**Changes to business models**	10.26%	8
Changes to building standards	52.83%	28		**Changes to building standards**	33.33%	26
Changes to accreditation standards	0.00%	0		**Changes to accreditation standards**	2.56%	2
Other (please specify)	15.09%	8		**Other (please specify)**	7.69%	6
	Answered	**53**			**Answered**	**78**

A.1.5.3 Respondent profiles

This section profiles the respondents to the survey. It will profile respondents by region, employment type, construction industry typology, company size (revenue) and the main activities and recent disciplines of the companies represented.

Figure A1.2 – Geographical profile of the companies represented by respondents to the CITB Building Skills for Net Zero Survey

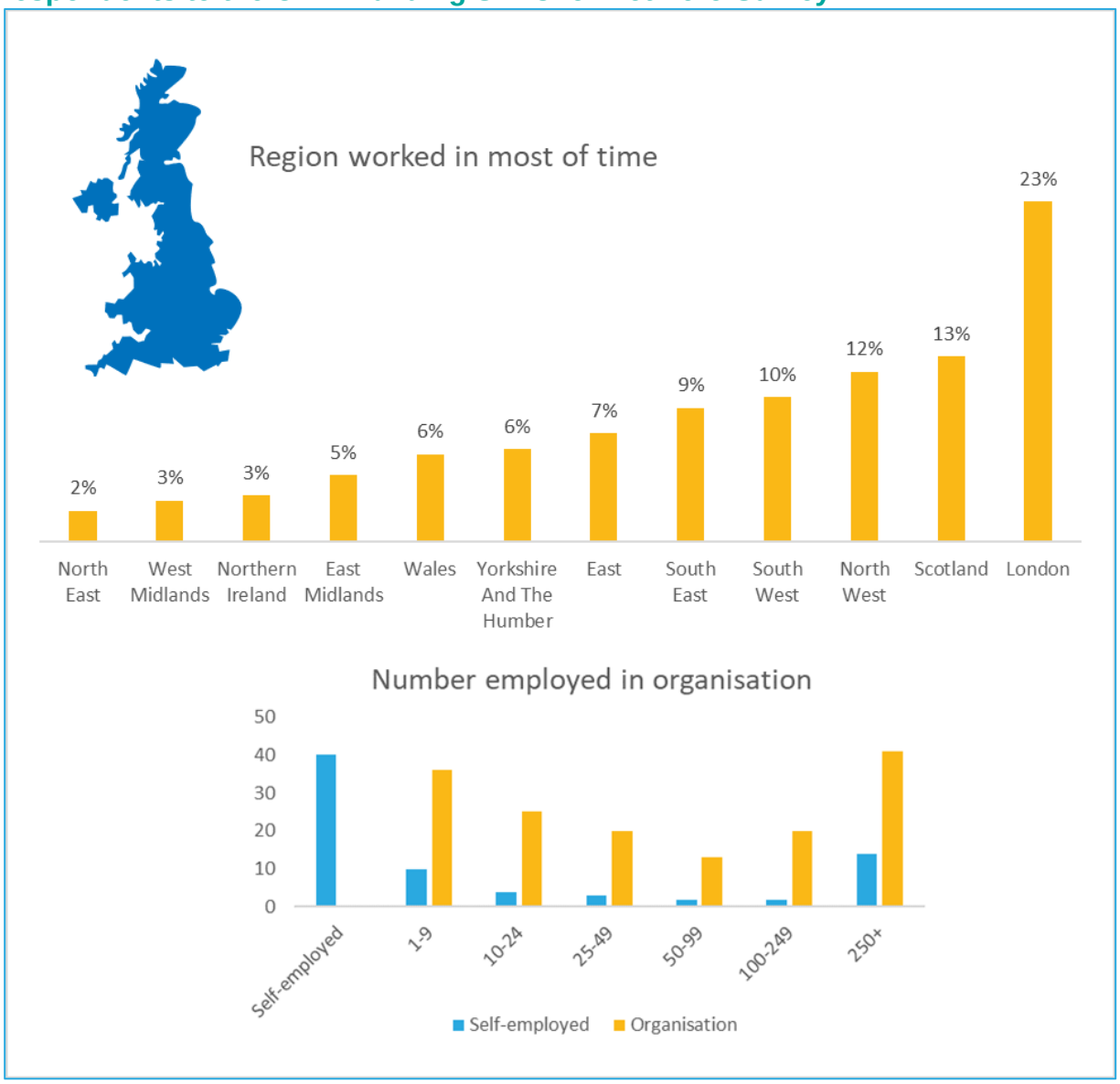


Figure A1.3 – Professional profile of the companies represented by respondents to the CITB Building Skills for Net Zero Survey

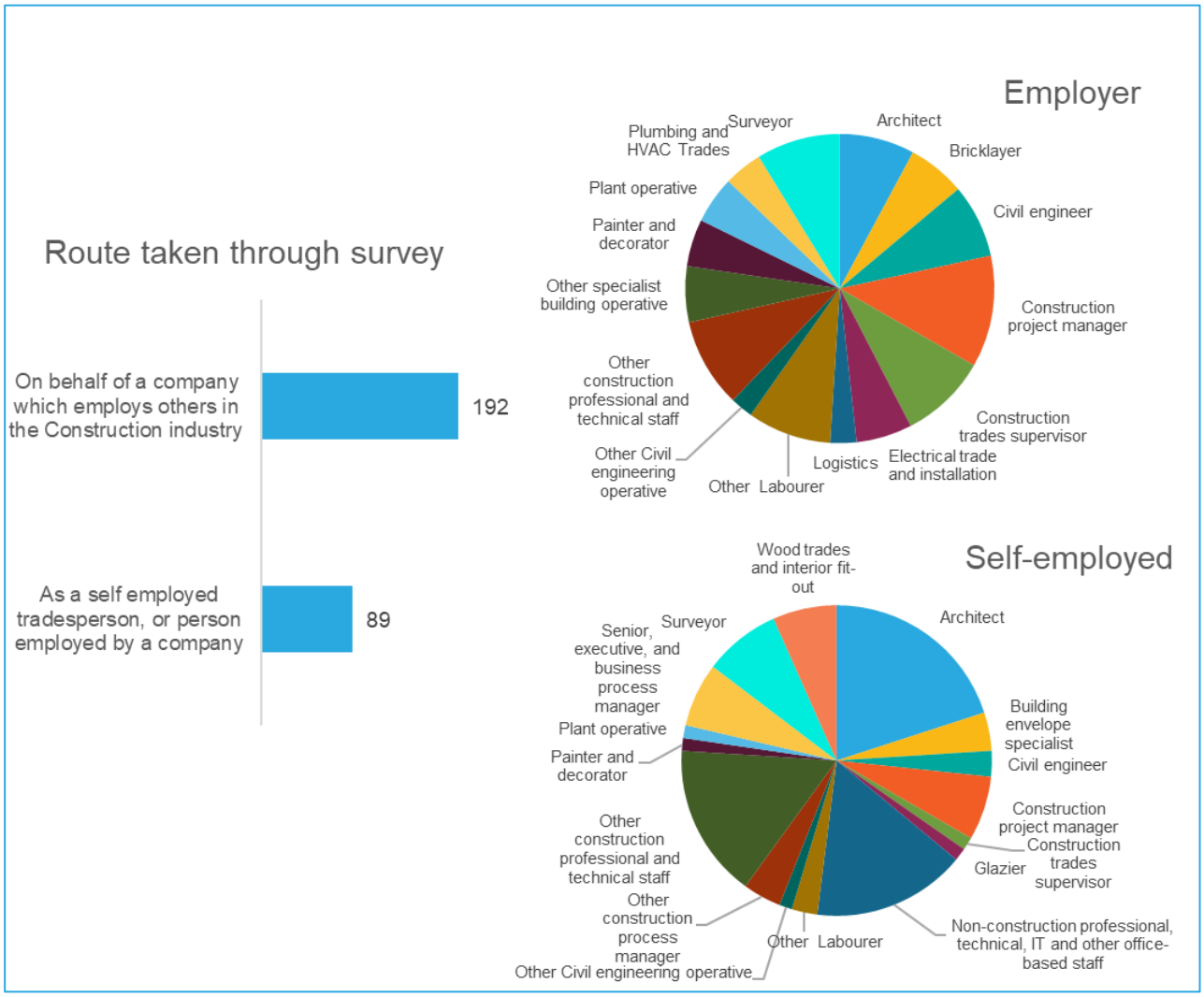


Figure A 1.4 – Annual revenue of the companies represented by respondents to the CITB Building Skills for Net Zero

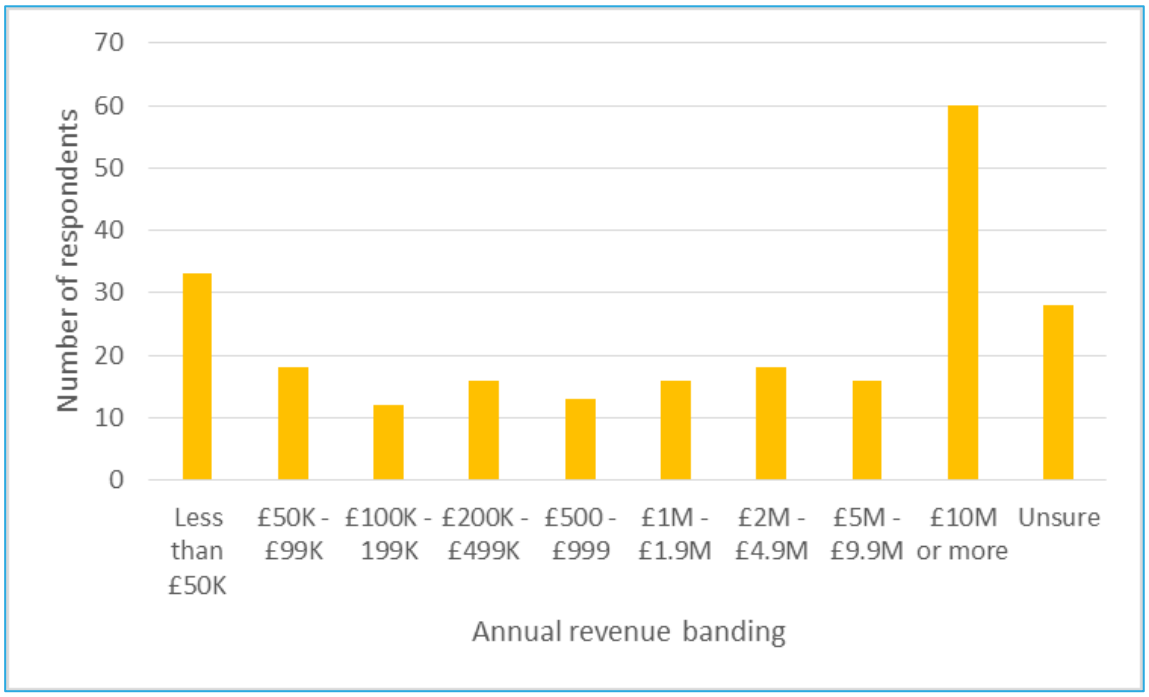


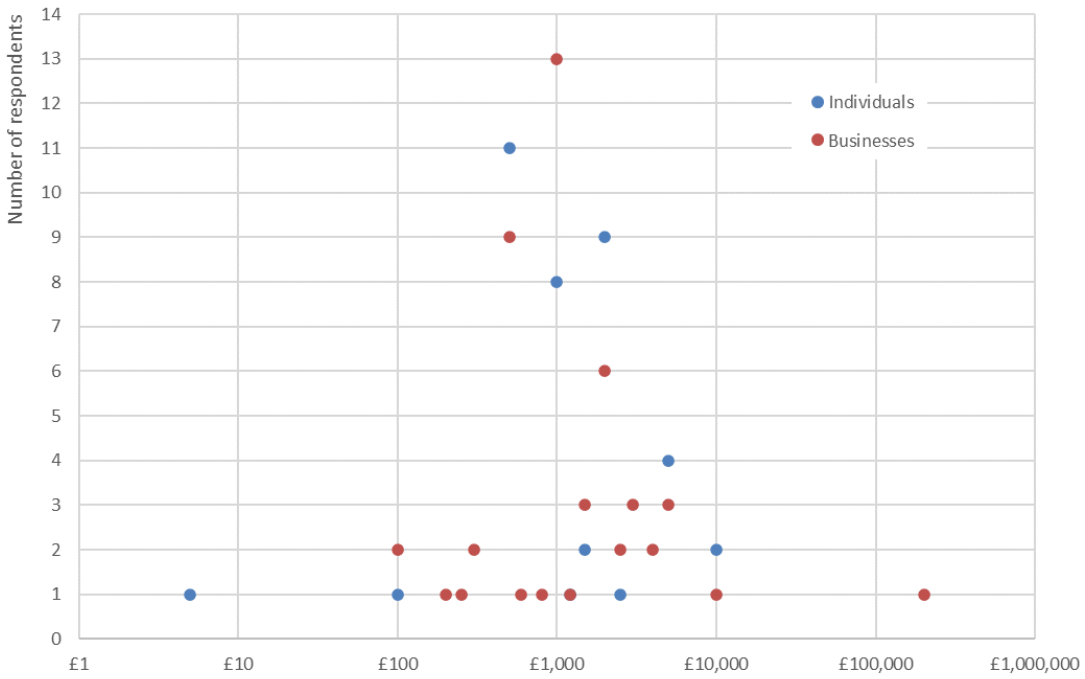
Table A1-4 – The main activities of the companies represented by respondents to the CITB Building Skills for Net Zero Survey

Answer Choices	Responses	
Building completion and finishing	15	7%
Specialised construction activities	19	8%
Electrical, plumbing and other construction installation activities	6	3%
Construction of residential and non-residential buildings	33	14%
Construction of roads and railways (and airport runways)	6	3%
Construction of utility projects	6	3%
Construction of other civil engineering projects	8	3%
Demolition and site preparation	3	1%
Development of building projects	8	3%
Retail / hire of construction materials	3	1%
Architecture, Planning or Surveying	36	16%
Engineering or technical consultancy	21	9%
Project management	1	4%
None of the above	0.00	0%

Table A1-5 - The predominant recent disciplines of the companies represented by respondents to the CITB Building Skills for Net Zero Survey

Answer Choices	Responses	
Construction - New house building	31	13%
Construction - Housing repair, maintenance and improvement, including extensions and loft conversions	33	14%
Construction - Commercial and retail work such as shops, offices and leisure facilities	20	9%
Construction - Industrial work such as factories and warehouses	3	1%
Construction - Civil engineering and infrastructure projects such as roads, bridges, airports, stadiums etc	20	9%
Construction - Public sector work specifically health and education facilities	8	3%
Construction - Historic Buildings (pre 1919)	11	5%
Construction - Energy efficiency retrofit	23	10%
Professional - Architects	17	7%
Professional - Quantity Surveyors	0	0%
Professional - Other surveying	6	3%
Professional - Building service engineers	1	0%
Professional - Planners/town planners	3	1%
Professional - Project Managers	4	2%
Professional - Multi disciplinary practices	22	10%
Unsure	4	2%
Other (please specify)	24	10%

Figure A1.5: Willingness to pay for training (Q.41 and Q.83)



A.1.6 Evidence Evaluation

A systematic review of the evidence gathered from the previous tasks was carried out to understand the complexity of information surrounding the UK's skills constraints on the deployment trajectories and the implications of accelerating the UK's journey to net-zero. The information from each task was validated with the results of the other tasks using the key themes mentioned in previous sections. Doing so ensured that the results presented a cohesive response to the seven research questions of the study, against which the body of the report was written. Findings from all the tasks are integrated throughout the report to maintain the narrative of the research conclusions and recommendations.

A.2.0 Model

As explained in section 4.2, the model is a scenario planning tool which has been developed to inform net-zero intervention deployment scenarios to 2050 by computing the impacts of those scenarios on the construction workforce. The model focusses on the additional workforce required to deliver those scenarios and the skills and qualifications requirements of that workforce.

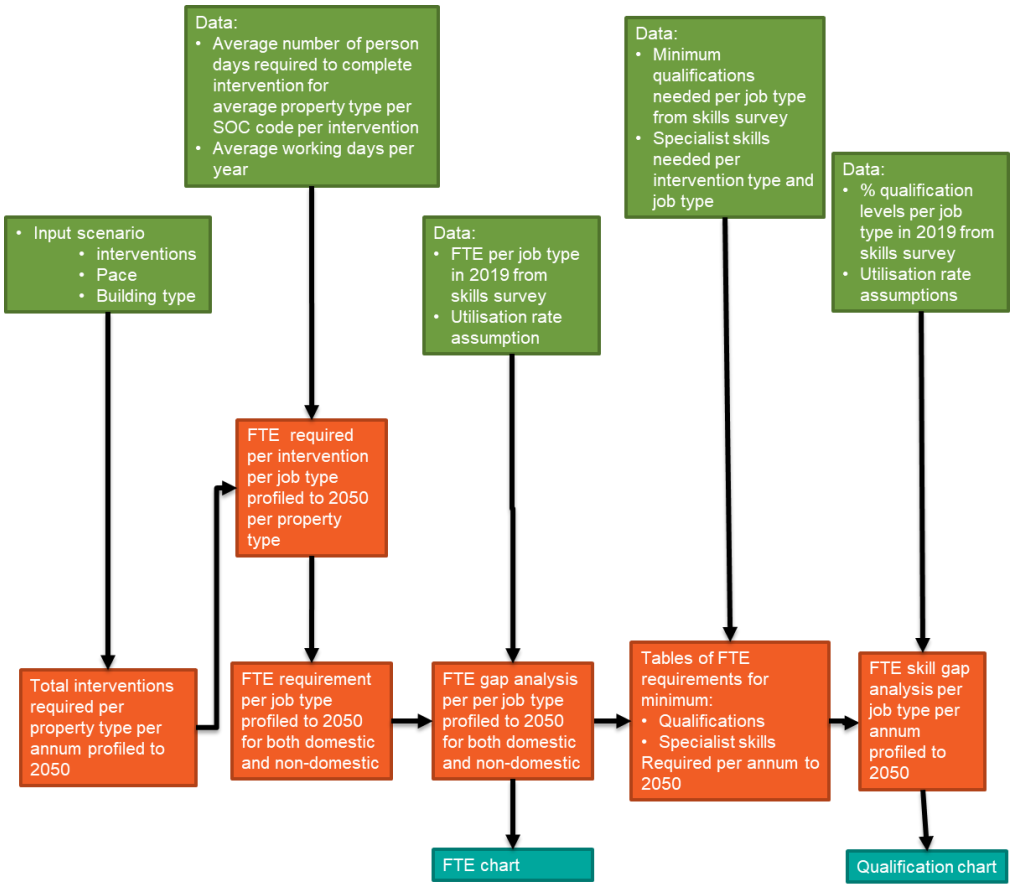
The model has been developed so that all input data is readily updateable. This is a key element of the model's design and allows the model to stay relevant for years to come. As technology develops and assumptions change, or better data is created, updating the input data will allow the model to continue to stay relevant for scenario planning.

In this section of the report the detail behind the mechanics of the model are explained including the relevant assumptions, input data and calculations.

A.2.1 Design

The model consists of three main steps and two main outputs. Figure A2-1 provides a graphical representation of the model, including the input data in green boxes, calculations in orange and outputs in turquoise.

Figure A2-1 Model map



The following explains in detail the how the model has been designed and outlines the main assumptions and input data by following the three main steps.

Step 1 – Model inputs

The basis of the model is the scenario input sheet where the net-zero deployment scenario input is completed by the model user. Through consultation with stakeholders including the steering group for this project a list of constraints for the possible input scenario has been developed. These constraints are necessary to toe the line between a model which is sufficiently complex to provide accurate enough predictions of the path ahead to fulfil the purpose of the model whilst not creating a model that is so complex to become unusable or without the relevant input data to populate it. The most significant constraints put on the input scenario are:

Property type – The model uses four standard property types, these are; new build domestic, new build non-domestic, existing domestic and existing non-domestic. These building types are defined in section A.2.4.1 and the assumption is that they approximate the UK building stock of that building type.

The decision to limit the model to four property types was made for several reasons.

Firstly, the scale of complexity within the UK housing stock is large. For example, within only existing domestic properties it could be argued that properties could be broken down by size, or by age, or a building category could be developed for traditional buildings vs non-traditional. It could also be argued that for specific interventions such as loft insulation, knowing if the roof is cold or warm could also be useful distinction. The list of possible building categories is endless and there is no clear-cut argument for splitting the property types further in one way or another.

Secondly, because the model produces outputs based on the impact on the whole construction sector for all property types any complexity will be averaged and summed in creating the outputs. Therefore, any complexity at the front end will require complexity in the input data too before finally being aggregated as the calculations of the model progress. Therefore, separating out property types further should not have any impact on the accuracy of the results.

Finally, for such complexity in property type to be utilised, net-zero deployment scenarios would need to be developed for each individual building type. From consultation with the relevant stakeholders, net-zero deployment scenarios are currently developed only for existing domestic properties as one category and are not split down further.

Possible interventions – The list of possible interventions has been limited to 18 different types of intervention which include measures relating to the building fabric such as insulation, cladding and glazing, heating methods including hydrogen boilers, direct electric, heat pumps and district heating and finally other technologies such as heat storage, heat distribution, PV, smart systems and solar thermal. The exact definitions used for these ‘standard interventions’ are described in section A.2.2 of this report. These interventions were chosen following discussions with stakeholders to be the most relevant for the transition to net-zero.

The model also takes into consideration the relevance of the interventions to different property types. For example, the model greys out the 'direct electric' heating option for non-domestic existing buildings, as this is unlikely to be implemented.

It is also worth noting that there are is an additional input line for the number of whole building retrofits which require the retrofit co-ordinator role for both domestic and non-domestic existing buildings per year.

Pace change – The model works on the basis that the UK will reach its net-zero target by 2050 and therefore models the period from 2021 – 2050. The input tab allows, for each intervention and property type, the pace of deployment to be varied. For years 2021 – 2030 this variation can be changed on an annual basis and from 2030 – 2050 this pace change is on a 5-yearly basis.

In conclusion, the first step of the model is the net-zero deployment scenario, input by the model user. The deployment scenario will consist of the number of interventions to be installed each year between 2021 – 2050 with pace changes permitted on an annual basis for the first 10 years and from then on, every 5 years for all four property types.

Step 2 – The FTE requirements

The first major output of the model are heat maps and charts of the Full Time Equivalent (FTE), split by Construction Skills Network Occupational Groups, required, on top of the construction sector workforce employed in 2019, to deliver the input net-zero deployment scenario. To derive these first outputs from the input scenario requires input data and assumptions, the most significant are described below:

Standard Occupational Classification – One of the key briefs for the modelling concerned its comparability to the CITB's Construction Skills Network Survey which uses 28 CSN Occupational Groups to define job types. These job types are therefore used throughout the model to define the types of jobs relevant to the construction workforce. It is acknowledged that there are some jobs, especially some aspects of heat networks and modern methods of construction, which do not fall in to the CSN Occupational Groups. The model assigns hours across the CSN Occupational Groups for measures relating to these disciplines, but there are some occupations which are outside the CSN framework, and for the purposes of the modelling, these are considered out of scope.

Time taken input data – One of the key pieces of input data gathered as part of the model development are tables of the 'time taken' to install an intervention for the 'standard property' for both domestic existing and non-domestic existing building types. As an example, for loft insulation in an existing domestic property, the time required to install loft insulation, to the requirements of net-zero, per CSN Occupational Groups is recorded. This data has been collated through a variety of means including, information gathered from interviews, conversations with trade bodies and installers and reports. The source of the input data is recorded in the model.

For new build properties a different method has been used. For all data collated for domestic and non-domestic existing properties, an 'efficiency' factor has been applied describing how much more efficient in terms of time it is to install the particular intervention in a new build property in comparison to retrofitting that intervention in an

existing property. This produces tables of 'time taken' per intervention for both new build domestic and non-domestic properties.

Utilisation rates – Finally, for this step of the model a utilisation factor is applied to the existing workforce to calculate how much of the existing construction workforce is available to install the interventions from the input scenario. From discussions with a major UK construction body during the interview process we received an estimate that currently 4% of the construction workforce is contracted to work relevant to net-zero.

Using the data derived as part of the 2019 Construction Skills Network survey the current FTE in the UK construction sector is known broken down by CSN Occupational Groups. We have applied a 96% utilisation factor across all CSN Occupational Groups meaning that 4% of the workforce in each of those CSN Occupational Groups is available for the input deployment scenario.

Therefore, to derive the outputs for this stage. The step 1 input scenario, consisting of the number of interventions installed per year for each property type, is multiplied by the time taken data for each property type to derive the total FTE required for each modelled year per CSN Occupational Group. Then finally, the number of current construction workforce available to work on these interventions is subtracted leaving only the additional workforce required, on top of the 2019 base workforce, to deliver the interventions.

In summary, this step calculates the total number of additional FTE required to deliver the input net-zero deployment scenario per CSN Occupational Group. This output is calculated using the assumptions that all relevant jobs fall into the 28 CSN Occupational Groups, 4% of the current construction workforce is available for net-zero work and on the 'time taken' input data. This output is then graphically represented in a series of charts discussed in more detail in section 4.2 of this report.

Step 3 – The skills and qualification requirements

In this final step of the model the skills and qualifications required to deliver the input net-zero scenario are considered and presented as outputs in heat maps and charts. Slightly different methodologies are used for either qualification level or specialist skills and these are explained below.

Qualification level – By 'qualification level' we are referring to NVQ levels, degrees, and PhD's. There is an assumption that any additional workforce needed to deliver the input scenario will require the same spread of these qualification as the current construction workforce. Using the CITB's 'Qualifications by SOC2010 occupation' dataset for summer 2018 – spring 2019 the model profiles the additional workforce required against the existing workforce to derive, for each modelled year, the FTE requirement at each qualification level.

The possibility of overqualification within these figures for the current construction workforce had been considered and, on consultation with stakeholders, it was found that the level of overqualification in the current workforce is thought to be minimal.

Specialist training - By 'specialist skills' we are referring both to certified courses such as the 'F-gas' and non-certified courses such as general 'sustainability training'. There is an assumption that all the workforce required to deliver the input scenario will require the

relevant specialist skills for the intervention they are installing. Therefore, both the additional workforce, on top of the current construction workforce, and the 4% of the existing workforce available to work on these interventions will require training in these specialist skills. This assumption has been made because although 4% of a CSN Occupational Group may be available to work on these interventions, they may not have the specialist skills required to install it. As an example, although 4% of CSN Occupational Group code 21, 'Plumbing and HVAC Trades', may be available to install heat pumps, it is not known how many of that workforce already have the 'F-gas' qualification. Although this assumption could lead to an overestimation of the amount of specialist skills training required, this is thought to be minimal.

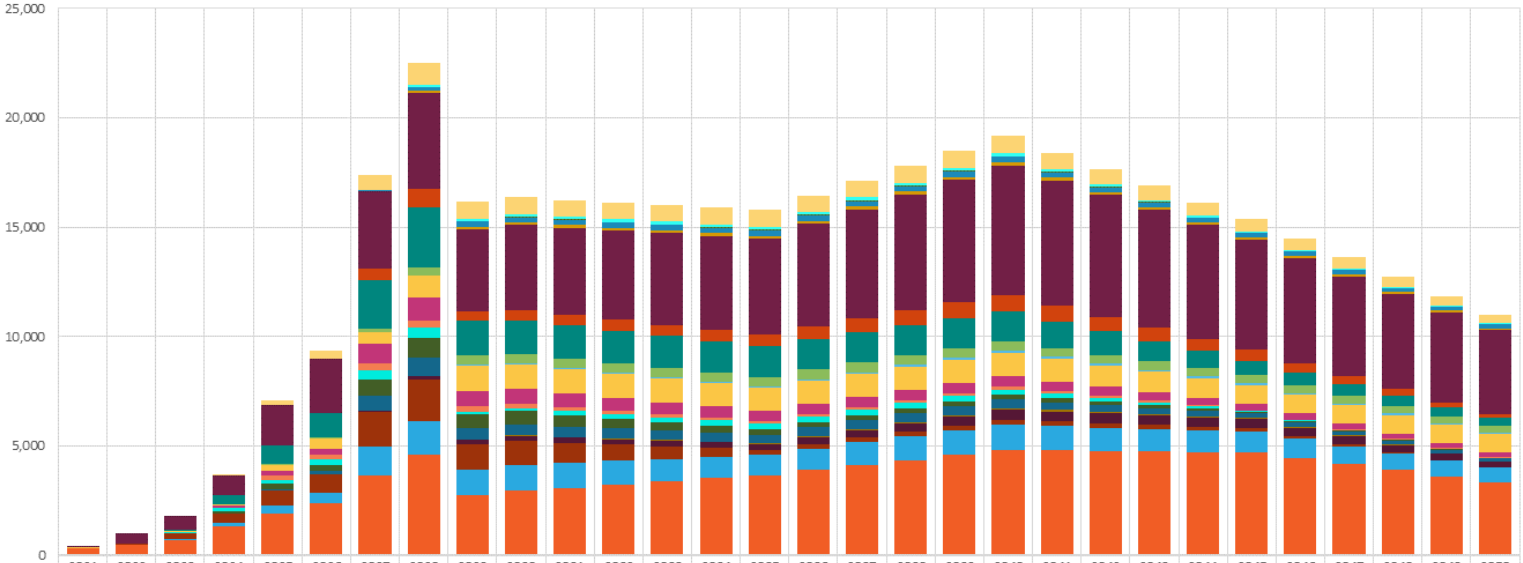
The specialist skills data is the second key piece of input data derived as part of the model development. The data is presented as percentages of the workforce required to install an intervention who require the specialist skill by intervention type. This data has been collated through a variety of means including, information gathered from interviews, conversations with trade bodies and installers and training colleges. The source of the input data is recorded in the model.

In conclusion, to derive the outputs for this final stage of the model, two steps are taken. Firstly, for the qualification levels, the additional FTE required, on top of the existing workforce, per intervention for each modelled year is multiplied by the profile of qualification levels in the existing workforce. Secondly, the total FTE required per intervention for each modelled year is multiplied by the specialist skills input data. This output is then graphically represented in a series of charts discussed in more detail in section 4.2.3 of this report.

A.2.2 Model output for devolved nations

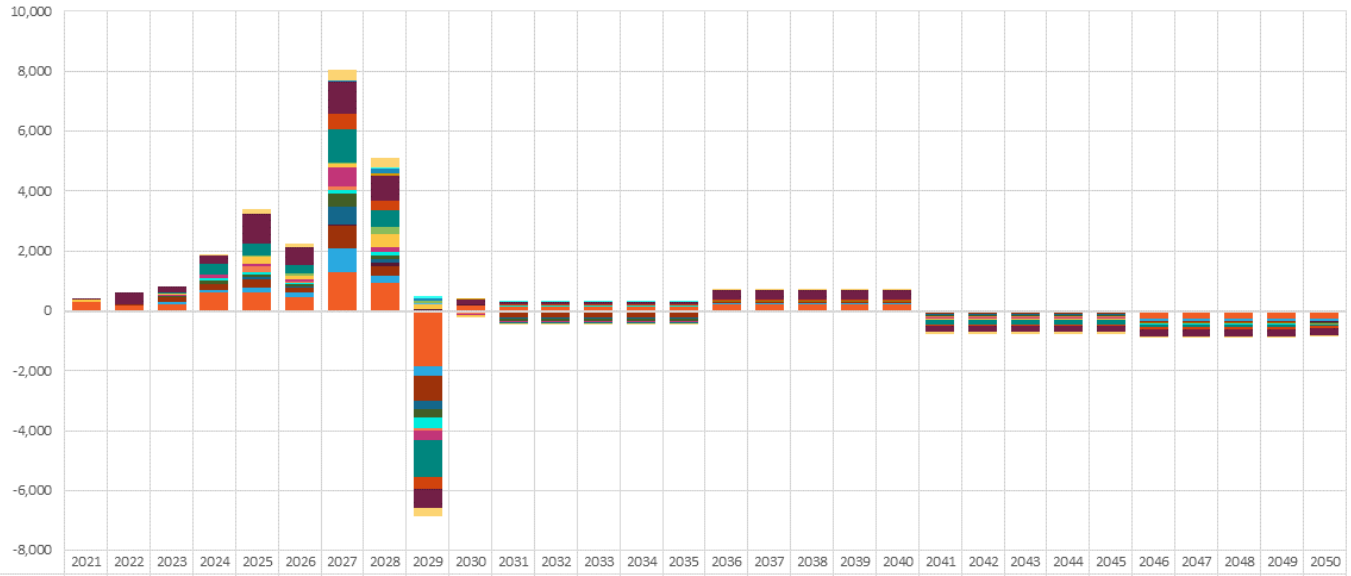
The model has been run using CSN baselines for Scotland and Wales, overlaid with specific Scottish and Welsh measure numbers from CCC. The following graphs illustrate the output from this process.

Figure A2.2.1: Graph of additional FTE requirement above 2019 year baseline CSN workforce per CSN Occupational Group profiled to 2050 for Scotland



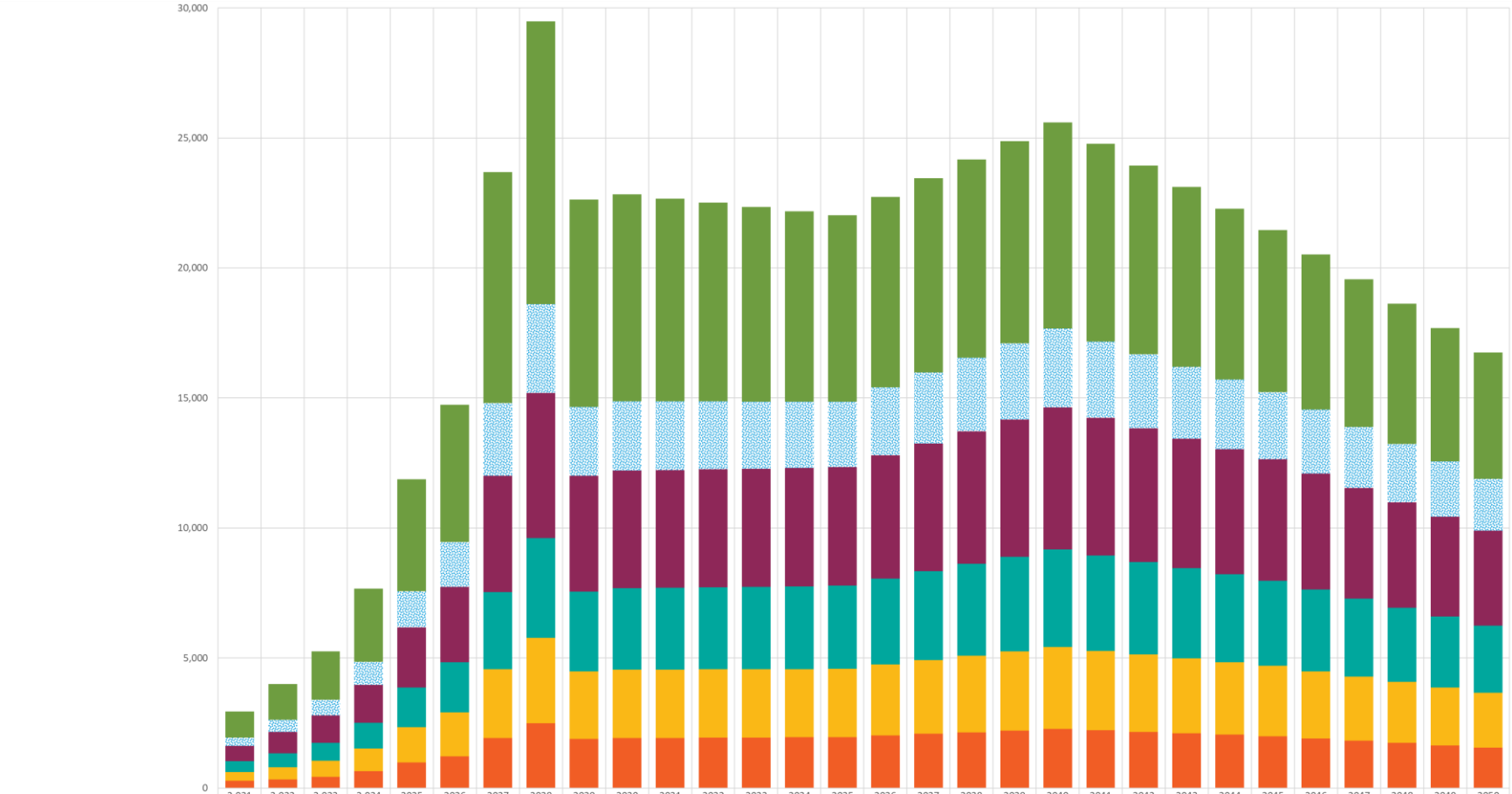
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Surveyors	0	0	0	44	215	342	711	1,029	764	763	762	760	758	756	754	764	774	784	793	803	753	703	653	603	552	525	497	469	442	414
Civil engineers	0	0	0	0	0	0	0	59	113	113	116	120	124	128	131	128	125	122	119	116	106	96	87	77	67	64	61	57	54	51
Non–construction operatives	0	0	0	0	0	0	0	7	34	34	35	37	39	41	43	41	40	38	37	35	30	25	21	16	11	9	8	6	4	3
Civil engineering operatives nec*	0	0	0	0	0	0	27	180	234	234	237	241	245	249	252	249	246	243	240	237	227	217	208	198	188	185	182	178	175	172
Logistics	0	0	0	0	0	0	28	100	114	117	120	122	124	126	128	132	137	141	145	149	144	140	135	130	125	118	112	106	99	93
Plumbing and HVAC Trades	45	439	618	876	1,857	2,471	3,519	4,373	3,761	3,914	4,002	4,090	4,179	4,267	4,356	4,668	4,980	5,293	5,605	5,917	5,740	5,564	5,387	5,210	5,033	4,799	4,564	4,329	4,095	3,860
Electrical trades and installation	0	0	0	0	0	0	528	844	426	442	467	492	517	542	567	608	650	691	733	775	717	659	601	543	486	420	355	290	225	160
Labourers nec*	0	0	61	428	844	1,126	2,248	2,786	1,569	1,547	1,514	1,482	1,449	1,417	1,384	1,376	1,367	1,358	1,350	1,341	1,207	1,073	940	806	672	608	544	479	415	351
Steel erectors/structural fabrication	0	0	0	0	18	70	116	346	426	426	432	437	443	449	454	450	445	440	436	431	416	402	387	373	358	353	348	343	338	333
Plant mechanics/fitters	0	0	0	0	0	0	0	17	40	44	46	48	50	52	55	63	72	81	89	98	95	92	89	86	83	74	65	56	47	38
Plant operatives	73	20	51	69	309	442	553	1,000	1,165	1,129	1,112	1,096	1,079	1,062	1,045	1,048	1,050	1,052	1,055	1,057	1,018	978	938	898	859	856	853	849	846	843
Scaffolders	0	0	17	110	199	264	909	1,039	691	662	629	596	563	530	497	498	499	500	501	502	461	419	378	336	295	278	262	245	229	212
Specialist building operatives nec*	0	0	0	0	176	220	310	322	247	207	179	152	124	97	69	80	91	102	112	123	103	82	62	41	21	25	30	35	40	45
Glaziers	0	0	30	121	201	258	388	493	142	143	169	194	220	246	272	262	252	241	231	221	186	152	117	83	49	38	27	16	5	0
Floorers	0	0	27	135	243	307	760	896	618	605	533	462	391	319	248	246	244	243	241	239	209	178	147	116	85	74	63	52	40	29
Roofers	0	0	0	3	74	128	701	809	516	489	471	452	434	415	397	397	397	397	397	397	357	317	278	238	199	185	170	156	142	128
Plasterers	0	0	0	0	0	0	0	10	29	32	34	35	37	39	41	48	55	62	69	76	74	71	69	66	63	56	49	42	34	27
Painters and decorators	0	0	0	0	0	0	29	159	209	229	239	249	258	268	278	310	342	375	407	439	435	431	427	423	419	388	356	324	293	261
Building envelope specialists	0	50	228	425	682	846	1,619	1,936	1,138	1,120	934	748	562	376	190	201	211	221	232	242	223	204	185	167	148	112	77	42	7	0
Construction Trades Supervisers	0	0	46	159	342	479	1,278	1,507	1,172	1,168	1,126	1,083	1,041	998	956	997	1,038	1,079	1,121	1,162	1,119	1,076	1,033	990	947	888	829	770	711	652
Construction Project Managers	309	478	711	1,309	1,919	2,383	3,674	4,605	2,758	2,943	3,087	3,231	3,375	3,519	3,663	3,892	4,121	4,350	4,579	4,809	4,788	4,767	4,745	4,724	4,703	4,433	4,162	3,891	3,620	3,350

Figure A2.2.2: Graph of annual difference in FTE required each year per CSN Occupational Group for Scotland



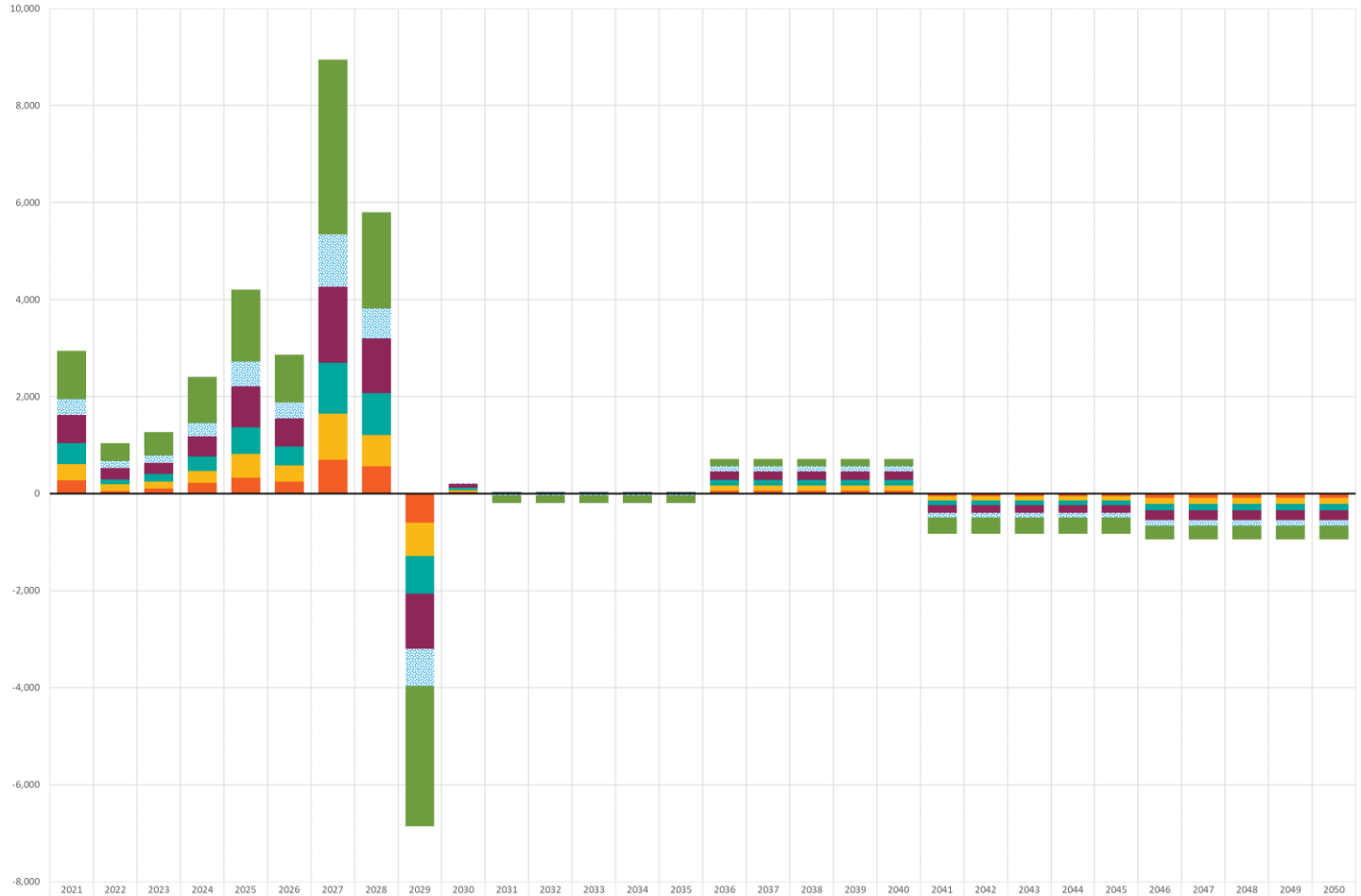
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Surveyors	0	0	0	44	171	127	369	318	-265	-1	-2	-2	-2	-2	-2	10	10	10	10	10	-50	-50	-50	-50	-50	-28	-28	-28	-28	-28
Civil engineers	0	0	0	0	0	0	0	59	54	0	4	4	4	4	4	-3	-3	-3	-3	-3	-10	-10	-10	-10	-10	-3	-3	-3	-3	-3
Non–construction operatives	0	0	0	0	0	0	0	7	27	0	2	2	2	2	2	-2	-2	-2	-2	-2	-5	-5	-5	-5	-5	-2	-2	-2	-2	-2
Civil engineering operatives nec*	0	0	0	0	0	0	27	153	54	0	4	4	4	4	4	-3	-3	-3	-3	-3	-10	-10	-10	-10	-10	-3	-3	-3	-3	-3
Logistics	0	0	0	0	0	0	28	72	15	3	2	2	2	2	2	4	4	4	4	4	-5	-5	-5	-5	-5	-6	-6	-6	-6	-6
Plumbing and HVAC Trades	45	394	179	258	982	613	1,048	854	-612	153	88	88	88	88	88	312	312	312	312	312	-177	-177	-177	-177	-177	-235	-235	-235	-235	-235
Electrical trades and installation	0	0	0	0	0	0	528	316	-418	16	25	25	25	25	25	42	42	42	42	42	-58	-58	-58	-58	-58	-65	-65	-65	-65	-65
Labourers nec*	0	0	61	367	416	282	1,122	539	-1,218	-22	-32	-32	-32	-32	-32	-9	-9	-9	-9	-9	-134	-134	-134	-134	-134	-64	-64	-64	-64	-64
Steel erectors/structural fabrication	0	0	0	0	18	52	47	229	81	0	6	6	6	6	6	-5	-5	-5	-5	-5	-15	-15	-15	-15	-15	-5	-5	-5	-5	-5
Plant mechanics/fitters	0	0	0	0	0	0	0	17	23	4	2	2	2	2	2	9	9	9	9	9	-3	-3	-3	-3	-3	-9	-9	-9	-9	-9
Plant operatives	73	-53	31	18	240	133	111	448	164	-35	-17	-17	-17	-17	-17	2	2	2	2	2	-40	-40	-40	-40	-40	-3	-3	-3	-3	-3
Scaffolders	0	0	17	94	89	65	645	130	-348	-29	-33	-33	-33	-33	-33	1	1	1	1	1	-41	-41	-41	-41	-41	-17	-17	-17	-17	-17
Specialist building operatives nec*	0	0	0	0	176	44	90	12	-75	-40	-28	-28	-28	-28	-28	11	11	11	11	11	-21	-21	-21	-21	-21	5	5	5	5	5
Glaziers	0	0	30	91	80	58	129	106	-351	0	26	26	26	26	26	-10	-10	-10	-10	-10	-34	-34	-34	-34	-34	-11	-11	-11	-11	-5
Floorers	0	0	27	108	108	65	452	137	-278	-13	-71	-71	-71	-71	-71	-2	-2	-2	-2	-2	-31	-31	-31	-31	-31	-11	-11	-11	-11	-11
Roofers	0	0	0	3	71	54	573	108	-292	-27	-18	-18	-18	-18	-18	0	0	0	0	0	-40	-40	-40	-40	-40	-14	-14	-14	-14	-14
Plasterers	0	0	0	0	0	0	0	10	19	3	2	2	2	2	2	7	7	7	7	7	-3	-3	-3	-3	-3	-7	-7	-7	-7	-7
Painters and decorators	0	0	0	0	0	0	29	129	50	20	10	10	10	10	10	32	32	32	32	32	-4	-4	-4	-4	-4	-32	-32	-32	-32	-32
Building envelope specialists	0	50	178	196	258	164	773	317	-798	-18	-186	-186	-186	-186	-186	10	10	10	10	10	-19	-19	-19	-19	-19	-35	-35	-35	-35	-7
Construction Trades Supervisers	0	0	46	113	184	136	799	230	-336	-3	-43	-43	-43	-43	-43	41	41	41	41	41	-43	-43	-43	-43	-43	-59	-59	-59	-59	-59
Non-construction professional, technical, IT, and other office-based staff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction Project Managers	309	169	233	598	610	464	1,290	932	-1,847	185	144	144	144	144	144	229	229	229	229	229	-21	-21	-21	-21	-21	-271	-271	-271	-271	-271

Figure A2.2.3: Graph of FTE requirement, in addition to the 2019 workforce base, per qualification level profiled to 2050 for Scotland



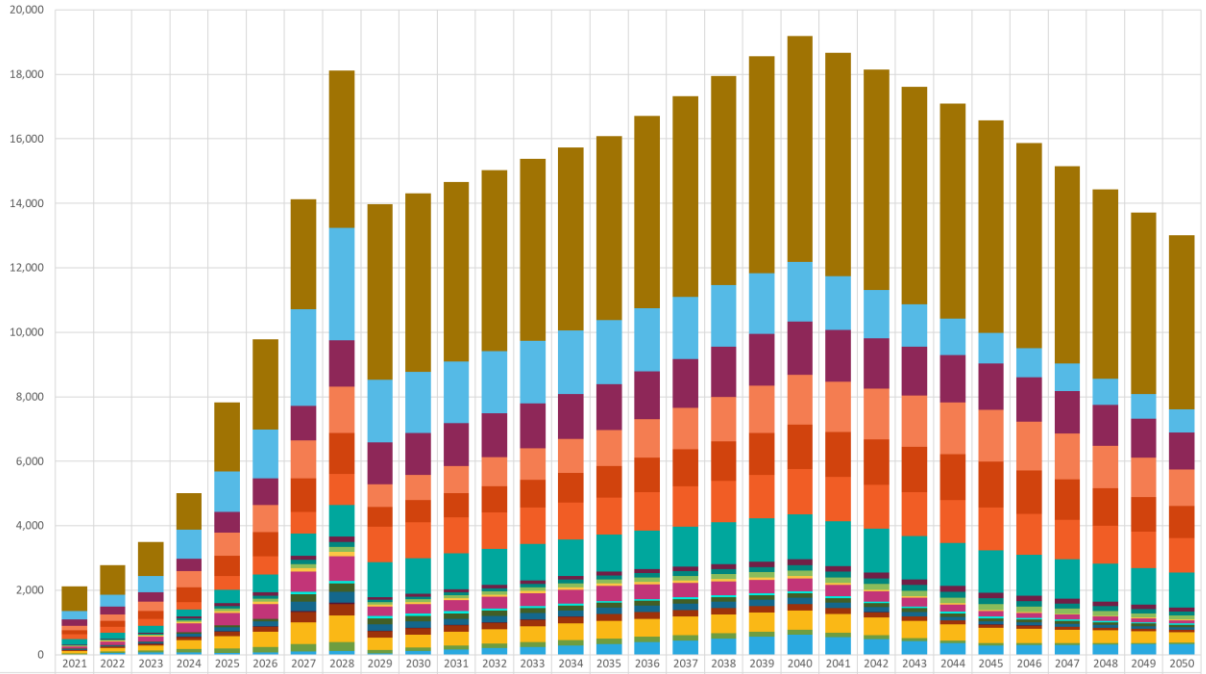
	2,021	2,022	2,023	2,024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Below NVQ level 2, other or no qualifications	1,001	1,371	1,860	2,814	4,294	5,276	8,881	10,864	7,974	7,956	7,798	7,641	7,483	7,326	7,168	7,320	7,472	7,624	7,776	7,928	7,591	7,253	6,916	6,579	6,242	5,963	5,685	5,406	5,127	4,849
NVQ level 2	324	470	617	884	1,392	1,723	2,796	3,414	2,648	2,673	2,643	2,612	2,581	2,550	2,519	2,621	2,723	2,825	2,927	3,029	2,939	2,849	2,759	2,670	2,580	2,465	2,350	2,235	2,120	2,005
NVQ level 3	580	816	1,049	1,465	2,313	2,894	4,464	5,586	4,449	4,523	4,529	4,536	4,542	4,548	4,554	4,736	4,917	5,099	5,280	5,462	5,302	5,142	4,982	4,823	4,663	4,459	4,255	4,052	3,848	3,645
NVQ level 4	434	535	692	993	1,535	1,926	2,977	3,844	3,071	3,123	3,139	3,154	3,169	3,184	3,199	3,311	3,422	3,533	3,644	3,755	3,659	3,563	3,467	3,371	3,275	3,137	2,999	2,860	2,722	2,584
Trade App'ships	335	472	609	860	1,355	1,689	2,637	3,281	2,595	2,635	2,632	2,628	2,625	2,622	2,619	2,725	2,831	2,938	3,044	3,150	3,061	2,971	2,881	2,792	2,702	2,583	2,465	2,346	2,227	2,109
First degree	274	327	435	654	982	1,225	1,925	2,488	1,887	1,920	1,929	1,937	1,946	1,954	1,963	2,024	2,086	2,147	2,209	2,270	2,216	2,161	2,107	2,052	1,997	1,908	1,819	1,730	1,641	1,552

Figure A2.2.4: Difference in FTE requirements for subsequent years for each qualification label profiled to 2050 for Scotland



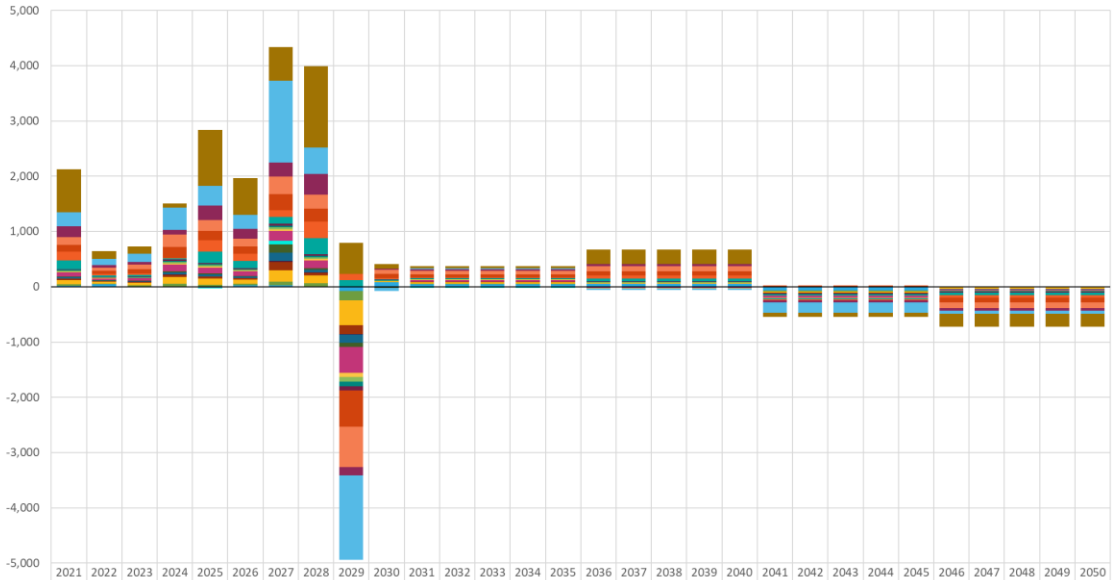
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Below NVQ level 2, other or no qualifications	1,001	370	489	954	1,480	982	3,605	1,983	-2,890	-18	-158	-158	-158	-158	-158	152	152	152	152	152	-337	-337	-337	-337	-337	-279	-279	-279	-279	-279
NVQ level 2	324	146	147	267	508	330	1,073	618	-765	25	-31	-31	-31	-31	-31	102	102	102	102	102	-90	-90	-90	-90	-90	-115	-115	-115	-115	-115
NVQ level 3	580	236	232	416	848	581	1,570	1,122	-1,137	74	6	6	6	6	6	182	182	182	182	182	-160	-160	-160	-160	-160	-204	-204	-204	-204	-204
NVQ level 4	434	102	157	300	542	391	1,051	867	-773	52	15	15	15	15	15	111	111	111	111	111	-96	-96	-96	-96	-96	-138	-138	-138	-138	-138
Trade App'ships	335	137	137	250	495	335	948	644	-687	40	-3	-3	-3	-3	-3	106	106	106	106	106	-90	-90	-90	-90	-90	-119	-119	-119	-119	-119
First degree	274	53	108	219	327	243	700	564	-601	33	8	8	8	8	8	62	62	62	62	62	-55	-55	-55	-55	-55	-89	-89	-89	-89	-89

Figure A2.2.5: FTE requirement for each specialist skill profiled to 2050 for Scotland



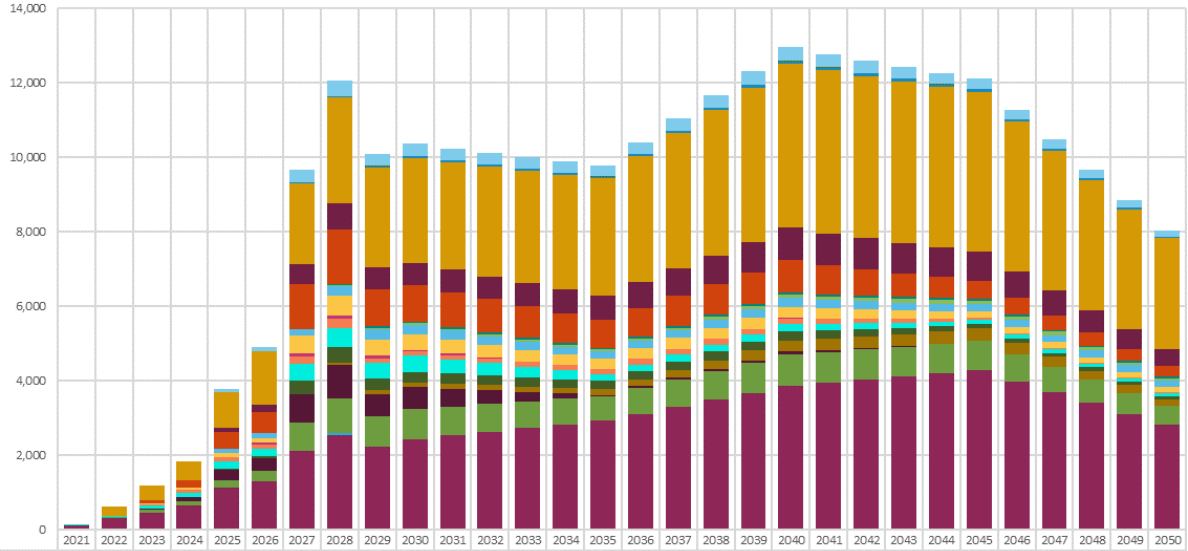
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Heat pump installation course	779	921	1,053	1,124	2,138	2,800	3,412	4,879	5,447	5,532	5,567	5,602	5,637	5,671	5,706	5,964	6,223	6,481	6,739	6,997	6,915	6,833	6,752	6,670	6,588	6,350	6,113	5,875	5,637	5,400
Asbestos Awareness Training	251	361	507	909	1,262	1,517	3,000	3,479	1,949	1,895	1,914	1,933	1,952	1,971	1,990	1,963	1,935	1,908	1,880	1,853	1,673	1,493	1,314	1,134	954	906	857	809	760	712
Electricity for plumbers course	199	246	297	380	643	819	1,073	1,446	1,296	1,311	1,334	1,357	1,380	1,403	1,426	1,470	1,515	1,559	1,604	1,649	1,605	1,562	1,518	1,475	1,432	1,376	1,320	1,264	1,209	1,153
Trustmark Approved Retrofit Coordinator	141	202	283	508	706	848	1,167	1,429	699	778	845	912	978	1,045	1,112	1,200	1,288	1,376	1,464	1,552	1,563	1,575	1,587	1,599	1,611	1,513	1,415	1,317	1,219	1,121
Trustmark Approved Retrofit Designer	125	179	252	452	627	754	1,038	1,270	621	692	751	810	870	929	988	1,066	1,145	1,223	1,301	1,379	1,390	1,400	1,411	1,421	1,432	1,345	1,258	1,170	1,083	996
Refrigeration, Heating & Ventilation Qualification	156	184	211	225	428	560	682	976	1,089	1,106	1,113	1,120	1,127	1,134	1,141	1,193	1,245	1,296	1,348	1,399	1,383	1,367	1,350	1,334	1,318	1,270	1,223	1,175	1,127	1,080
F Gas	156	184	211	225	428	560	682	976	1,089	1,106	1,113	1,120	1,127	1,134	1,141	1,193	1,245	1,296	1,348	1,399	1,383	1,367	1,350	1,334	1,318	1,270	1,223	1,175	1,127	1,080
Trustmark Approved Retrofit Installer	16	22	31	56	78	94	130	159	78	86	94	101	109	116	124	133	143	153	163	172	174	175	176	178	179	168	157	146	135	125
Trustmark Approved Retrofit Advisor	16	22	31	56	78	94	130	159	78	86	94	101	109	116	124	133	143	153	163	172	174	175	176	178	179	168	157	146	135	125
Trustmark Approved Retrofit Assessor	16	22	31	56	78	94	130	159	78	86	94	101	109	116	124	133	143	153	163	172	174	175	176	178	179	168	157	146	135	125
Pro-Fitter/GGF: Surveyors	13	19	27	48	67	80	110	135	53	53	59	65	71	77	83	81	79	76	74	71	63	55	47	39	31	29	26	23	21	18
Pro-Fitter/GGF: Windows and Doors - Novice/GQA Accredited	75	108	152	272	378	454	626	766	301	301	335	370	404	438	473	459	445	432	418	404	359	313	267	222	176	162	147	133	118	103
BPEC, Solar Thermal Systems NOS Mapped	0	0	0	0	0	1	73	76	80	76	70	64	59	53	47	49	50	52	53	54	53	52	51	50	49	48	47	46	45	44
BPEC, Working at Heights Access Training	13	18	25	45	63	77	223	250	178	171	166	161	156	152	147	147	147	147	147	147	137	127	117	107	97	94	90	86	83	79
BPEC, Award in the Installation and Maintenance of Small Scale Solar Photovoltaic Systems (Level 3)	25	36	51	91	126	152	300	348	195	189	191	193	195	197	199	196	194	191	188	185	167	149	131	113	95	91	86	81	76	71
CITB SMSTS (Site Management Safety Training Scheme)	1	3	6	9	13	15	31	36	24	23	20	17	14	10	7	7	8	8	8	8	8	8	7	7	6	6	5	5	4	4
Gas Smart	26	37	52	94	130	157	310	359	201	196	198	200	202	203	205	203	200	197	194	191	173	154	136	117	99	93	88	83	78	73
Diploma in smart metering	77	111	156	279	388	466	676	820	374	390	422	455	487	519	551	563	575	587	599	611	584	558	532	506	479	449	418	387	357	326
Battery Storage Systems Training course	28	40	56	101	140	168	231	283	111	111	124	137	149	162	175	170	164	159	154	149	133	116	99	82	65	60	54	49	44	38
Hydrogen boiler conversion courses	15	59	68	75	52	77	102	113	36	119	161	202	243	285	326	384	442	500	559	617	551	486	420	354	289	297	306	315	324	332

Figure A2.2.6 Difference in FTE requirements for subsequent years for specialist skills profiled to 2050 for Scotland



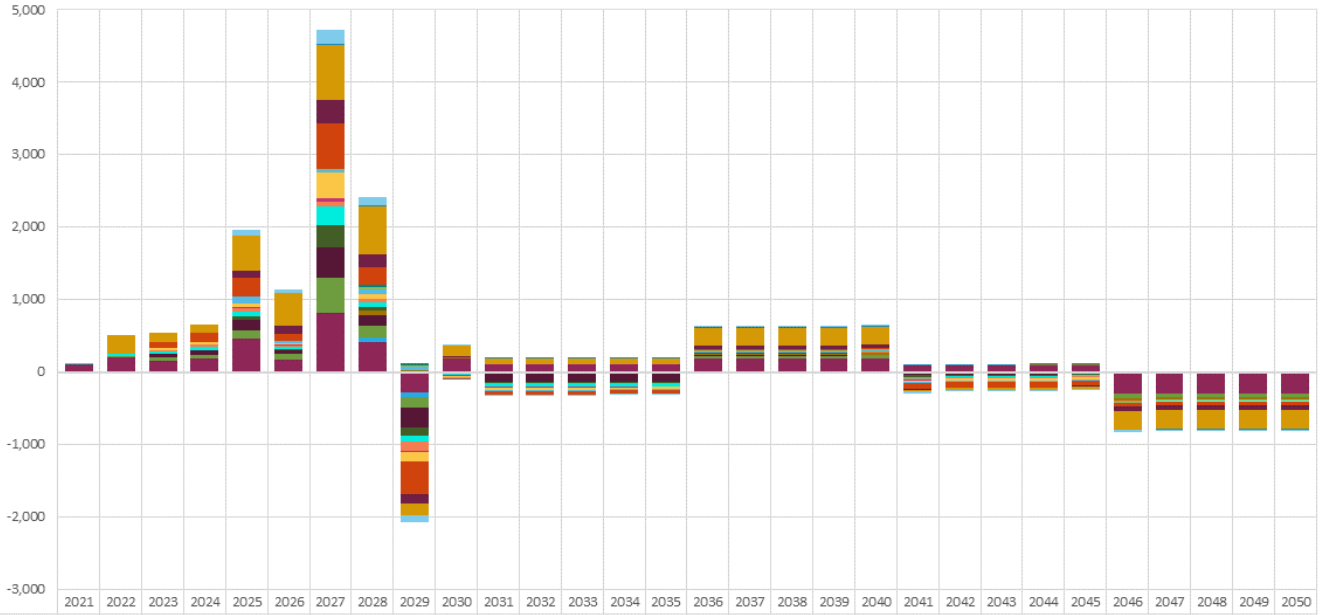
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Heat pump installation course	779	142	132	71	1,014	662	613	1,466	568	86	35	35	35	35	35	258	258	258	258	258	-82	-82	-82	-82	-82	-238	-238	-238	-238	-238
Asbestos Awareness Training	251	109	146	402	354	254	1,483	479	-1,530	-54	19	19	19	19	19	-27	-27	-27	-27	-27	-180	-180	-180	-180	-180	-49	-49	-49	-49	-49
Electricity for plumbers course	199	47	51	83	263	176	255	373	-150	15	23	23	23	23	23	45	45	45	45	45	-43	-43	-43	-43	-43	-56	-56	-56	-56	-56
Trustmark Approved Retrofit Coordinator	141	61	82	225	198	142	319	261	-730	80	67	67	67	67	67	88	88	88	88	88	12	12	12	12	12	-98	-98	-98	-98	-98
Trustmark Approved Retrofit Designer	125	54	73	200	176	126	284	232	-649	71	59	59	59	59	59	78	78	78	78	78	11	11	11	11	11	-87	-87	-87	-87	-87
Refrigeration, Heating & Ventilation Qualification	156	28	26	14	203	132	123	293	114	17	7	7	7	7	7	52	52	52	52	52	-16	-16	-16	-16	-16	-48	-48	-48	-48	-48
F Gas	156	28	26	14	203	132	123	293	114	17	7	7	7	7	7	52	52	52	52	52	-16	-16	-16	-16	-16	-48	-48	-48	-48	-48
Trustmark Approved Retrofit Installer	16	7	9	25	22	16	35	29	-81	9	7	7	7	7	7	10	10	10	10	10	1	1	1	1	1	-11	-11	-11	-11	-11
Trustmark Approved Retrofit Advisor	16	7	9	25	22	16	35	29	-81	9	7	7	7	7	7	10	10	10	10	10	1	1	1	1	1	-11	-11	-11	-11	-11
Trustmark Approved Retrofit Assessor	16	7	9	25	22	16	35	29	-81	9	7	7	7	7	7	10	10	10	10	10	1	1	1	1	1	-11	-11	-11	-11	-11
Pro-Fitter/GGF: Surveyors	13	6	8	21	19	13	30	25	-82	0	6	6	6	6	6	-2	-2	-2	-2	-2	-8	-8	-8	-8	-8	-3	-3	-3	-3	-3
Pro-Fitter/GGF: Windows and Doors - Novice/GQA Accredited	75	33	44	120	106	76	171	140	-465	0	34	34	34	34	34	-14	-14	-14	-14	-14	-46	-46	-46	-46	-46	-15	-15	-15	-15	-15
BPEC, Solar Thermal Systems NOS Mapped	0	0	0	0	0	1	73	3	4	-4	-6	-6	-6	-6	-6	1	1	1	1	1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
BPEC, Working at Heights Access Training	13	5	7	20	18	14	147	27	-73	-7	-5	-5	-5	-5	-5	0	0	0	0	0	-10	-10	-10	-10	-10	-4	-4	-4	-4	-4
BPEC, Award in the Installation and Maintenance of Small Scale Solar Photovoltaic Systems (Level 3)	25	11	15	40	35	25	148	48	-153	-5	2	2	2	2	2	-3	-3	-3	-3	-3	-18	-18	-18	-18	-18	-5	-5	-5	-5	-5
CITB SMSTS (Site Management Safety Training Scheme)	1	2	3	3	4	2	16	5	-12	-1	-3	-3	-3	-3	-3	0	0	0	0	0	0	0	0	0	0	-1	-1	-1	-1	-1
Gas Smart	26	11	15	41	37	26	153	49	-158	-6	2	2	2	2	2	-3	-3	-3	-3	-3	-19	-19	-19	-19	-19	-5	-5	-5	-5	-5
Diploma in smart metering	77	34	45	123	109	78	210	144	-445	16	32	32	32	32	32	12	12	12	12	12	-26	-26	-26	-26	-26	-31	-31	-31	-31	-31
Battery Storage Systems Training course	28	12	16	44	39	28	63	52	-172	0	13	13	13	13	13	-5	-5	-5	-5	-5	-17	-17	-17	-17	-17	-5	-5	-5	-5	-5
Hydrogen boiler conversion courses	15	44	9	7	-22	24	25	11	-77	83	41	41	41	41	41	58	58	58	58	58	-66	-66	-66	-66	-66	9	9	9	9	9

Figure A2.2.7: Graph of additional FTE requirement above 2019 year baseline CSN workforce per CSN Occupational Group profiled to 2050 for Wales



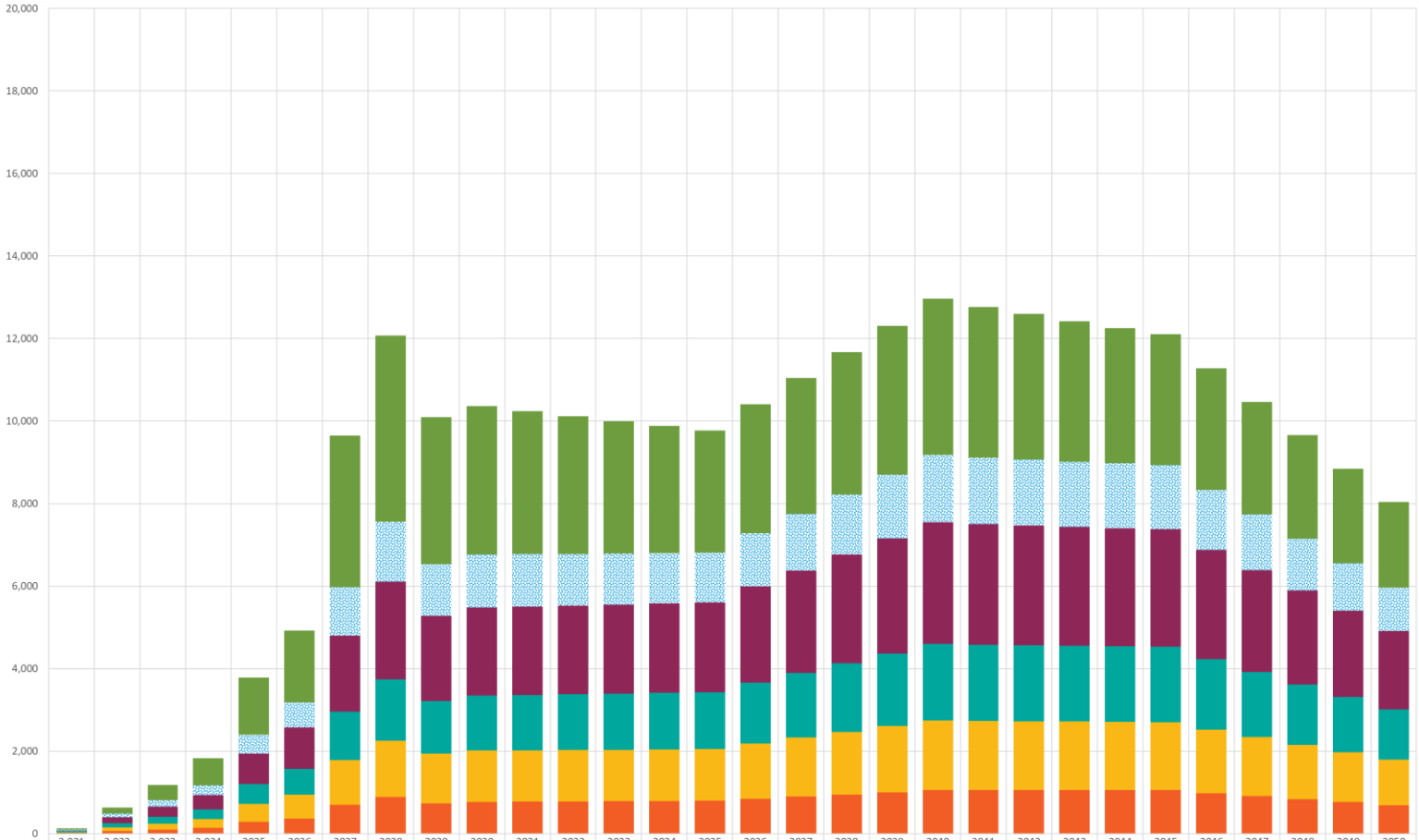
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Surveyors	0	0	0	0	73	122	324	433	330	332	324	315	307	299	290	308	327	345	363	381	360	338	316	295	273	252	231	210	188	167
Civil engineering operatives nec*	0	0	0	0	0	0	0	0	6	6	5	5	5	5	4	6	7	9	10	12	10	8	6	5	3	2	1	0	0	0
Logistics	0	0	0	0	0	0	15	37	42	44	45	45	46	47	48	52	57	62	67	71	72	72	73	73	74	68	62	56	50	44
Plumbing and HVAC Trades	0	255	384	489	977	1,433	2,190	2,844	2,683	2,814	2,880	2,946	3,012	3,078	3,144	3,394	3,644	3,894	4,144	4,394	4,370	4,346	4,322	4,297	4,273	4,012	3,751	3,490	3,228	2,967
Electrical trades and installation	0	0	0	0	98	198	523	703	575	591	602	612	623	633	643	687	730	774	817	861	846	831	816	801	786	722	659	595	532	469
Labourers nec*	0	0	84	217	470	568	1,203	1,445	988	978	933	887	842	797	751	773	795	817	839	861	786	712	638	564	490	446	403	360	317	273
Steel erectors/structural fabrication	0	0	0	0	0	0	0	34	51	51	50	50	49	49	49	51	53	55	57	59	57	54	51	49	46	45	44	42	41	40
Plant mechanics/fitters	0	0	0	0	0	0	8	35	45	49	50	52	54	55	57	65	72	80	87	95	97	100	103	106	108	99	89	79	69	59
Plant operatives	0	0	0	0	95	133	165	244	285	266	250	234	218	202	186	197	208	219	229	240	229	218	208	197	186	187	188	188	189	190
Scaffolders	0	0	24	56	111	129	480	533	411	395	370	345	321	296	271	278	284	291	298	305	278	252	226	200	174	166	158	150	141	133
Specialist building operatives nec*	0	0	0	0	13	34	86	94	74	52	36	20	4	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0
Glaziers	0	6	29	59	110	126	194	236	110	110	119	128	136	145	154	155	156	157	158	159	138	117	95	74	53	47	41	35	28	22
Floorers	16	40	76	118	181	202	457	525	438	430	380	329	279	228	177	181	184	188	191	195	176	158	140	122	104	99	94	89	84	79
Roofers	0	0	0	0	44	59	370	414	311	296	280	264	248	232	215	221	227	233	239	245	220	196	172	147	123	116	108	101	94	87
Painters and decorators	0	0	0	0	0	0	0	74	103	119	128	136	144	152	160	186	211	237	263	288	300	311	322	334	345	310	275	240	204	169
Building envelope specialists	0	0	48	119	266	318	740	886	601	591	479	367	255	142	30	39	49	58	67	76	57	39	20	1	0	0	0	0	0	0
Construction Trades Supervisers	0	17	66	112	222	301	778	934	799	803	774	745	716	687	658	695	731	768	804	841	828	815	803	790	777	723	670	616	563	509
Non-construction professional, technical, IT, and other office-based staff	0	0	0	0	0	0	0	62	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0
Other construction process managers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	11	0	0	0	0	0	0
Construction Project Managers	111	321	468	658	1,124	1,298	2,116	2,533	2,246	2,433	2,533	2,633	2,733	2,833	2,932	3,118	3,304	3,490	3,675	3,861	3,944	4,027	4,110	4,193	4,275	3,985	3,695	3,405	3,115	2,825

Figure A2.2.8: Graph of annual difference in FTE required each year per CSN Occupational Group for Wales



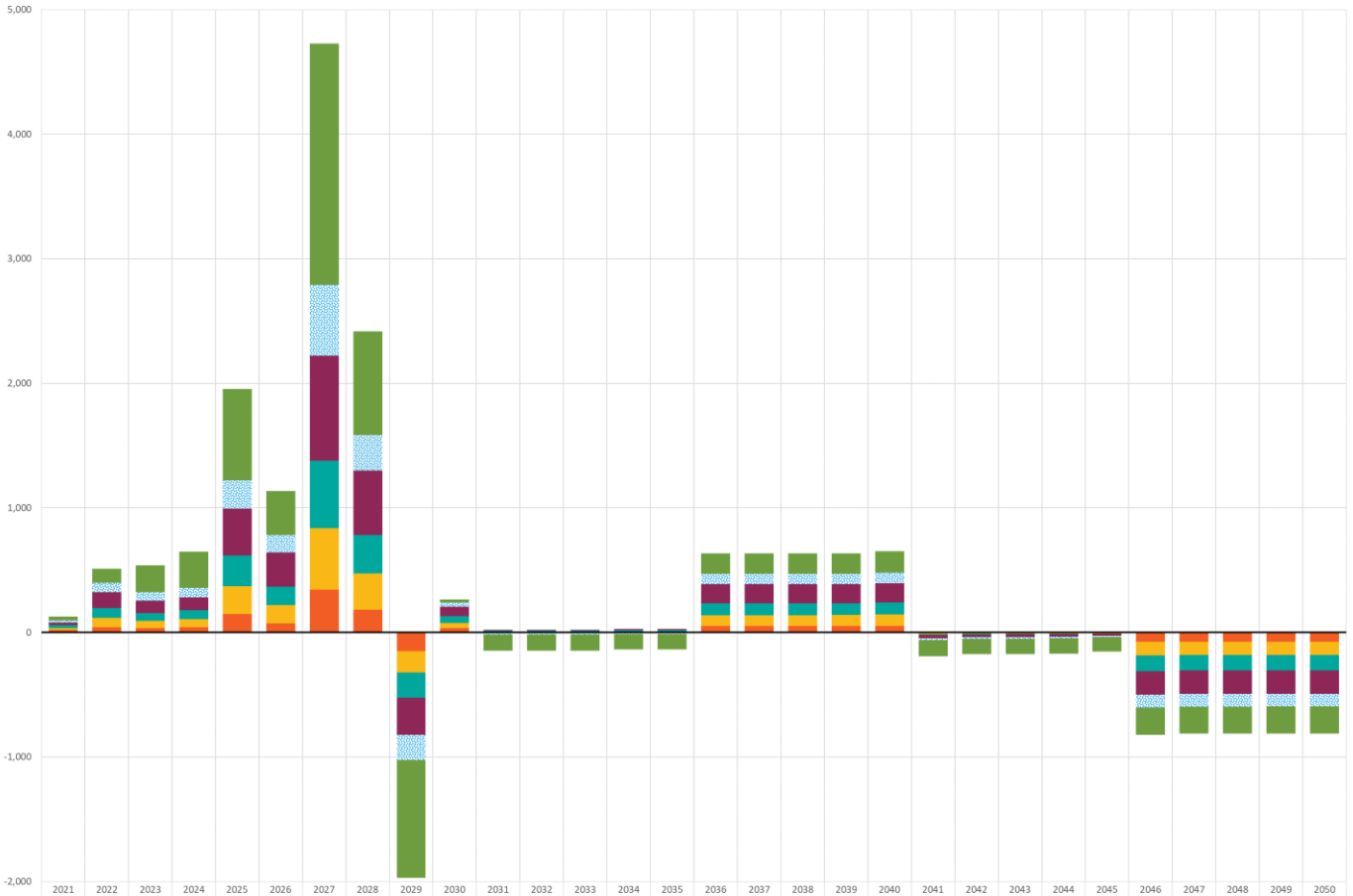
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Surveyors	0	0	0	0	73	49	202	109	-103	2	-8	-8	-8	-8	-8	18	18	18	18	18	-22	-22	-22	-22	-22	-21	-21	-21	-21	-21
Civil engineering operatives nec*	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	1	1	1	1	1	-2	-2	-2	-2	-2	-1	-1	-1	0	0
Logistics	0	0	0	0	0	0	15	23	4	2	1	1	1	1	1	5	5	5	5	5	0	0	0	0	0	-6	-6	-6	-6	-6
Plumbing and HVAC Trades	0	255	130	105	488	457	757	654	-162	131	66	66	66	66	66	250	250	250	250	250	-24	-24	-24	-24	-24	-261	-261	-261	-261	-261
Electrical trades and installation	0	0	0	0	98	100	325	180	-129	17	10	10	10	10	10	44	44	44	44	44	-15	-15	-15	-15	-15	-63	-63	-63	-63	-63
Labourers nec*	0	0	84	133	253	97	636	242	-457	-10	-45	-45	-45	-45	-45	22	22	22	22	22	-74	-74	-74	-74	-74	-43	-43	-43	-43	-43
Steel erectors/structural fabrication	0	0	0	0	0	0	0	34	17	0	0	0	0	0	0	2	2	2	2	2	-3	-3	-3	-3	-3	-1	-1	-1	-1	-1
Plant mechanics/fitters	0	0	0	0	0	0	8	27	11	3	2	2	2	2	2	8	8	8	8	8	3	3	3	3	3	-10	-10	-10	-10	-10
Plant operatives	0	0	0	0	95	38	32	79	42	-19	-16	-16	-16	-16	-16	11	11	11	11	11	-11	-11	-11	-11	-11	1	1	1	1	1
Scaffolders	0	0	24	32	55	18	351	53	-122	-16	-25	-25	-25	-25	-25	7	7	7	7	7	-26	-26	-26	-26	-26	-8	-8	-8	-8	-8
Specialist building operatives nec*	0	0	0	0	13	21	52	9	-20	-22	-16	-16	-16	-4	0	0	0	0	1	8	-9	0	0	0	0	0	0	0	0	0
Glaziers	0	6	23	30	51	15	69	42	-126	0	9	9	9	9	9	1	1	1	1	1	-21	-21	-21	-21	-21	-6	-6	-6	-6	-6
Floorers	16	24	36	42	63	21	256	67	-87	-7	-51	-51	-51	-51	-51	3	3	3	3	3	-18	-18	-18	-18	-18	-5	-5	-5	-5	-5
Roofers	0	0	0	0	44	15	311	43	-102	-15	-16	-16	-16	-16	-16	6	6	6	6	6	-24	-24	-24	-24	-24	-7	-7	-7	-7	-7
Painters and decorators	0	0	0	0	0	0	0	74	30	16	8	8	8	8	8	26	26	26	26	26	11	11	11	11	11	-35	-35	-35	-35	-35
Building envelope specialists	0	0	48	71	147	52	423	146	-285	-10	-112	-112	-112	-112	-112	9	9	9	9	9	-19	-19	-19	-19	-1	0	0	0	0	0
Construction Trades Supervisers	0	17	49	47	110	79	477	156	-136	4	-29	-29	-29	-29	-29	37	37	37	37	37	-13	-13	-13	-13	-13	-54	-54	-54	-54	-54
Non-construction professional, technical, IT, and other office-based staff	0	0	0	0	0	0	0	62	-62	0	0	0	0	0	0	0	0	0	0	9	-9	0	0	0	0	0	0	0	0	0
Other construction process managers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	-11	0	0	0	0
Construction Project Managers	111	210	147	190	466	175	818	417	-287	187	100	100	100	100	100	186	186	186	186	186	83	83	83	83	83	-290	-290	-290	-290	-290

Figure A2.2.9: Graph of FTE requirement, in addition to the 2019 workforce base, per qualification level profiled to 2050 for Wales



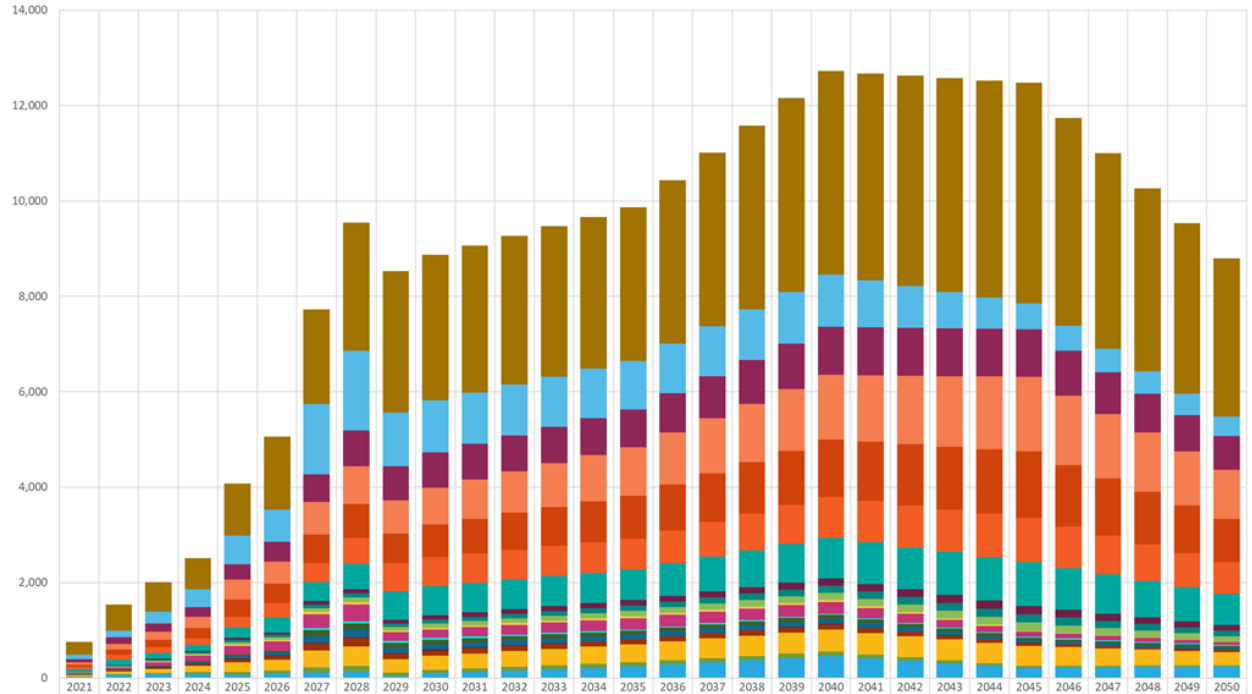
	2,021	2,022	2,023	2,024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Below NVQ level 2, other or no qualifications	32	145	363	654	1,388	1,743	3,681	4,512	3,568	3,592	3,464	3,335	3,207	3,083	2,960	3,124	3,288	3,453	3,617	3,786	3,656	3,530	3,405	3,281	3,165	2,945	2,728	2,510	2,293	2,076
NVQ level 2	17	90	158	233	459	600	1,169	1,453	1,251	1,284	1,267	1,251	1,234	1,220	1,207	1,290	1,372	1,455	1,538	1,623	1,607	1,594	1,581	1,569	1,560	1,456	1,354	1,252	1,150	1,048
NVQ level 3	19	147	245	350	730	1,003	1,847	2,364	2,063	2,138	2,145	2,151	2,158	2,166	2,175	2,330	2,484	2,639	2,793	2,950	2,926	2,904	2,882	2,860	2,842	2,653	2,465	2,277	2,089	1,901
NVQ level 4	24	104	166	237	483	630	1,171	1,480	1,279	1,333	1,342	1,351	1,360	1,370	1,381	1,474	1,568	1,662	1,755	1,851	1,844	1,840	1,835	1,832	1,830	1,705	1,583	1,461	1,339	1,217
Trade App'ships	15	91	151	216	437	584	1,078	1,370	1,200	1,243	1,244	1,245	1,246	1,248	1,251	1,339	1,427	1,515	1,604	1,694	1,682	1,671	1,661	1,651	1,643	1,534	1,426	1,318	1,211	1,103
First degree	21	61	95	138	287	361	704	887	736	771	776	781	786	792	798	849	900	952	1,003	1,056	1,055	1,056	1,057	1,059	1,062	986	911	837	763	689

Figure A2.2.10: Difference in FTE requirements for subsequent years for each qualification label profiled to 2050 for Wales



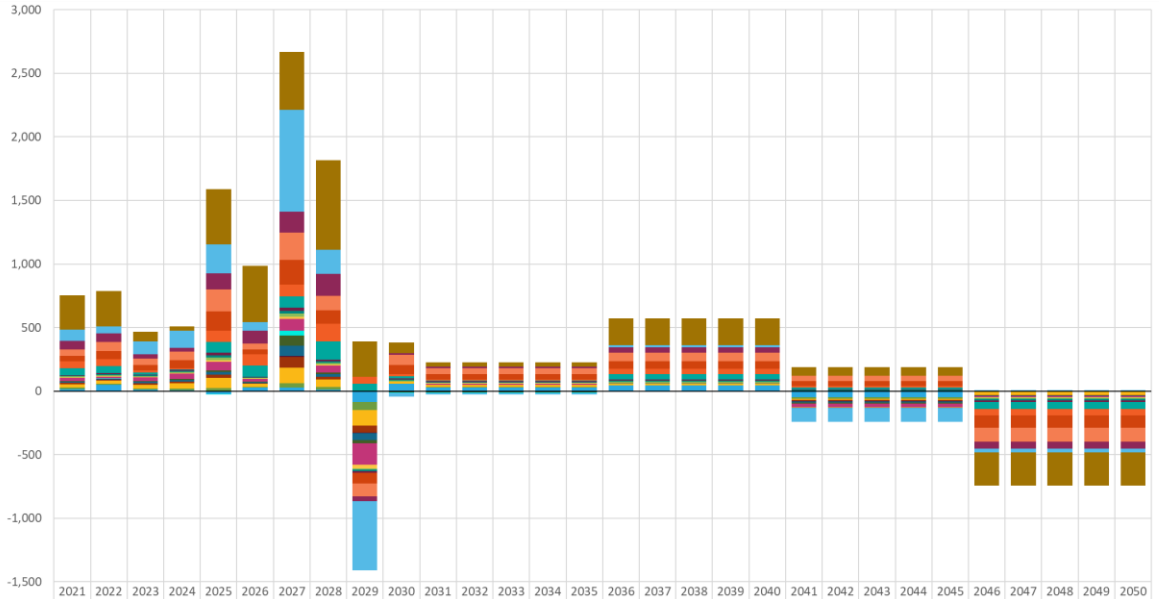
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Below NVQ level 2, other or no qualifications	32	114	218	291	734	355	1,938	831	-944	24	-128	-128	-128	-124	-123	164	164	164	165	169	-130	-125	-125	-124	-116	-220	-217	-217	-217	-217
NVQ level 2	17	74	68	75	226	140	569	284	-202	33	-17	-17	-17	-14	-13	82	82	82	83	85	-16	-13	-13	-12	-10	-104	-102	-102	-102	-102
NVQ level 3	19	127	99	104	380	273	844	517	-301	75	7	7	7	8	9	154	154	154	155	157	-25	-22	-22	-21	-18	-190	-188	-188	-188	-188
NVQ level 4	24	80	62	70	246	147	541	309	-201	54	9	9	9	10	11	94	94	94	94	96	-7	-4	-4	-3	-2	-125	-122	-122	-122	-122
Trade App'ships	15	76	60	65	221	147	494	292	-170	43	1	1	1	2	3	88	88	88	88	90	-12	-10	-10	-10	-8	-109	-108	-108	-108	-108
First degree	21	40	34	43	149	74	343	183	-151	35	5	5	5	6	6	51	51	51	51	53	-1	1	1	2	3	-76	-74	-74	-74	-74

Figure A2.2.11: FTE requirement for each specialist skill profiled to 2050 for Wales



	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Heat pump installation course	267	544	622	656	1,090	1,535	1,988	2,690	2,968	3,053	3,085	3,118	3,150	3,183	3,216	3,427	3,639	3,851	4,062	4,274	4,343	4,412	4,482	4,551	4,620	4,358	4,097	3,835	3,574	3,312
Asbestos Awareness Training	89	145	245	378	604	672	1,475	1,665	1,121	1,092	1,078	1,064	1,050	1,035	1,021	1,036	1,050	1,065	1,079	1,093	985	877	769	661	553	525	498	470	442	415
Electricity for plumbers course	69	133	166	196	321	421	583	755	716	732	743	754	765	776	787	831	874	918	961	1,005	1,002	999	997	994	992	935	878	821	764	707
Trustmark Approved Retrofit Coordinator	50	122	173	243	416	459	677	794	695	775	823	871	919	967	1,016	1,083	1,151	1,219	1,286	1,354	1,396	1,438	1,480	1,523	1,565	1,456	1,347	1,239	1,130	1,022
Trustmark Approved Retrofit Designer	44	108	154	216	370	408	602	705	618	689	732	774	817	860	903	963	1,023	1,083	1,143	1,204	1,241	1,279	1,316	1,353	1,391	1,294	1,198	1,101	1,005	908
Refrigeration, Heating & Ventilation Qualification	53	109	124	131	218	307	398	538	594	611	617	624	630	637	643	685	728	770	812	855	869	882	896	910	924	872	819	767	715	662
F Gas	53	109	124	131	218	307	398	538	594	611	617	624	630	637	643	685	728	770	812	855	869	882	896	910	924	872	819	767	715	662
Trustmark Approved Retrofit Installer	6	14	19	27	46	51	75	88	77	86	91	97	102	107	113	120	128	135	143	150	155	160	164	169	174	162	150	138	126	114
Trustmark Approved Retrofit Advisor	6	14	19	27	46	51	75	88	77	86	91	97	102	107	113	120	128	135	143	150	155	160	164	169	174	162	150	138	126	114
Trustmark Approved Retrofit Assessor	6	14	19	27	46	51	75	88	77	86	91	97	102	107	113	120	128	135	143	150	155	160	164	169	174	162	150	138	126	114
Pro-Fitter/GGF: Surveyors	5	8	13	20	32	36	52	61	32	32	34	36	38	40	42	42	43	43	43	43	38	33	28	24	19	17	16	14	13	11
Pro-Fitter/GGF: Windows and Doors - Novice/GQA Accredited	27	43	73	113	181	201	292	347	181	181	192	204	215	227	238	240	241	242	244	245	217	189	161	133	106	97	89	81	72	64
BPEC, Solar Thermal Systems NOS Mapped	0	0	0	0	0	0	40	41	43	41	37	34	30	27	23	24	25	26	27	27	27	26	25	24	24	23	23	22	22	21
BPEC, Working at Heights Access Training	4	7	12	19	30	34	114	124	99	95	91	87	83	79	74	76	77	79	80	82	76	70	64	57	51	49	48	46	44	42
BPEC, Award in the Installation and Maintenance of Small Scale Solar Photovoltaic Systems (Level 3)	9	14	24	38	60	67	147	167	112	109	108	106	105	104	102	104	105	106	108	109	99	88	77	66	55	53	50	47	44	41
CITB SMSTS (Site Management Safety Training Scheme)	1	1	3	4	6	7	16	18	14	13	12	10	8	6	4	4	4	5	5	5	5	4	4	4	3	3	3	2	2	2
Gas Smart	9	15	25	39	62	69	152	172	116	113	111	110	108	107	105	107	108	110	111	113	102	91	79	68	57	54	51	49	46	43
Diploma in smart metering	27	54	83	123	203	225	348	408	284	301	317	332	348	364	380	396	412	428	445	461	453	444	436	428	420	391	361	332	303	274
Battery Storage Systems Training course	10	16	27	42	67	74	108	128	67	67	71	75	80	84	88	89	89	90	90	91	80	70	60	49	39	36	33	30	27	24
Hydrogen boiler conversion courses	18	68	78	84	60	87	116	128	42	98	126	154	182	210	237	282	326	370	414	459	409	360	311	261	212	218	224	230	236	242

Figure A2.2.12 Difference in FTE requirements for subsequent years for specialist skills profiled to 2050 for Wales



	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Heat pump installation course	267	277	78	34	434	445	453	702	278	84	33	33	33	33	33	212	212	212	212	212	69	69	69	69	69	-262	-262	-262	-262	-262
Asbestos Awareness Training	89	56	100	134	225	68	803	191	-544	-29	-14	-14	-14	-14	-14	14	14	14	14	14	-108	-108	-108	-108	-108	-28	-28	-28	-28	-28
Electricity for plumbers course	69	65	33	30	125	101	161	172	-39	16	11	11	11	11	11	43	43	43	43	43	-3	-3	-3	-3	-3	-57	-57	-57	-57	-57
Trustmark Approved Retrofit Coordinator	50	72	51	70	173	43	218	117	-98	80	48	48	48	48	48	68	68	68	68	68	42	42	42	42	42	-109	-109	-109	-109	-109
Trustmark Approved Retrofit Designer	44	64	45	62	154	39	194	104	-87	71	43	43	43	43	43	60	60	60	60	60	37	37	37	37	37	-97	-97	-97	-97	-97
Refrigeration, Heating & Ventilation Qualification	53	55	16	7	87	89	91	140	56	17	7	7	7	7	7	42	42	42	42	42	14	14	14	14	14	-52	-52	-52	-52	-52
F Gas	53	55	16	7	87	89	91	140	56	17	7	7	7	7	7	42	42	42	42	42	14	14	14	14	14	-52	-52	-52	-52	-52
Trustmark Approved Retrofit Installer	6	8	6	8	19	5	24	13	-11	9	5	5	5	5	5	8	8	8	8	8	5	5	5	5	5	-12	-12	-12	-12	-12
Trustmark Approved Retrofit Advisor	6	8	6	8	19	5	24	13	-11	9	5	5	5	5	5	8	8	8	8	8	5	5	5	5	5	-12	-12	-12	-12	-12
Trustmark Approved Retrofit Assessor	6	8	6	8	19	5	24	13	-11	9	5	5	5	5	5	8	8	8	8	8	5	5	5	5	5	-12	-12	-12	-12	-12
Pro-Fitter/GGF: Surveyors	5	3	5	7	12	4	16	10	-29	0	2	2	2	2	2	0	0	0	0	0	-5	-5	-5	-5	-5	-1	-1	-1	-1	-1
Pro-Fitter/GGF: Windows and Doors - Novice/GQA Accredited	27	17	30	40	68	20	91	55	-167	0	11	11	11	11	11	1	1	1	1	1	-28	-28	-28	-28	-28	-8	-8	-8	-8	-8
BPEC, Solar Thermal Systems NOS Mapped	0	0	0	0	0	0	40	1	2	-2	-3	-3	-3	-3	-3	1	1	1	1	1	-1	-1	-1	-1	-1	0	0	0	0	0
BPEC, Working at Heights Access Training	4	3	5	7	11	4	80	11	-26	-4	-4	-4	-4	-4	-4	2	2	2	2	2	-6	-6	-6	-6	-6	-2	-2	-2	-2	-2
BPEC, Award in the Installation and Maintenance of Small Scale Solar Photovoltaic Systems (Level 3)	9	6	10	13	23	7	80	19	-54	-3	-1	-1	-1	-1	-1	1	1	1	1	1	-11	-11	-11	-11	-11	-3	-3	-3	-3	-3
CITB SMSTS (Site Management Safety Training Scheme)	1	1	2	1	2	1	9	2	-4	0	-2	-2	-2	-2	-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Smart	9	6	10	14	23	7	83	20	-56	-3	-1	-1	-1	-1	-1	1	1	1	1	1	-11	-11	-11	-11	-11	-3	-3	-3	-3	-3
Diploma in smart metering	27	26	30	40	80	22	123	60	-123	17	16	16	16	16	16	16	16	16	16	16	-8	-8	-8	-8	-8	-29	-29	-29	-29	-29
Battery Storage Systems Training course	10	6	11	15	25	8	34	20	-62	0	4	4	4	4	4	0	0	0	0	0	-10	-10	-10	-10	-10	-3	-3	-3	-3	-3
Hydrogen boiler conversion courses	18	50	10	6	-24	26	29	13	-86	56	28	28	28	28	28	44	44	44	44	44	-49	-49	-49	-49	-49	6	6	6	6	6

A.2.3 Route map

Critically constrained, requiring major effort and investment.
Moderately constrained, requiring significant effort and investment.
Achievable within existing resources, requiring direction.

Indicative timeline	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2035	2040	2045	2050
Cross Cutting: Consultation to establish responsibilities within route map														
Consult with standards developers, training providers and awarding bodies														
Cross Cutting: Appeal														
Marketing careers in construction														
Cross Cutting: Embedding Decarbonisation into all Built Environment NVQs														
Assess existing content and coverage														
Develop new training syllabus														
Inter-trade awareness														
Low-carbon systems														
Implementation on new training syllabus														
Cross Cutting: Embedding Operational Performance Gap into all Built Environment NVQs														
Assess existing content and coverage														
Develop new training syllabus														
Implementation on new training syllabus														
Hydrogen Changeover														
Assess/agree numbers that need changeover hydrogen qualification vs moderate or extensive training														
Training syllabus and certification process agreement and development														
Review/ agree if sign off on a certain number of installations is required to move from a qualified installer to accredited installer														
Assessment of existing training capacity/ facilities and development needs														
Develop further training facilities if required														
Recruit train the trainers														
Deliver train the trainer training														
Recruit training and accreditation assessors														
Recruitment of surveyors and engineers for hydrogen conversions														
Deliver changeover hydrogen qualification training (existing gas safe engineers)														
Deliver moderate/ extensive hydrogen training (ex gas safe engineers/ new entrants)														
Deliver accredited installer assessments														
Retrofit Building Surveyors (Increasing Numbers)														
Assess current training capacity/ facilities against potential numbers of building surveyors needed, and development need														
Develop further training facilities if required														

Recruit train the trainers													
Increase capacity of trainers													
Recruit training assessors													
Recruitment of potential surveyors (new entrants)													
Deliver surveyor qualification training													
Retrofit Assessors (PAS2035) Training for Existing Building Surveyors (Links to Building Passports)													
Roll out existing certified PAS2035 Retrofit Assessor training syllabus and certification process													
Review / agree if sign off on a certain number of surveys is required to move from a qualified surveyor to an accredited surveyor													
Develop further training facilities if required													
Recruit train the trainers													
Deliver train the trainer training													
Recruit training/ accreditation assessors													
Recruitment of potential surveyors (from existing surveyor base)													
Deliver surveyor qualification training													
Deliver accredited surveyor assessments													
Further develop/ roll out survey protocols and templates													
Retrofit Traditional (Pre 1919) Assessors Training for Existing Building Surveyors (links to Building Passports)													
Roll out of SQA accredited Level 3 Award qualification Energy Efficiency Measures for Older and Traditional Buildings to existing surveyors													
Review / agree if sign off on a certain number of surveys is required to move from a qualified surveyor to an accredited surveyor													
Develop further training facilities if required													
Recruit train the trainers													
Deliver train the trainer training													
Recruit training/ accreditation assessors													
Recruitment of potential surveyors (from existing surveyor base)													
Deliver surveyor qualification training													
Deliver accredited surveyor assessments													
MMC Retrofit: Surveyors Training Where MMC Retrofit to be Installed (links to Building Passports)													
Develop an accredited qualification for MMC Retrofit surveying for existing surveyors. (Focuses on for example laser measuring and structural load bearing for external cladding systems)													
Review / agree if sign off on a certain number of surveys is required to move from a qualified surveyor to an accredited surveyor													
Develop further training facilities if required													
Recruit train the trainers													
Deliver train the trainer training													
Recruit training/ accreditation assessors													
Recruitment of potential surveyors (from existing surveyor base)													
Deliver surveyor qualification training													
Deliver accredited surveyor assessments													
Retrofit Designers (Increasing Numbers)													
Assess current training capacity/ facilities against potential numbers of retrofit designers needed; and development need													
Develop further training facilities if required													
Recruit train the trainers													
Deliver train the trainer training													
Recruit training assessors													

Recruitment of potential designers (new entrants)
Deliver surveyor qualification training
MMC Retrofit: Designers
Training syllabus and certification process agreement and development.
Assess current training capacity/ facilities against potential numbers of qualified designers needed; and development need
Review / agree if sign off on a certain number of designs are required to move from a qualified designer to an accredited designer
Develop further training facilities if required
Recruit train the trainers
Deliver train the trainer training
Recruitment of designers
Deliver designer qualification training
Retrofit Co-ordinator (PAS2035) (Including Operational Performance Gap)
Roll out of retrofit co-ordinator qualifications (e.g. existing Level 5 Diploma in Retrofit Coordination and Risk Management)
Review/ agree if sign off on a certain number of installations is required to move from a qualified co-ordinator to accredited co-ordinator
Assess current training capacity/ facilities against potential numbers of qualified coordinators needed; and development need. (Welsh Retrofit Skills Academies/ Retrofit Academy/ BSI/ Trustmark key stakeholders here)
Develop further training facilities if required
Recruit train the trainers
Deliver train the trainer training
Recruit training/ accreditation assessors
Recruitment of retrofit co-ordinators (from existing construction project management base)
Deliver retrofit co-ordinator qualification training
Deliver accredited retrofit co-ordinator assessments
Retrofit (Fabric First) Installers - Insulation, Airtightness, and Glazing Installers/ technicians (including detailing/ operational performance gap)
Retrofit (Fabric First) Installers - Insulation, Airtightness, and Glazing Installers/ Technicians (Including Detailing/ Operational Performance Gap)
Assess current training capacity/facilities against potential numbers of qualified installers needed
Development of additional fabric first course syllabus (critically including detailing, operational performance gap and quality assurance)
Review/ agree if sign off on a certain number of installations is required to move from a qualified installer to accredited installer
Develop further training facilities if required
Recruit train the trainers
Recruit training and accreditation assessors
Deliver train the trainer training
Deliver installer training
Deliver accredited installer assessments
MMC Retrofit – Installers/ Project Managers

Assess current training capacity/facilities against potential numbers of qualified installers needed														
Development of additional MMC retrofit course syllabus (critically including logistics, operational performance gap and quality assurance)														
Review/ agree if sign off on a certain number of installations is required to move from a qualified installer to accredited installer														
Develop further training facilities if required														
Recruit train the trainers														
Recruit training and accreditation assessors														
Deliver train the trainer training														
Deliver installer training														
Development of a standard skills card system and accreditation process to allow installers to move between manufacturers														
Deliver accredited installer assessments														
Heat Pump Changeover														
Assess current training capacity/facilities against potential numbers of qualified HP installers needed (GSHP and ASHP)														
Training syllabus and certification process agreement and development (GSHP and ASHP)														
Review/ agree if sign off on a certain number of installations is required to move from a qualified installer to accredited installer														
Assessment/ development of training centre capacity (GSHP and ASHP)														
Assess capacity to deliver ground loop installations (GSHP installation only)														
Develop further training facilities if required														
Recruit training and accreditation assessors (GSHP and ASHP)														
Recruitment of potential designers and installers on heat pump installation (GSHP and ASHP) (existing fossil fuel boiler installers and new entrants)														
Deliver heat pump qualification training (GSHP and ASHP)														
Deliver ground loop installations training (GSHP only)														
Assess and increase capacity to deliver F Gas and Part P certificate training (GSHP and ASHP) as required														
Deliver F Gas and Part P certificate training (GSHP and ASHP)														
Deliver accredited installer assessments														
Onsite PV, Solar Thermal and Energy Management Systems														
Assess current training capacity/ facilities against potential numbers of qualified installers needed; and development need														
Develop further training facilities if required														
Recruit train the trainers														
Deliver train the trainer training														
Recruit training assessors														
Recruitment of potential PV/solar thermal installers														
Deliver PV/ solar thermal qualification training														
Assess and increase capacity to deliver required Working at Heights and Part P certificate training as required														
Deliver Working at Heights and Part P certificate training														
Heat Networks: Project Developers														
Assess current capacity to provide on-the-job experience against potential numbers of experienced project developers needed														
Assess current resources and mentoring groups for project developers														

Engineering graduates gaining 5 years+ on the job experience sitting alongside existing project developers on heat network schemes, to become experienced project developers
Heat Networks: Project Designers
Assess current capacity to provide on-the-job experience against potential numbers of experienced project designers needed
M&E Design Graduates need 2 years+ on the job experience to be Heat Network Designer Engineer
Heat Networks: Commissioning Base
Contracting commission base - specialist delivery contractors/installers
Assess current training capacity/ facilities against potential numbers of qualified installers needed; and development need
Develop further training facilities if required
Recruit train the trainers
Deliver train the trainer training
Recruit training assessors
Deliver Working at Heights and Part P certificate training
Clerk of works (Including Performance Gap)
Training syllabus and certification process agreement and development
Assessment of existing training capacity/ facilities and development needs
Recruit train the trainers
Deliver train the trainer training
Recruitment of Clerks of Works
Deliver Clerk of Works qualification training
New Build: Planning
Develop syllabus integrating sustainability into Planning
Implement syllabus among existing planners, and in training
New Build: Future Homes Standard Type Assessors
Assess current training capacity/facilities against potential numbers of qualified assessors required (BREEAM assessor equivalents)
Review/ agree if sign off on a certain number of buildings is required to move from a qualified assessor to for example accredited assessor
Develop further training facilities if required
Recruit train the trainers
Deliver train the trainer training
Recruit training assessors
Deliver training
Deliver accredited assessor assessments
Policy
Develop retrofit incentive mechanism
Owner-occupiers (residential and commercial)
Landlords
Public sector
Local Authority
Housing Associations
Develop Building Passports
Support for Modern Methods of Construction
New build
Retrofit

Performance Gap													
Mandatory licensing													
Procurement													
Develop procurement templates for new-build and retrofit projects which include measures to ensure quality construction													
Organisational competence													
Encourage development of quality management systems													
Oversight													
Covered in Clerk of Works training													
Require Clerk of Works oversight as a condition of Planning (Building Control in Scotland)													

A.2.4 Standard interventions

The numbers in the table below refer to the interventions detailed in Section A.2.4.2 below, and show how they have been applied to different building types.

Interventions **(CCC in bold)**	Domestic	Non domestic	Traditional (domestic) (pre 1919)
Loft insulation	1		
Cavity wall insulation	2		
External Solid wall insulation	3		3
High-rise cladding		4	
Internal wall insulation	5		
Floor insulation (solid and suspended)	6	7	
Glazing	8	9	8
Hydrogen, biogas	10		
Direct electric heating	11		
Heat pumps	12	13	12
Heat networks	14		
Thermal storage	15		15
Heat distribution	16		17
On-site generation	18		
Smart systems	19	20	19
Solar thermal	21		
Airtightness and heat recovery	22	23	22
Retrofit (additionality only)	24	25	26
New-build (additionality only)	27	28	

A.2.4.1 Standard buildings

Average 3 bed semi-detached house (Domestic and Traditional) – 2 storey. External dimension 6.5m x 6.5m by 5m high walls, brick construction. 210m^2 total wall area. Windows 10@ 2x1m = 20m^2 glazing. Internal wall insulation (excluding abutting wall) 140m^2. Cavity wall insulation or external wall insulation on 3 walls – 140m^2, taking account for the internal abutting wall.

6.5m x 6.5m = 42m^2. Therefore 40m^2 internal ground floor insulation. 80m^2 total floor area for underfloor heating. Loft footprint = 40m^2. Total sq meterage = 80m^2 total footprint.

Average high rise block (Domestic and/or Commercial) - 10 storey, 30m (19 windows per floor x 2 walls x 10 storeys)x 20m (12 windows per floor x2 walls x 10 storeys) x 40m high = external envelope 24,000m^2 and 620 window tower block. If windows account for 50% of the façade then 12,000m^2 of cladding required.

A.2.4.2 Intervention details

1. **Loft insulation retrofit** (Domestic and could data be applied to a proportion of Traditional as well if needed) - 200mm of loose fill insulation into a 3 bed semi-detached house, typical access, 40m^2 loft footprint[120]
2. **Cavity wall insulation retrofit** (Domestic) – Average 3 bed semi-detached house – 2 storey. External dimension 6.5m x 6.5m x 5m high walls. Cavity wall insulation on 3 walls using glued polystyrene beads– 140m^2. Include job types and time associated with initial survey (e.g. borescope inspection), planning, installation and supervision/ quality assurance.
3. **Low rise external solid wall insulation retrofit** (Domestic, Low rise commercial and some traditional) – Average 3 bed semi-detached brick house – 2 storey. External dimension 6.5m x 6.5m x 5m high walls. External wall insulation on 3 walls (total 140m^2) using a lightweight, low thermal conductivity, rigid phenolic foam external wall insulation system (100mm insulation thickness) with a render finish. Include job types and time associated with the design/ specification process as well as the installation.
4. **High rise cladding retrofit** (Domestic and Commercial) - 10 storey, 30m (19 windows per floor x 2 walls x 10 storeys)x 20m (12 windows per floor x2 walls x 10 storeys) x 40m high = external envelope 24,000m^2 and 620 window tower block. If windows account for 50% of the façade then 12,000m^2 of cladding required. Include job types and time associated with the design/ specification

[120] Average UK home 85m2 floor area, so half of that/ assuming two storey.
https://www.bbc.co.uk/news/uk-14916580

process, preparation and the installation (including supervision/quality assurance) of a rendered external wall insulation systems incorporating Mineral Fibre insulation in the form of rigid batts which are directly attached to the wall using a combination of adhesive bonding and mechanical fixing, with a fully reinforced, polymer-enhanced cementitious basecoat is applied directly onto the insulation. To include:

- Preliminary Works & Application – structural survey to understand if walls can withstand additional load exposed by the insulation system. Design and specification. Assume the retrofit is undertaken using mast climbers with scaffold protection at ground floor level to maintain safe access. (account for and estimate job types and time for installation, if possible). Some typical preparatory works and adaptations (i.e. rainwater goods/waste pipes/ overflow outlets/soil stacks/boiler flues/roof overhang/BT works/satellite dishes, etc.) are also completed before installation.
- Direct Fix Application: External Wall Insulation System. With insulation boards being mechanically fixed and/or adhesively bonded with supplementary mechanical fixings. After fixing, the boards receive a cementitious base coat and glass fibre alkali resistant reinforcing mesh, corner reinforcements and a finishing second coat of cementitious bedding mortar.

5. **Internal solid wall insulation retrofit** (Traditional and Domestic) - Average 3 bed semi-detached house – 2 storey. Internal wall insulation (including abutting wall) 140m^2. Include job types and time associated with the design/ specification process, stripping back wall (presume plaster and wallpaper) and the installation (including supervision/quality assurance) of general purpose, rigid polyisocyanurate (PIR) insulation board laminated to 12.5 mm plasterboard.
6. **Solid floor insulation retrofit** (Domestic)- Average 3 bed semi-detached house – 2 storey ~6.5m x 6.5m = 42m^2. Therefore 40m^2 internal ground floor insulation required on a solid concrete floor, remove original screed layer and replace with thinner screed layer and vacuum insulated panels (VIPs) to minimise the loss of floor-to-ceiling height. Include job types and time associated with the design/ specification process, stripping of some existing carpet and screed and the installation (including supervision/quality assurance) of new screed and VIPs.
7. **Suspended floor insulation retrofit** (Traditional)- Average 3 bed semi-detached house – 2 storey ~6.5m x 6.5m = 42m^2. Suspended floor, therefore 40m^2 internal ground floor insulation requiring removal of floor boards, cutting of rigid insulation, and slotted between the floor joists, plus reinstatement of floor boards.
8. **Glazing retrofit** (Domestic and Traditional) - Average 3 bed semi-detached house – 2 storey. Windows 10@ 2x1m = 20m^2. Currently single gazed timber frame, require removal and replacement with uPVC double glazed units throughout.
9. **Glazing retrofit** (Commercial) - 10 storey, 30m (19 windows per floor x 2 walls x 10 storeys)x 20m (12 windows per floor x2 walls x 10 storeys) x 40m high = 620 window tower block ~ 12,000m^2 of glazing replacement required. Include job

types and time associated with the design/ specification process, preparation and the installation (including supervision/quality assurance) of new double glazing. Assume currently single glazed metal frame, require removal and replacement with uPVC double glazed units throughout. Assume the retrofit is undertaken with a mix of internal and external access on a typical job e.g. using mast climbers with scaffold protection at ground floor level to maintain safe access.

10. **Hydrogen boiler retrofit installation** (Domestic, Traditional, extrapolate to commercial) – Whilst we recognise that this technology is still at prototype stage and not commercially available, it would be valuable to have feedback on the estimated installation requirements in a typical 3 bed domestic semi-detached property associated with the conversion of a gas mains boiler to hydrogen boiler. Including job types and time associated with any of the following required:
    - Initial surveys to assess the condition of the gas pipework and undertake an inventory of the gas appliances and gas tightness test will be required to test the integrity of the pipework; (BEIS study - 1-2 hrs[121])
    - Pre-conversion preparations to the property, assuming existing pipework is welded (soldered) copper and requires replacement (; and,
    - The installation of a new hydrogen boiler (BEIS study 1 day) and conversion of a hob, oven and gas fire (BEIS study - ½ day each); and any quality assurance/ testing.
11. **Direct electric heating retrofit** – (Domestic) Average 3 bed semi-detached house with 10 existing electric resistive and storage heaters being replaced with modern equivalents. Include job types and time associated with survey/specification process, removal of old heaters and installation of new (including supervision/quality assurance).
12. **Heat pump retrofit** (Domestic and Traditional) – Installation of an air source heat pump (air to water monobloc system) and new hot water tank into an average 3 bed semi-detached property, replacing an existing gas boiler and hot water tank. Include job types and time associated with the specification process, preparation and the installation (including supervision/quality assurance). Assuming some minor additional pipework to connect the ASHP, but that the existing wet radiator system doesn't require additional work.
13. **Heat pump retrofit** (Non domestic) - Installation of a ground source heat pump in a commercial building linked to a cascaded system of three 45kW ground source heat pumps and a borehole ground array, connecting to existing internal heating infrastructure. Include job types and time associated with the specification

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121 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/760508/hydrogen-logistics.pdf

process, preparation and the installation (including supervision/quality assurance).

14. **Heat networks.**

    Assumed to be based on low-temperature 4th and 5th generation networks, requiring additional equipment in buildings to raise temperature to a useful level. Additional time is allocated based on figures for heat pump installation, for retrofit applications in both residential and non-residential context. For new-build, the additional work required to connect to existing heat network infrastructure is deemed to be no greater than the installation of business as usual heating systems.

15. **Thermal storage retrofit installation** (Domestic, Traditional), e.g. water tank or phase change (cf. Sunamp). Average 2 storey, 3 bed semi-detached house with existing air source heat pump requires installation of a 7kWh phase change heat battery. Include job types and time associated with the specification process, preparation and the installation (including supervision/quality assurance).
16. **Heat distribution – underfloor heating** (Domestic) – Average 3 bed semi-detached house with existing 8 radiator wet system and an ASHP. The property needs the removal of the existing wet system and installation of a water-based low profile under floor heating system, total floor area 80m^2. Include job types and time associated with the specification process, preparation and the installation (including supervision/quality assurance), assuming removal of radiators and some existing plumbing required along with connection to ASHP.
17. **Heat distribution radiator installation** (Traditional) Average 3 bed semi-detached house with 8 radiators, being replaced with 8 modern wet radiators, no the modification required. Include job types and time associated with the specification process, preparation and the installation (including supervision/quality assurance).
18. **Onsite generation via PV retrofit** (Domestic, Commercial, Traditional) – Average 2 storey, 3 bed semi-detached house with a tiled sloping roof. Installation of 4 KWp system made up of 16 standard panels (~ 28m² of the roof area), associated roof racking, inverter installation and associated electrical connection. Include job types and time associated with the specification process, preparation and the installation (including supervision/quality assurance).
19. **Smart systems** – domestic. Installation of a smart, connected system monitoring consumption and controlling temperatures down to the level of zones or individual rooms. Capable of modulating consumption based on time-of-use tariffs, grid carbon intensity or other signals.
20. **Smart systems** – non-domestic. Installation of a Building Energy Management System capable of monitoring and controlling zones, and of modulating consumption based on occupancy
21. **Solar Thermal Panels Retrofit** – Average 2 storey, 3 bed semi-detached house with existing combi boiler. Installation to include 2 x flat plate solar thermal panels to roof and a new 160 litre hot water cylinder plus some associated plumbing to connect to the combi boiler system and create a modulating combi

22. preheat system with solar tempering valve. Include job types and time associated with the specification process, preparation and the installation (including supervision/quality assurance).

[122]

23. **Airtightness and heat recovery** – domestic and traditional. Air-tightness improvement programme including testing and draft-stripping to achieve a maximum of 7 m3/hr/m2 of air loss at a pressure of 50 Pa.
24. **Airtightness and heat recovery** – Non-domestic. Air-tightness improvement programme including testing and draft-stripping to achieve a maximum of 10 m3/hr/m2 of air loss at a pressure of 50 Pa.
25. **Domestic retrofit**. Excluding the on-site activities covered elsewhere in this survey, all activities required to design and co-ordinate a domestic retrofit programme in the standard domestic dwelling, in compliance with PAS 2035.
26. **Non-domestic retrofit**. Excluding the on-site activities covered elsewhere in this survey, all activities required to design and co-ordinate a non-domestic retrofit programme in the average high-rise block, in compliance with PAS 2035.
27. **Traditional retrofit**. Excluding the on-site activities covered elsewhere in this survey, all activities required to design and co-ordinate a retrofit programme in a traditional building, in compliance with PAS 2035.
28. **Domestic new-build.** Excluding the on-site activities covered elsewhere in this survey, all activities required to deliver a domestic new-build project based on the standard domestic dwelling.
29. **Non-domestic new-build.** Excluding the on-site activities covered elsewhere in this survey, all activities required to deliver a non-domestic new-build project based on the standard high-rise building.

[122] https://www.solartwin.com/solartwin-features/basic/plumbing-in-solar-thermal-to-a-combi-boiler-combination-boiler-geyser/

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