Retrofitting traditional buildings – helping progress to net zero

An analysis of the current skills gap and economic impacts of implementing a full retrofit programme for traditional buildings

A report for Grosvenor, the National Trust, Historic England, Peabody and The Crown Estate

CAPITAL ECONOMICS

27 September 2022

Alexandra Dreisin, Andrew Evans, Moneli Hall-Harris and Kaine Wright

Contents

Basis of engagement

Capital Economics is a leading independent international macro-economic research consultancy, providing research on Europe, the Middle East, United States, Canada, Africa, Asia and Australasia, Latin America and the United Kingdom, as well as analysis of financial markets, commodities and the consumer and property sectors.

We produce publications for world-wide distribution and offer support to clients in their respective time-zones through our offices in London, New York, Toronto and Singapore.

In addition, we undertake bespoke research projects commissioned by companies, government agencies, and trade associations. We have helped our clients to produce substantial and detailed research, to present to investors and shareholders and to lobby government bodies. Our independent reports are used to plan for the future, influence internal business decisions, and to shape public opinion. We have the experience, the resources and the capability to meet tight deadlines and cater to the most specific of briefs.

Our economists work closely with clients throughout all projects to ensure they are satisfied with the final product, and that the content is clear, relevant and accessible to the target audience.

Disclaimer: This research has been commissioned by Grosvenor from Capital Economics, an independent macroeconomics research consultancy. The views expressed remain those of Capital Economics and are not necessarily shared by Grosvenor.

While every effort has been made to ensure that the data quoted and used for the research behind this document is reliable, there is no guarantee that it is correct, and Capital Economics Limited and its subsidiaries can accept no liability whatsoever in respect of any errors or omissions. This document is a piece of economic research and is not intended to constitute investment advice, nor to solicit dealing in securities or investments.

Our full terms and conditions of business, and the basis for any engagement we may undertake for you, are available on demand.

Aim of the report and acknowledgements

- Capital Economics was commissioned by Grosvenor to estimate the number of workers required to carry out an example retrofit programme on traditional properties across the UK to help progress towards to net zero.
- The purpose of this report is to provide indicative estimates of the number and type of skilled workers required to complete a programme of retrofitting traditional buildings under different scenarios.
- Although an indicative programme of work is used in the analysis, the report should not be used to advocate for specific interventions to be deployed across the traditional building stock. The scope of the report does not extend to assessing the quality of workers or the best way to up-skill workers to conduct retrofitting work on traditional buildings.
- Capital Economics would like to thank the following parties for their contributions to the report: The Crown Estate, Drakon Heritage, Grosvenor, Historic England, the National Trust, Peabody, PJ Harte and Seddons.

Executive summary

Capital Economics has been commissioned by Grosvenor to research and report on the current skills gap and economic impacts of implementing a full retrofit programme across the UK in the context of progressing to net zero. The key findings are:

Reducing building emissions will help to achieve net zero and retrofitting traditional properties has large role to play

- Buildings are responsible for nearly one fifth of the UK's greenhouse gas emissions.
- Government net zero policy has focused on reducing the operational carbon emissions of the UK's existing properties. These are the emissions from the use of buildings and appliances within them. Policies include minimum EPC rating standards, heat pump targets, and the phase out of gas boilers. Meeting these targets will require most properties to undertake some degree of retrofitting; 80% of buildings that will be present in 2050 exist today.
- The UK has around 6.7 million traditional properties and improving their energy performance will play a key role in helping the UK to achieve net zero.

The construction sector is facing a shortage of skilled labour, and there are competing demands for workers' time

- Since the start of 2021, pandemic-related factors and Brexit have contributed to skills shortages in construction. Labour supply is estimated to continue to be squeezed by Brexit and an ageing workforce.
- Strong investment and a projected 8.7 million rise in the number of households between 2020 and 2050 will drive demand for construction work. We forecast construction sector output to be 58% larger in 2050 than it was in 2021, which will require an additional 1.1 million construction jobs to be filled.
- While overall demand for construction workers increases, the Construction Industry Training Board (CITB) estimates that for the built environment to achieve net zero, the construction industry will need an additional 350,000 workers.
- Retrofitting traditional properties requires additional expertise and experience to follow the dual mandate set out by the British Standards Institution of preserving heritage significance and improving energy efficiency. A 2019 report by CEBR estimates that in the heritage sector overall, about half of which relates to construction, eleven per cent of employers reported a skills gap, while six per cent identified a skills shortage.

Executive summary

Carrying out a retrofit programme on the UK's stock of traditional properties could require between 57,000 and 166,000 workers

- Quantifying the number of *additional* workers needed to carry out an example retrofit programme on traditional properties requires an estimate of how many workers are already in the sector who could feasibly carry out the work. We estimate that there are currently 100,000 workers working with traditional buildings in occupations relevant to retrofit.
- In our base case, to help the UK reach net zero, we generate a scenario where all traditional properties receive loft insulation, window glazing, low energy lighting, heat pumps and mechanical ventilation. All interventions are installed at a constant rate. Some buildings will have external and internal wall insulation, but not all traditional buildings will be suitable for wall insulation.
- Under the base case retrofit scenario, in addition to the 100,000 workers already working in relevant sectors, we estimate that an average of 105,000 additional full-time equivalent workers will be required each year between 2021 and 2050. The demand for the total number of skilled workers is likely to be greater as it is unlikely that all workers will spend all of their working hours retrofitting.
- As with all forecasts, there are significant uncertainties around the modelling assumptions; we therefore run various sensitivity and scenario analyses which suggests that the average increase in workers required ranges from an annual average of 57,000 to 166,000.
- Delaying the ramp up of the retrofit programme is projected to lead to a backlog of work and a surge in demand for workers in the 2030s.
- Relative to current employment levels by occupation, the projected need for skilled workers to deliver a retrofit programme for traditional properties is most acute for scaffolders, planners/designers, plasterers and window glaziers/fitters.

Filling the skills gaps to deliver a retrofit programme for traditional properties will stimulate economic activity

- Ensuring that the workforce has the skills to retrofit traditional properties will have knock-on benefits for the rest of the economy. Output from retrofitting traditional properties will stimulate spending in firms' supply chains and generate revenues for other businesses in both construction and other sectors of the economy. Meanwhile, workers will spend their incomes on goods and services.
- In total, £35 billion of output will be supported annually under our base case scenario, which in turn supports around 290,000 jobs.

1. The UK built environment and net zero

- In 2019, around seventeen per cent of greenhouse gas emissions came from buildings, with over three-quarters of this from residential buildings, and the rest from non-residential.
- Government net zero strategy has targeted the reduction of operational carbon of existing residential buildings. Key policies include the phasing out of gas boilers and targets for the installation of heat pumps.
- The UK has around 6.7 million traditional properties and improving their energy performance will play a key role in helping the built environment reach net zero by 2050.

Reducing emissions of building stock will help to achieve net zero by 2050

Buildings account for 17% of UK Greenhouse Gas emissions

The UK government made a legal commitment in June 2019 to achieve net zero greenhouse gas emissions by 2050. In Scotland, the government target is 2045.[1]

Improving the carbon efficiency of buildings, both in the construction process, and the use of buildings, will prove integral to achieving net zero. In 2019, around seventeen per cent of greenhouse gas emissions came from buildings, with over three-quarters of this from residential buildings, and the rest from non-residential.[2]

Operational carbon emissions are targeted by policymakers

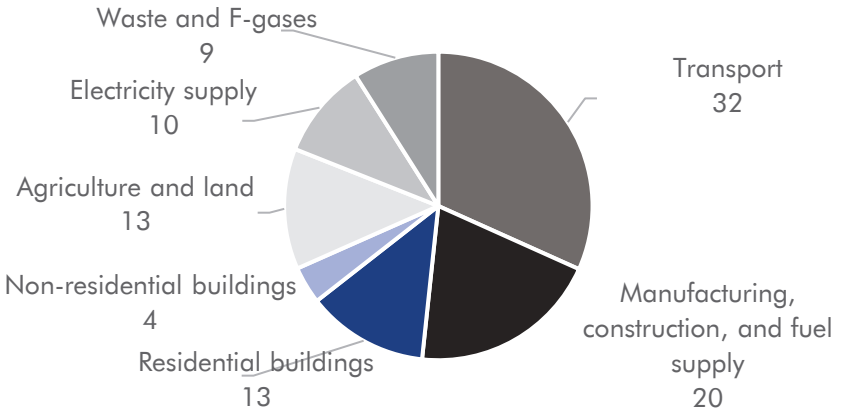
Emissions from buildings can generally be split into two forms:

1. Operational carbon – emissions from the use of buildings, e.g., heating water, lighting and appliances, cooking, and ventilation.
2. Embodied carbon – emissions from construction, repair and maintenance, and demolition of buildings, along with the extraction, manufacturing and transportation of materials and equipment used.

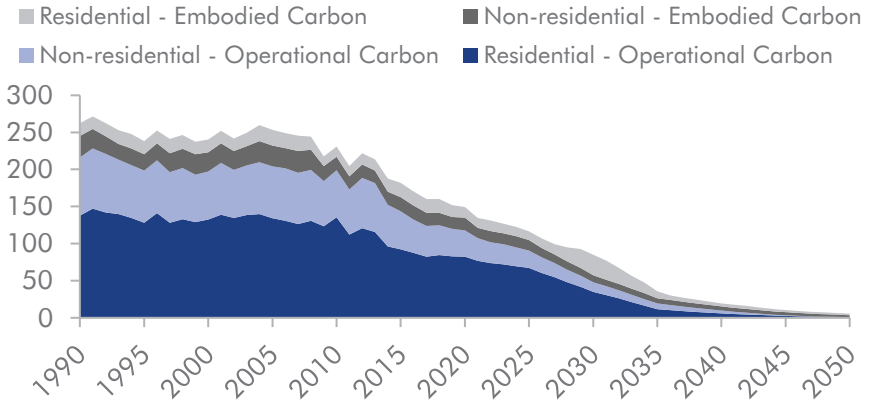
In 2018, buildings' operational carbon was estimated to be over three times higher than their embodied carbon. (See bottom chart.) As such, policies have focused on reducing emissions from the use of buildings. The net zero trajectory laid out by the Green Building Council models a drastic reduction in operational carbon over the next thirty years.[3]

However, construction work will always be associated with embodied carbon emissions and construction activity is forecast to continue to grow. (See page 25.) Therefore, there will also be a need for policy to focus on reducing emissions in order to tackle climate change.

UK greenhouse gas emissions by sector (2019, share of UK emissions, %)



Net zero trajectory recommended by the UK Green Building Council for residential and non-residential buildings ($MtCO_2e$)



Sources: Capital Economics, Top chart: Climate Change Committee, *The Sixth Carbon Budget Dataset,* 2021. Bottom chart: UK GBC, *Net Zero Whole Life Carbon Roadmap for the Built Environment*, 2021.

Government policy focuses on emission abatement in existing residential buildings, particularly through low-carbon heat

The government published its 'Net Zero Strategy' in October 2021. Policies include ending the sale of new petrol and diesel cars by 2030 in favour of electric vehicles, plans to decarbonise the UK's power system by 2030, and delivering 5GW of hydrogen production capacity by 2030 to halve emissions from gas and oil.[4]

In addition, the accompanying 'buildings and heat' strategy outlined targets to end the installation of gas boilers by 2035, to install 600,000 heat pumps a year by 2028, and to trial hydrogen heating in a village.[5] These policies add to pre-existing targets for Energy Performance Certificate (EPC) ratings. [6]

Key policies for heat and buildings outlined in the 2021 'Net Zero Strategy' and EPC requirements

Energy Performance Certificate (EPC) ratings

- In 2017, the government committed to getting rented homes to EPC C by 2030 (proposals have been made to bring this forward to 2028) and owner-occupied homes by 2035.

Boilers

- Ambition that by 2035, no new gas boilers will be sold
- New £350 million three-year Boiler Upgrade Scheme. Households will be offered up to £5,000 for low-carbon heating systems.

Heat pumps

- New £60 million Heat Pump Ready programme to support the government's target of 600,000 installations a year by 2028.

Hydrogen

- Launch Hydrogen Village trial to inform decision on role of hydrogen in heating system by 2026

Sources: Capital Economics, and HM Government, *Net Zero Strategy: Build Back Greener* (HH Associated Ltd: London) and *Heat and Buildings Strategy* (HH Associated Ltd: London), and Department for Business, Energy, & Industrial Strategy, *Clean Growth Strategy* , October 2017.

Modelling by the CCC points to low carbon heat being a key avenue to reduce around 75% of the emissions from residential buildings

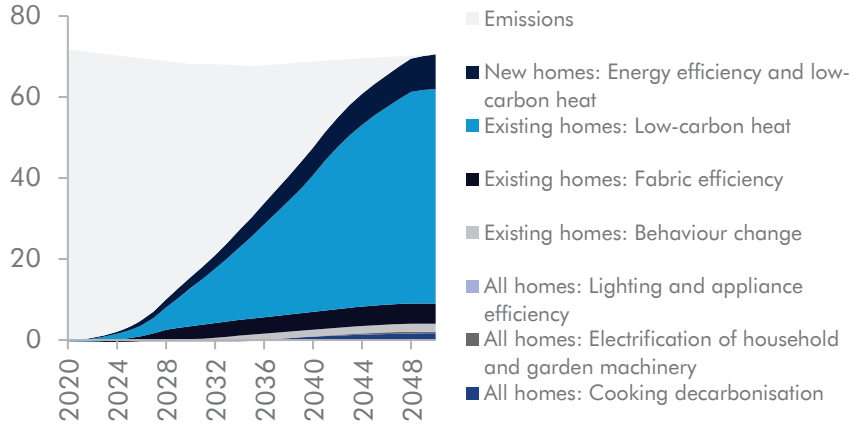
CCC modelling points to low carbon heat as a policy solution

The Climate Change Committee (CCC) published its 'Sixth Carbon Budget' in 2020.[7] The report used a bottom-up approach to produce a set of pathways which could be followed to help to achieve the net zero target and eliminate buildings emissions by 2050. The CCC's central scenario, the 'Balanced Net Zero Pathway' considered four main avenues to reduce emissions from residential and non-residential buildings: behaviour change, increasing the energy efficiency of the building stock, improving the energy efficiency of lighting and electrical appliances, and switching away from fossil-fuel based heat. Some specific assumptions used included the following:

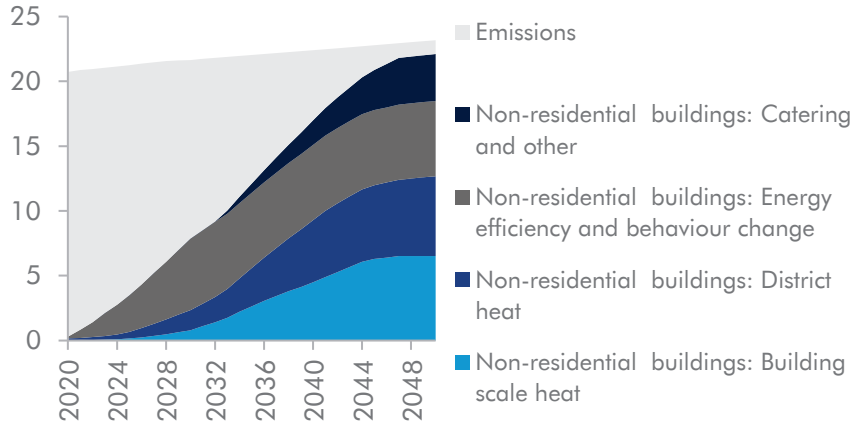
- Fifteen million homes receive wall, roof or floor insulation and a further eight million receive draught-proofing.
- Rapid scale-up of supply chains, e.g., loft insulations rise from 27,000 insulated in 2020, to over 700,000 each year by 2025.
- By 2030, heat pump sales reach over one million each year in new and existing homes.
- Hydrogen trials are scaled up to enable rapid grid conversion from 2030 onwards.
- Low-carbon heat networks are built over 2020-2050.
- Commercial properties deploy faster than residential, phasing out high-carbon fossil boilers by 2026 and 2033 for gas boilers.

The CCC recorded residential building emissions at 72 $mtCO_2e$ in 2020. According to their central scenario, by 2050, 53 $mtCO_2e$ which is equivalent to 75% could be abated using low-carbon heat in existing homes. (See top chart.) For non-residential buildings, district heat interventions will play a key role. (See bottom chart.) [8]

CCC net zero pathway residential buildings emissions abatement ($mtCO_2e$)



CCC net zero pathway non-residential buildings emissions abatement ($mtCO_2e$)



Sources: Capital Economics and Climate Change Committee, 'Sector explorer' in *The Sixth Carbon Budget Dataset,* 2021. Available from https://www.theccc.org.uk/2021/02/01/the-numbers-behind-the-budget-six-ways-to-explore-the-sixth-carbon-budget-dataset/

With focus being on existing buildings, effective retrofits are seen to play a key role

Retrofitting requires understanding all elements of a building

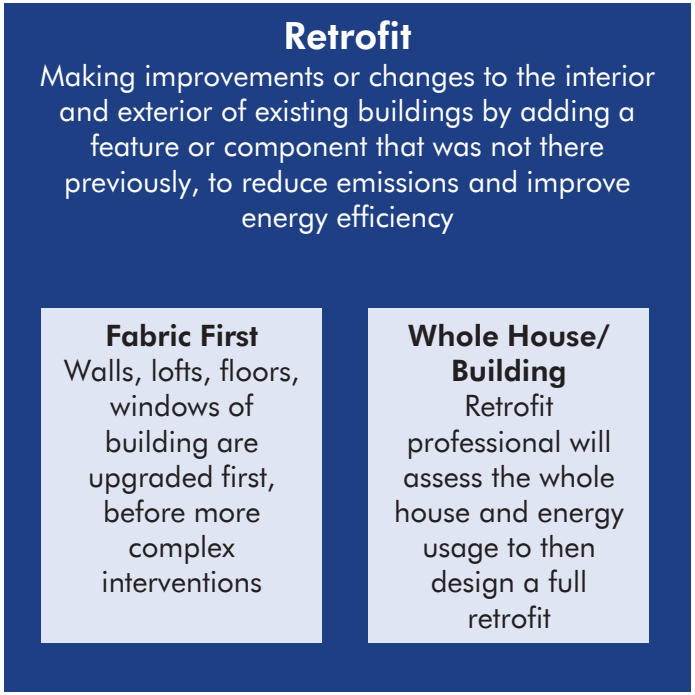
Carrying out a retrofit involves making improvements or changes to the interior and exterior of existing buildings by adding a feature or component that was not there previously, often with the aim of reducing emissions and improving energy efficiency. [9,10] The Constructive Leadership Council describe retrofitting as an 'integrated approach' and highlight the need for 'quality in design, installation and customer care'. [11]

Retrofitting therefore requires an understanding of how all elements of a building work together. A retrofit is different from a renovation or refurbishment of a building but carrying out a retrofit may involve some of the same processes.

There are two main approaches to retrofitting:

1. A 'fabric first' approach, whereby walls, lofts, floors, windows, of the building are upgraded first, ensuring insulation and ventilation are sufficient. Then more complex interventions such as heating, hot water or lighting systems are tackled.
2. A 'whole house' approach, whereby a retrofit professional will assess all components of the house and the energy used and design a full retrofit.

Examples of retrofitting interventions on buildings



Sources: Capital Economics, CITB, Historic England and Construction Leadership Council

There are around 6.7 million traditional properties in the UK, many of which will require energy improvements

We define traditional properties as those built pre-1919

We define traditional properties as those built pre-1919 in this report. We have estimated the stock of UK traditional properties by combining a range of sources, including data from the Valuation Office Agency, breakdowns by property type from a 2020 Historic England publication, and data for Scotland and Northern Ireland from the countries' statistics offices and official housing surveys. (See appendix page 49 for detailed sources.) We estimate that there are around 6.7 million pre-1919 properties in the UK as of 2021.

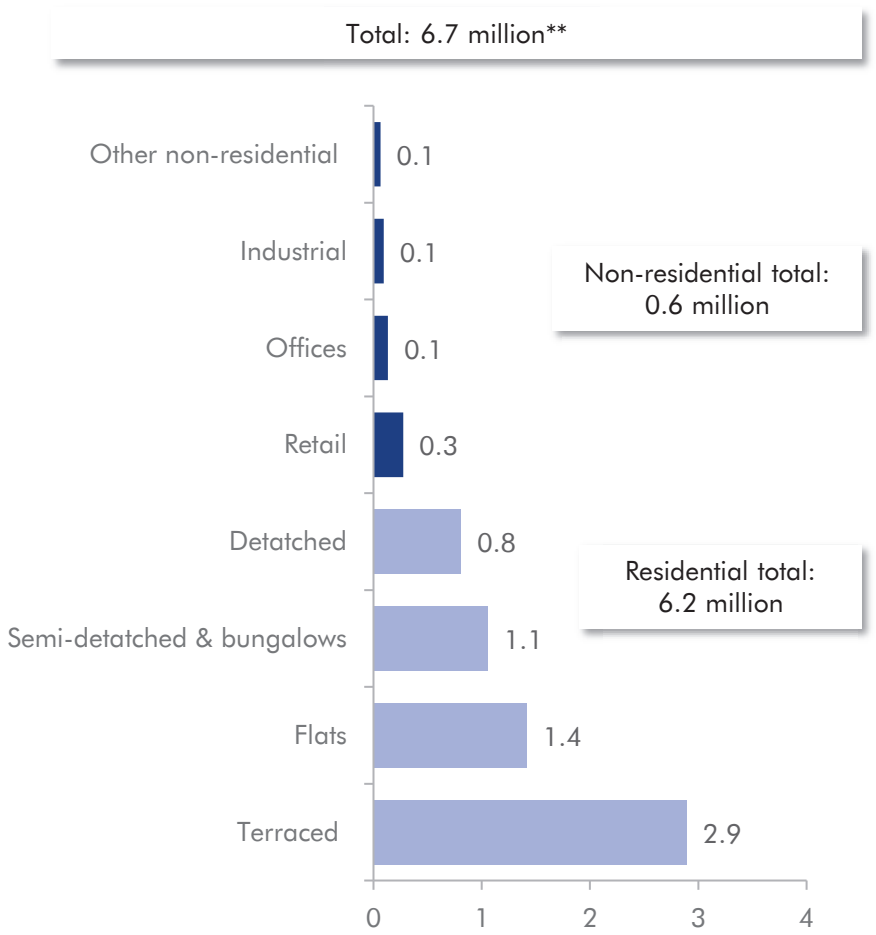
Retrofitting needs to tackle both residential and non-residential properties

There are around 6.2 million traditional residential properties, which equates to 21% of the UK's total residential housing stock. This share varies by region ranging from around 30% in Wales to around eleven per cent in Northern Ireland.[12] (See top left chart on page 14.)

We estimate that there are 0.6 million non-residential properties built pre-1919. This is a sizeable proportion of the non-residential property stock. In 2015, in England and Wales, traditional properties made up a third of all non-residential properties.[13] Around half of the non-residential traditional stock is used for retail.[14] (See bottom left chart on page 14.)

Although we estimate that there are over ten times as many residential traditional properties as non-residential in the UK, the retrofit job will be sizeable for both sectors. Our calculations for the average floorspace suggests a traditional industrial property could be over seven times the size of a traditional terraced house.[15] (See bottom right chart on page 14.)

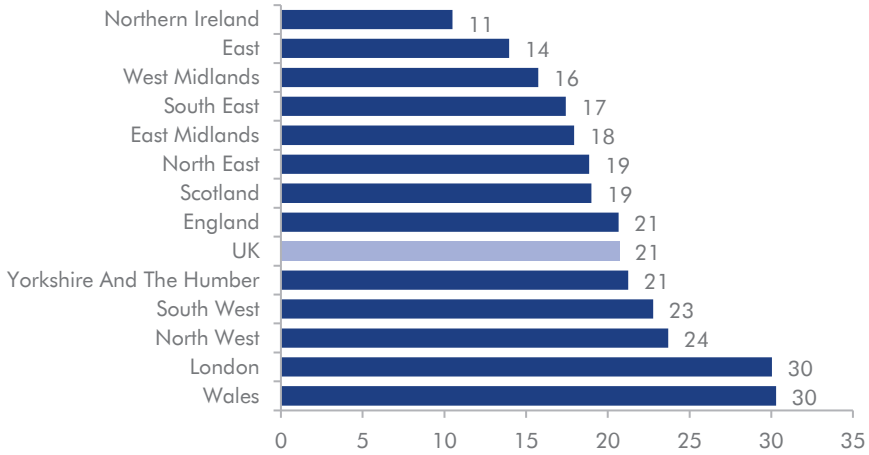
UK traditional buildings stock by type*, 2021 (millions)



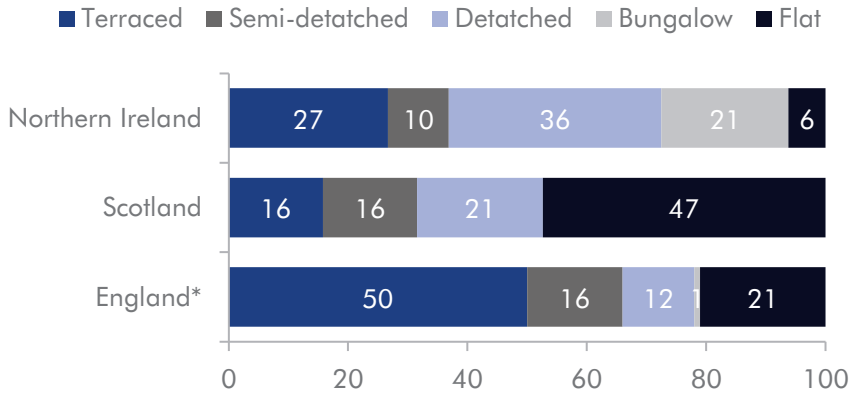
Sources: Capital Economics, Valuation Office Agency, Historic England, Scottish Government, Historic Scotland, English Heritage, CITB, Open Data Northern Ireland, and Ministry of Housing English Housing Survey. (See page 49 for detail.) *Note: assumptions were made for non-residential properties in Northern Ireland and the breakdown by use-class for both Northern Ireland and Scotland. **Breakdowns do not sum to 6.7 million due to rounding.

Traditional properties vary by type across the regions of the UK

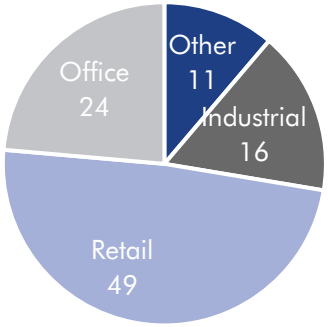
Share of residential buildings built pre-1919 as a share of total residential buildings in a given region (%)



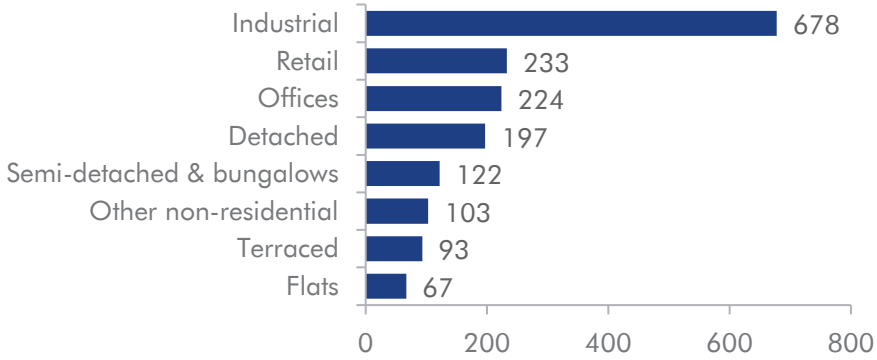
Share of residential buildings built pre-1919 broken down by property-type (%)



Share of non-residential buildings in England and Wales built pre-1919 broken down by end-use (%)



UK traditional buildings average floorspace by property type** (square metres)



Sources: Capital Economics, Valuation Office Agency (VOA), Historic England, Scottish Government, Historic Scotland, English Heritage, CITB, Open Data Northern Ireland, and Ministry of Housing English Housing Survey. (See page 49 for detail.) Notes: *Wales data unavailable so modelling assumes same breakdown as England average. **Capital Economics estimates. Average residential floorspace estimated used Ministry of Housing, Communities & Local Government, *Floor space in English homes*, July 2018. Non-residential floorspace estimated using data on average non-residential floorspace by region from VOA (all property ages) and adjusting based on the ratio of average residential property floorspace (all ages) relative to average residential property floorspace (pre-1919).

A properly retrofitted traditional property has been projected to have lower overall carbon emissions by 2050 than a new build

Opportunity to reduce emissions by retrofitting traditional stock

According to official EPC ratings, older properties are less likely to be energy efficient. Energy Performance Certificates (EPC) classify the energy efficiency of a property. Government policy has set requirements for properties to have a rating of at least C, but the English Housing survey found over 80% of houses built before 1919 did not meet this standard in 2019. [16] However, a 2020 report published by Historic England notes that the EPC rating method does not accurately reflect the energy usage of traditional buildings.[17] Regardless, there is an opportunity to reduce carbon emissions by retrofitting older buildings.

Embodied carbon savings are one of many benefits

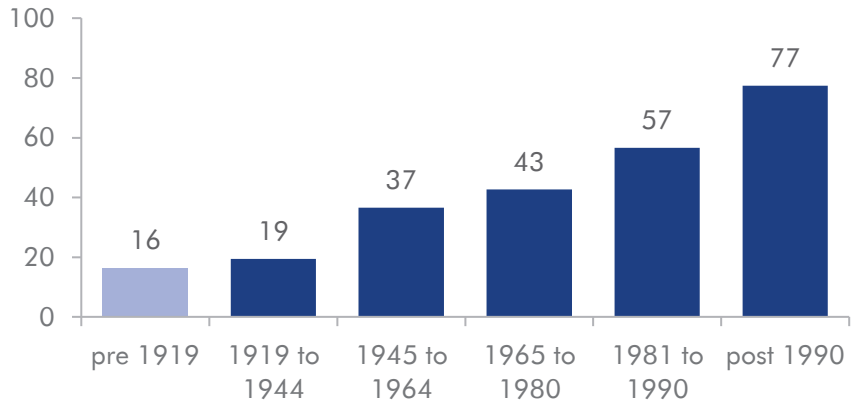
Evidence demonstrates that refurbishment and retrofit is more efficient than demolition and rebuild.

First, the embodied carbon emissions associated with new builds are significantly higher than from retrofitting. Heritage Counts found that nearly a third of carbon emitted by a new building is embodied carbon, compared to less than ten per cent for a retrofitted traditional property. A 'typical' traditional building that is properly retrofitted is projected to have lower overall carbon emissions by 2050 than a new build.[18]

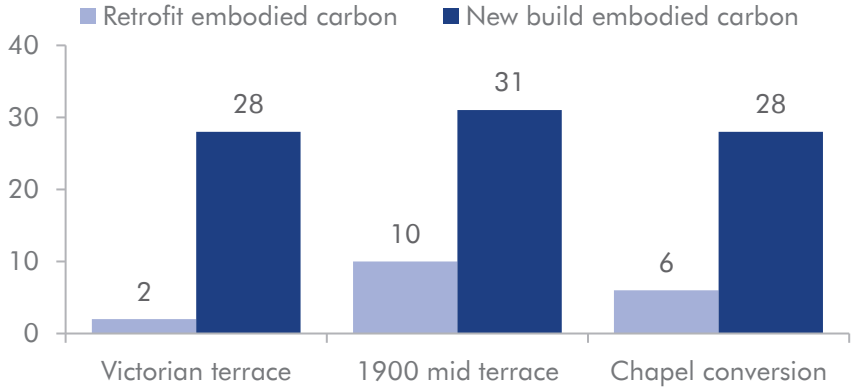
Second, these buildings are valued by society. Evidence shows that there is a premium associated with the character and distinctive nature of heritage assets. [19] Non-residential traditional properties are increasingly being converted into multiple residential properties. [20]

Third, the heritage sector, which includes multiple industries such as tourism and construction, brings revenue to the economy and supports jobs. In a 2020 study, CEBR found that the heritage sector added an estimated £14.7 billion to UK gross value added in 2019.[21]

Share of homes in England with an EPC rating of A, B or C by property age, 2019 (%)



Share of a residential building's total emissions which are embodied carbon from retrofitting versus building new (%)



Sources: Capital Economics, (top chart): Department for Levelling Up, Housing and Communities and Ministry of Housing, Communities & Local Government, *English Housing Survey Energy Report 2019-20, Energy efficiency profile,* 2021. (bottom chart): Historic England, *Know your home, know your carbon: reducing carbon emissions in traditional homes,* 2020, p.46.

2. Outlook for UK construction sector and skills shortages

- Between 2009 and 2019, the compound annual growth rate of output from the construction sector averaged 2.5% per annum, outperforming the 2.1% seen for the economy as a whole. This has largely been driven by strength in demand for new housing and infrastructure.
- Since the start of 2021, pandemic-related factors and Brexit have contributed to skills shortages in construction. In March 2022, 53% of respondents to a RICS survey noted skills shortages, and 74% reported labour shortages as a factor limiting production. These are record-highs for the survey.
- Labour supply will continue to be squeezed by Brexit and an ageing workforce, given that a fifth of construction workers are over the age of 55.
- Strong investment and a projected 8.7 million rise in the number of households between 2020 and 2050 will drive demand for construction work. We forecast the sector to be 58% larger in 2050 than it was in 2021, which will require an additional 1.1 million construction jobs to be filled.

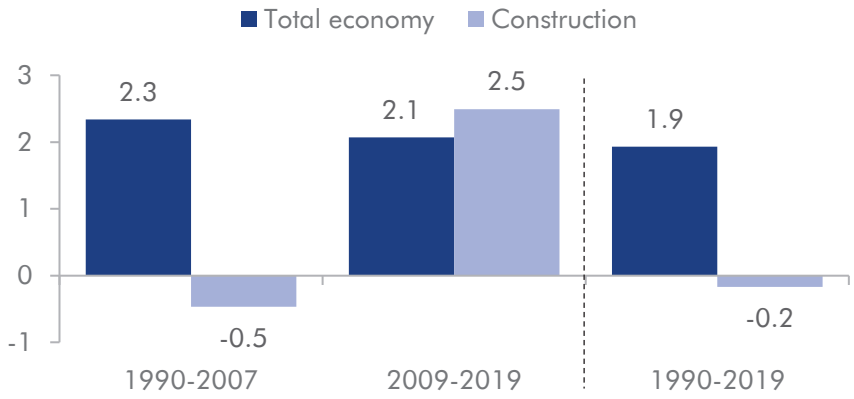
Construction output has picked up since the Global Financial Crisis

The UK construction industry directly contributed £129 billion to the economy in 2021, equivalent to 6.2% of economic output.[22]

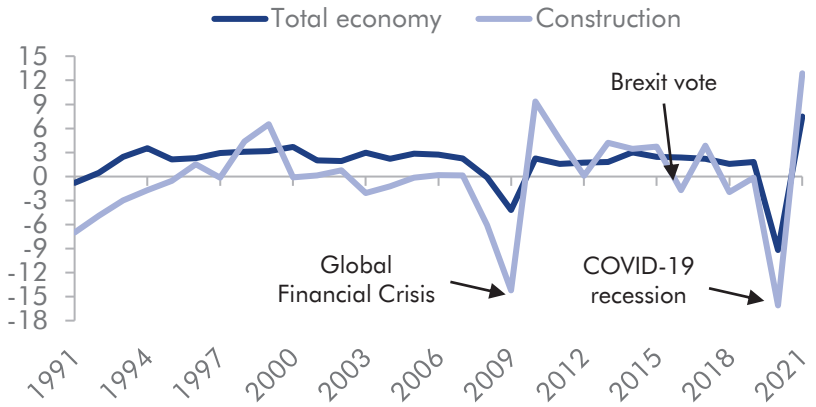
The sector has grown strongly over much of the past decade as it recovered from the recessionary depths of the 2008 Global Financial Crisis. After adjusting for inflation, construction gross value added expanded at a compound annual rate of growth of 2.5% between 2009 and 2019 compared to 2.1% per annum for the economy as a whole.[23]

However, construction has grown at a slower pace than the economy over the longer-term. While gross domestic product increased by an average of 1.9% from 1990 to 2019, construction output has fallen by an average of 0.2% per annum. Slower than average growth over a prolonged period has seen the industry's share of the economy fall from over 11.0% in 1990 to its current 6.0% in real terms.[24]

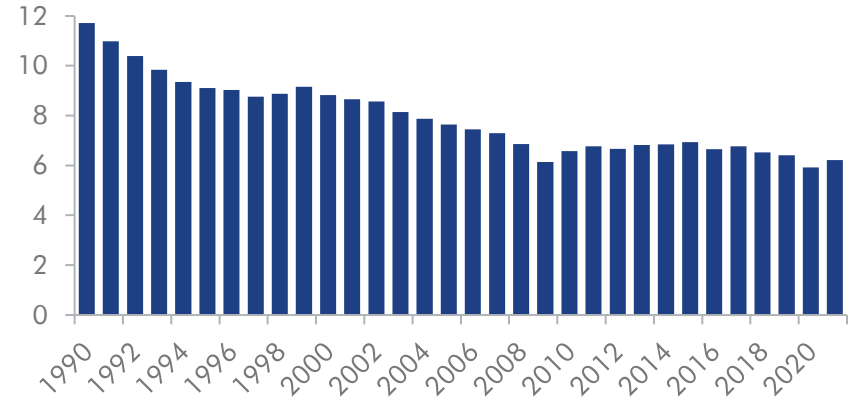
Growth in total UK economy and construction output (2019 prices, compound annual growth, %)



UK total economy and construction real gross value added (2019 prices, year-on-year change, %)



UK construction real gross value added as a share of total economy (2019 prices, %)



Sources: Capital Economics and the Office for National Statistics, *GDP output approach UK Quarter 1 2022*

Growth has largely been driven by demand for new housing and infrastructure work, rather than repair and maintenance work on homes

R&M is the second largest construction segment

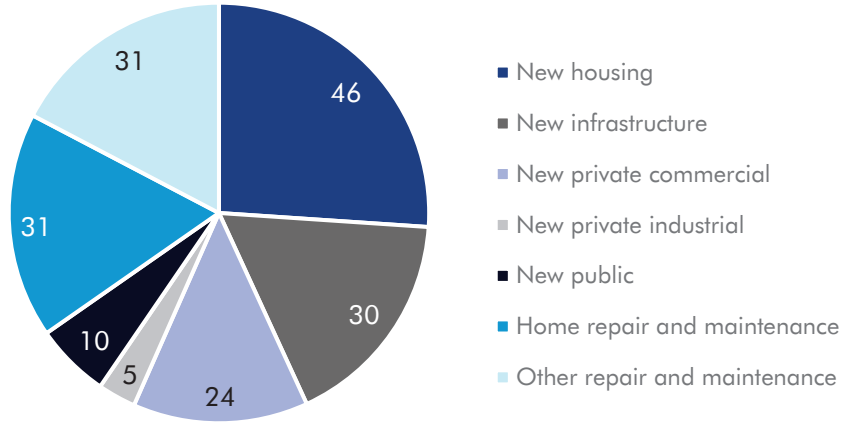
New work accounted for roughly two-thirds of the value of all construction output in 2021, and housing is the largest single contributor, delivering £46 billion of output. Repair and maintenance on homes is the second largest output segment with £31 billion of work completed in 2021, closely followed by repair and maintenance on other buildings and infrastructure. The repair and maintenance sectors include retrofitting work.[25]

Housing R&M has been held back by weak income growth

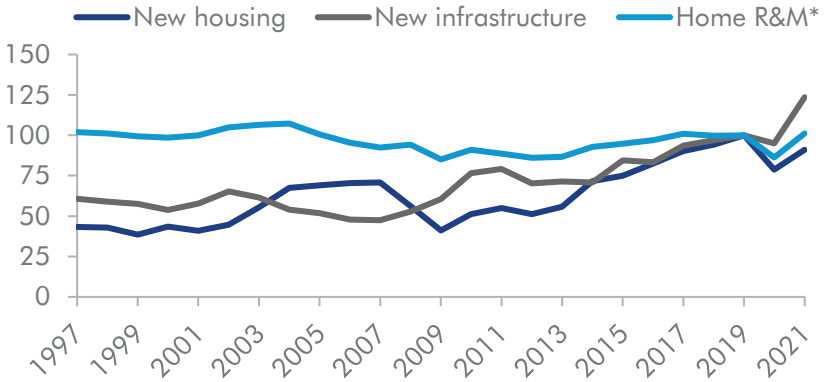
Over both the longer term and in more recent years construction output growth has been driven by new housing and new infrastructure work. In the five years to 2019, the output of new housing and new infrastructure rose by 40% and 41%, respectively. A shortage of homes and supportive government policies have helped drive strong home growth figures, while infrastructure has benefited from higher public investment.[26]

In contrast, home repair and maintenance work, which includes conversions of non-residential premises to homes as well as improvements, repairs and maintenance work (including retrofitting), increased by just seven per cent in the five years to 2019, as real household disposable incomes remained under pressure following the financial crisis.[27]

Value of construction output in Great Britain (£ billion, current prices, 2021)



Construction sector output in Great Britain by type of work (index, 2019=100)



Sources: Capital Economics and the Office for National Statistics, *Output in the construction industry reference tables March 2022*. *Home repair and maintenance includes work on: home improvements, such as extensions and new kitchens and bathrooms; repairs and maintenance; conversion of non-residential premises to homes

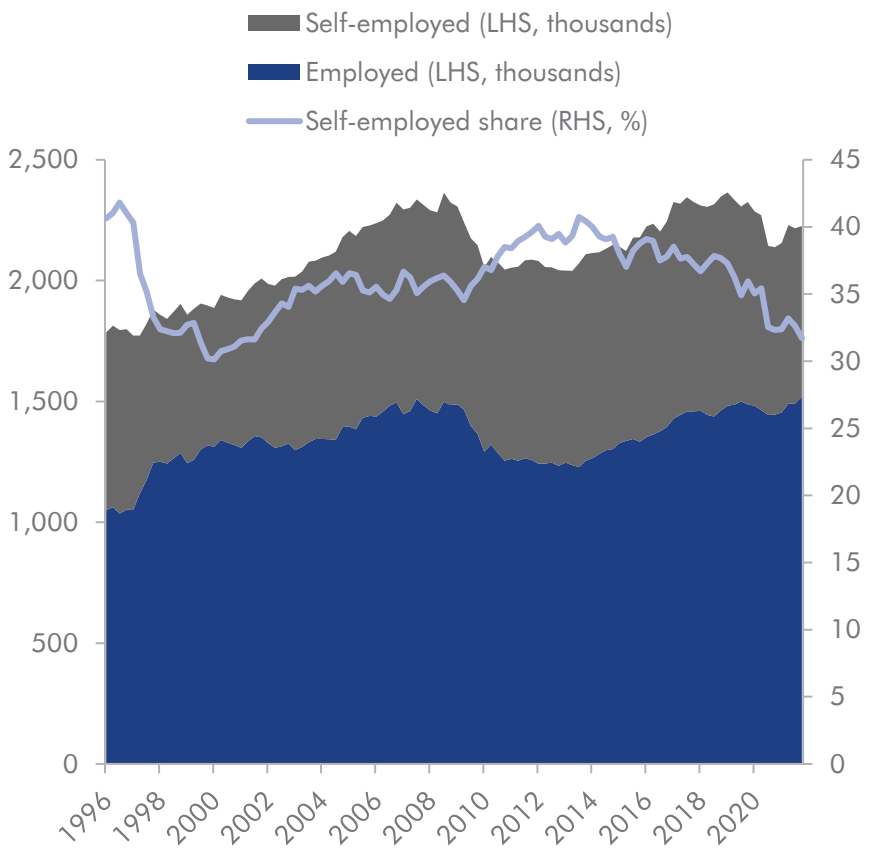
Employment in the construction sector has rebounded since the pandemic

Nearly one-third of the construction workforce is self-employed

There were 2.2 million jobs in the construction industry in 2021, accounting for 6.3% of all jobs in the UK. Roughly 32% of the construction workforce is self-employed, compared to eleven per cent of the workforce as a whole.[28]

Employment in construction fell during the Global Financial Crisis and struggled to recover in the following years, only returning to its 2008 level in 2019. With the onset of the COVID-19 global pandemic in 2020, employment in construction fell again. However, the sharp decline in construction output in 2020 was not fully reflected in job losses, with significant support coming from the UK Government's furlough scheme. Employment fell by "only" about five per cent in 2020, compared to a sixteen per cent fall in output. The fall in construction employment that did occur, however, was driven largely by falls in self-employment, with falls in the number of self-employed construction workers making up 77% of the fall in construction employment between the end of 2019 and the end of 2020. Since then, employment in construction has rebounded, with nearly 88,000 more people employed in construction in Q4 2021 than the same time the year before.[29]

UK construction employment (thousands) and self-employed share of total employment



Sources: Capital Economics and the Office for National Statistics, Jobs by Industry

Skills shortages have quickly re-emerged as output has recovered

42% of firms reported skills shortages during 2014 to 2019

As the construction sector recovered from the Global Financial Crisis, skills shortages quickly re-emerged. Skills shortages occur when firms struggle to find candidates with the right skills to fill vacancies, compared to skills gaps which are where existing employees do not have all the required skills to successfully conduct all aspects of their role.

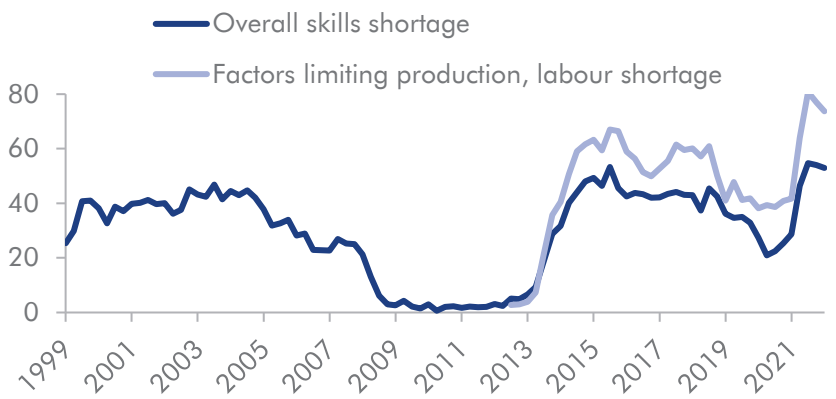
Between 2014 and 2019, an average of 42% of respondents to a Royal Institute of Chartered Surveyors (RICS) survey reported experiencing skills shortages, while 55% cited labour shortages as a factor constraining production.

Since the start of 2021, the share of respondents reporting these shortages has risen to the highest levels on record. By March 2022, 53% of respondents reported they were experiencing skills shortages, whilst 74% cited labour shortages as a factor to limiting production. A combination of pandemic-related factors and Brexit contributed to these shortages.[30]

Record number of unfilled jobs at the start of 2022

These acute skills shortages have pushed vacancies to record levels, as employers struggle to find skilled staff. At the beginning of 2022, job vacancies in the construction industry had risen to the highest level since official records began in 2001. In the three months from February to April, unfilled jobs rose to 49,000, just over 81% higher than the previous February to June period. This equates to around 3.3 vacancies for every 100 jobs in the industry.[31]

Factors limiting building activity and share of respondents reporting skills shortages in the UK (%)



Construction vacancies in the UK (thousands)

Sources: Capital Economics, RICS, Office for National Statistics and Refinitiv

A fifth of the construction workforce is aged 55 or over and most will have retired by 2030

The population and labour force are ageing

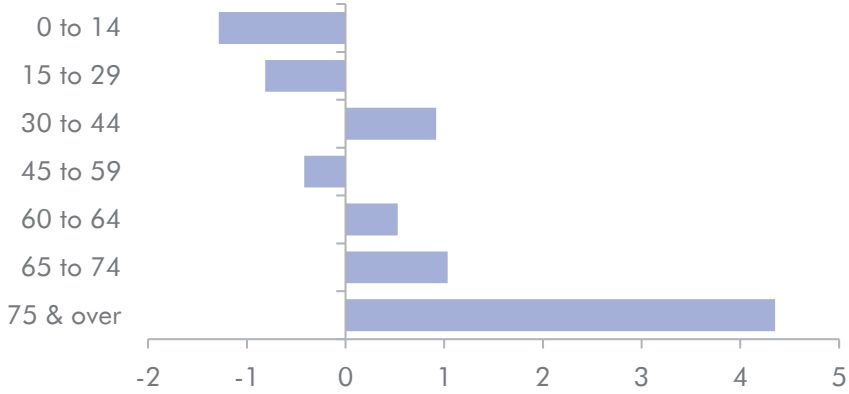
The UK's population is ageing and this will constrain the labour pool from which the construction sector can draw. Although official projections are for the population to expand by 4.3 million by 2050, the population aged 15 to 59 is expected to fall by 0.3 million. In contrast, the number aged between 60 and 74 years old is projected to increase by 0.8 million, but a 4.4 million rise in those aged 75 and over accounts for the bulk of the growth.[32]

The physical demand of construction is a concern for older workers

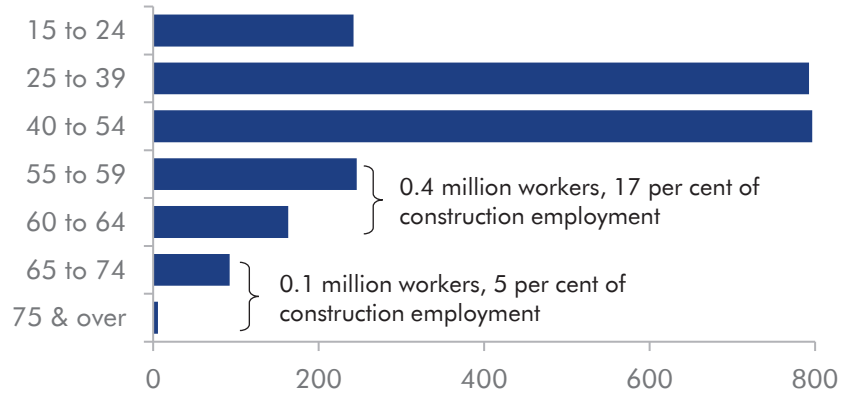
The ageing population is reflected in the age profile of those employed in construction. In 2019, nearly 0.1 million workers, five per cent of the workforce, were aged 65 or over. A further 0.4 million, seventeen per cent of the sector's workforce, were aged between 55 and 64 and the bulk of this cohort will have reached or surpassed their state pension age by 2030 and are likely to retire.[33]

While the increase in the state pension age to 67 and beyond may help keep some construction workers in the workforce for longer, a concern for the industry is the physical ability of older workers to continue in the sector. Research published by the Construction Industry Training Board shows that 25% of the workers aged 50 and over that leave the sector before retirement age do so because of the physical demands of the work, while 85% of workers aged 50 and over cite health issues as the main challenge they face. (See page 22.) [34]

Office for National Statistics forecast population change by age group in the UK, 2020 to 2050 (millions)



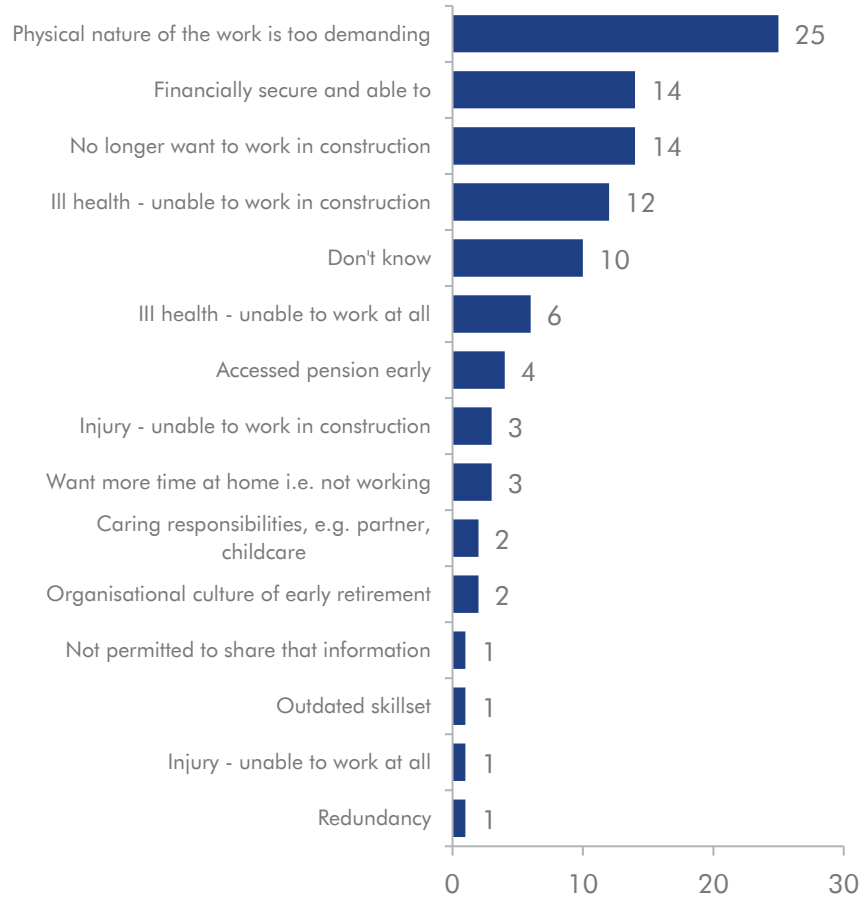
Construction employment by age group in 2019 in the UK (thousands)



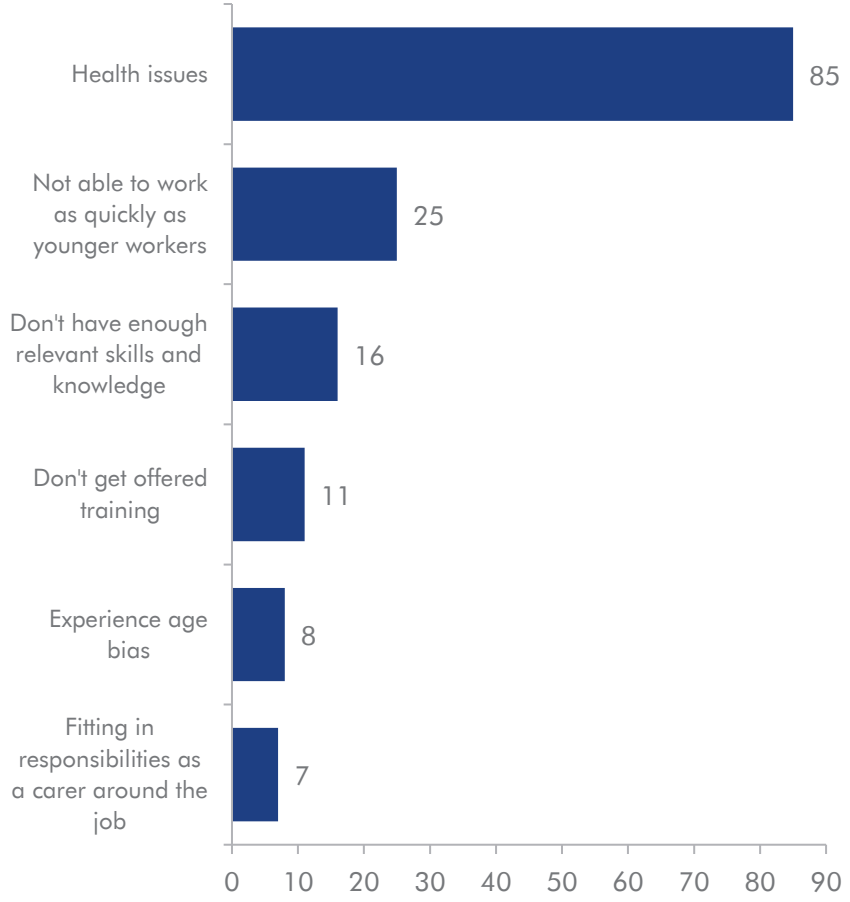
Sources: Capital Economics, Office for National Statistics *Population Projections United Kingdom 2020-based*, and Eurostat.

The physical demands of construction work are a challenge for older construction workers

Why 50+ workers leave construction before statutory pension age in Great Britain, share of responses, 2018, per cent



Main challenges facing workers aged 50+ in Great Britain, share of responses, 2018, per cent



Sources: Capital Economics and Fuller Working survey for Construction Industry Training Board

Growth in the number of EU nationals in the construction workforce has come to an end

Net immigration from Europe has fallen sharply since 2015

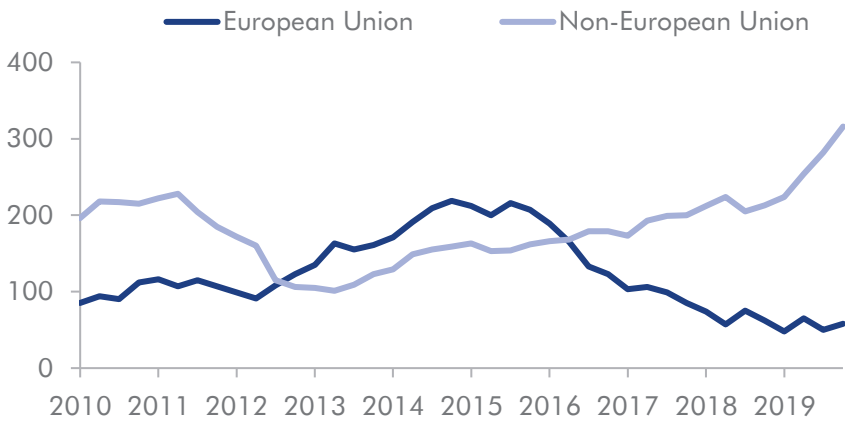
Immigration has supplemented the ageing UK workforce. Overseas nationals accounted for eleven per cent of workers in 2019, with European Union nationals comprising seven per cent and other overseas nationals four per cent. Net immigration from the European Union peaked at an annual rate of over 200,000 in late 2015 but fell back to 60,000 in 2019. The number of European Union nationals returning home since 2015 increased following the Brexit referendum and as economic performance on the continent improved. This trend was further exacerbated in 2020 with the outbreak of coronavirus. The number of Europeans arriving in the country has also decreased. Moreover, all of the decrease in arrivals is due to fewer people arriving for work, while the number arriving for study or other reasons has edged up. Net immigration from other countries has risen sharply since 2018.[35]

The rise of EU workers in UK construction is reversing

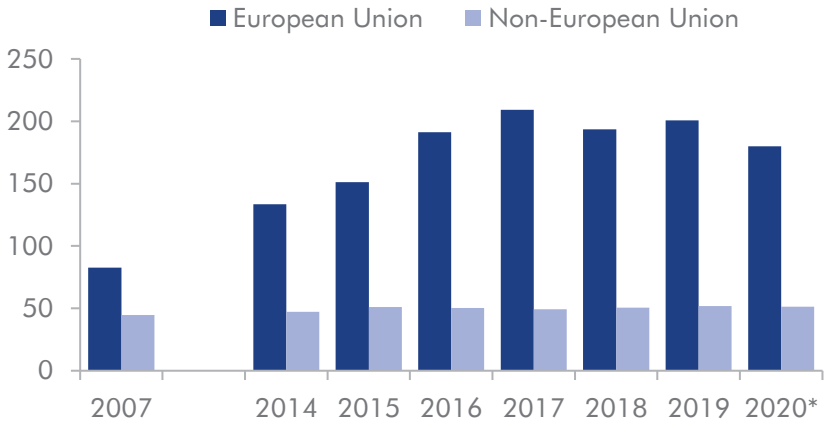
Developments in the construction workforce have been similar to those nationally, but construction is more reliant on European Union nationals (nine per cent of employment) and less reliant on other overseas workers (two per cent). In 2007, 83,000 European Union nationals worked in construction and this number rose to around 200,000 in 2019. The number of other overseas nationals working in construction was 45,000 in 2007 and around 50,000 in 2019. Over the same period, employment of UK nationals in the sector fell by about 120,000.[36]

In the first three quarters of 2020, the number of Europeans working in the UK fell by 8.5%. This suggests a fall in employment of European Union nationals in construction of about 20,000 in 2020 on average, albeit with the decrease likely to be larger in the second half of the year. Employment of other overseas nationals appears to have been little changed last year.[37]

Net migration into the United Kingdom by citizenship (thousands)



Number of overseas nationals employed in construction in the United Kingdom (thousands)



Sources: Capital Economics and the Office for National Statistics *Long-term migration statistics UK* and *Annual Population Survey*. Note: *estimate

A rebound in economic growth and a rising number of households will support demand for construction work

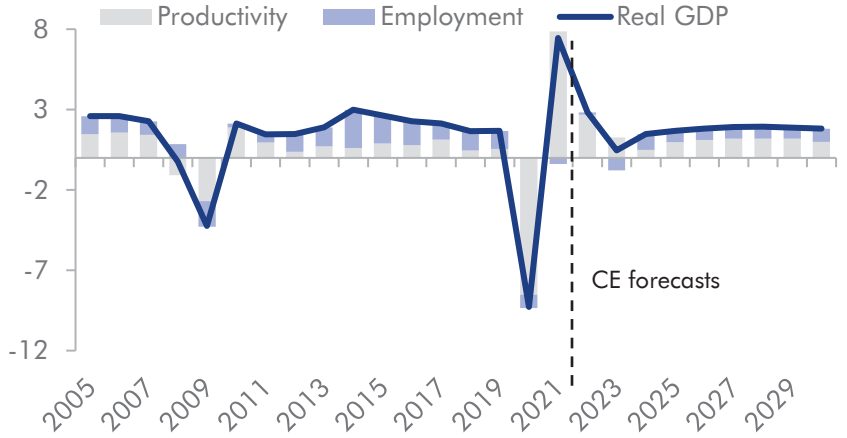
Productivity growth rebound to drive long term growth

The combination of Brexit and the pandemic led to significant falls in UK net migration in the last few years, which has weighed on growth in the size of the labour force. Labour force growth is likely to slow further after 2030 due to the ageing population. Meanwhile, trade frictions because of Brexit are likely to weigh on productivity growth. However, we expect this to be offset by a global rebound in productivity growth over the medium-term, linked to the digital revolution and increased use of technology in the workplace triggered by the pandemic.[38]

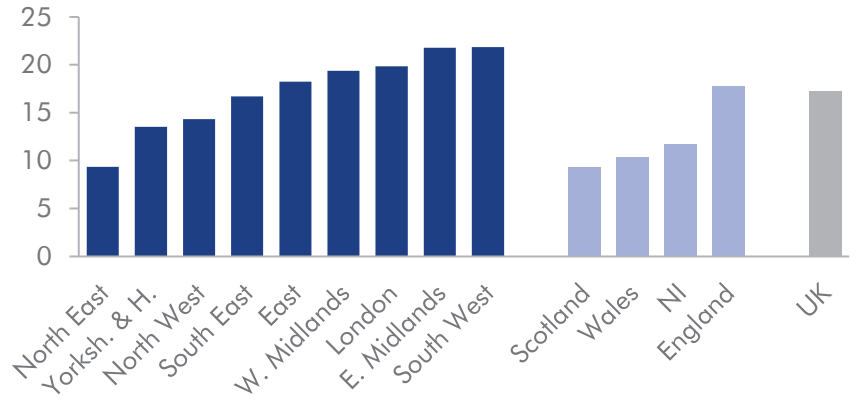
An additional 8.7 million households are expected by 2050

Based on official projections, we expect there to be an additional 8.7 million households in 2050 compared to 2020, an increase of 17.3%. These households will need housing and other physical infrastructure. Requirements are expected to be greatest in the Midlands and the southern regions, which the Office for National Statistics forecasts will see growth in the number of households outpacing the national average. The South West and the East Midlands are projected to see the most rapid rate of increase in the number of households at 21.8% from 2020 to 2050. Both a growing economy and increasing household numbers will increase the need for construction workers. [39]

UK output per worker, employment and real GDP (2016 prices), (all year-on-year growth, %)



Growth in the number of households, 2020 to 2050, by English region and UK nation (%)



Sources: Capital Economics and the Office for National Statistics, National Records of Scotland, Welsh Government, Northern Ireland Statistics and Research Agency

We expect increased investment to drive growth in the construction sector, meaning more construction workers will be needed

Construction sector forecast to be 58% bigger by 2050

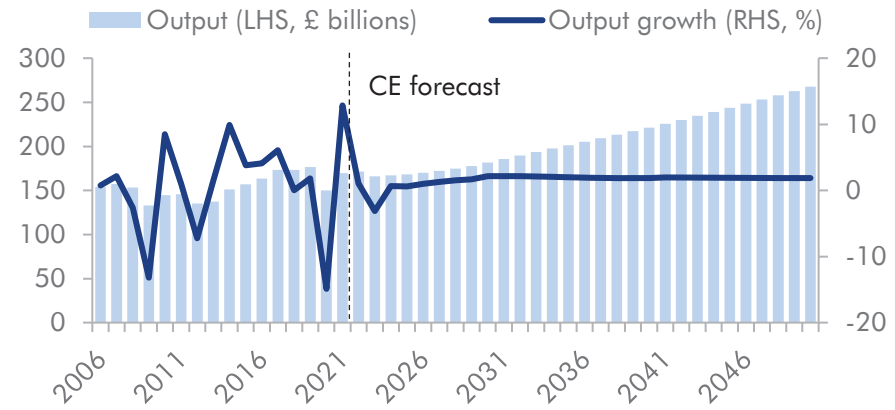
Net investment in the economy includes spending on land improvements, plant, construction of roads, residential buildings and commercial and industrial buildings. Therefore, it is a key driver of the construction sector. Whilst we expect investment to fall in 2023, largely due to a slow down in the housing market, we then expect it to recover and sustain steady growth beyond. This will lead to growing construction output and we estimate that by 2050 the construction sector will be £98 billion, or 58%, bigger than in 2021.[40]

Growth in the sector will require more construction workers

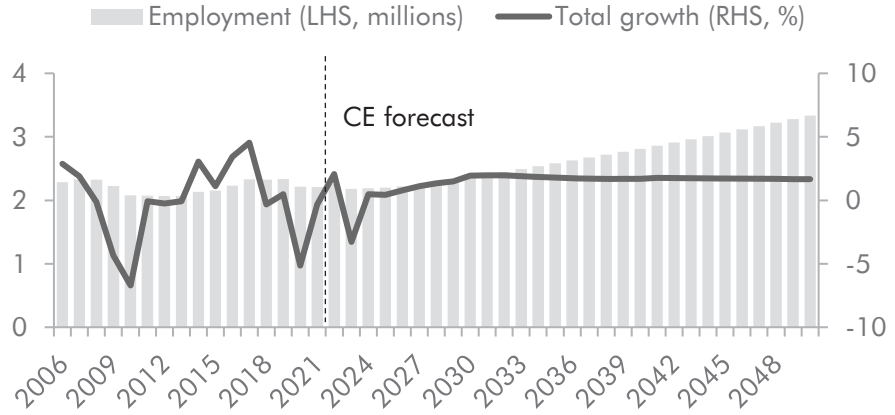
To deliver this growth in output, there will need to be an increase in the number of construction workers. Assuming productivity grows in line with its historic trend, we expect the growth in the construction sector output to require about 1.1 million additional construction workers by 2050, relative to 2021.[41]

The construction sector will play a key role in the UK achieving net zero. This, combined with the additional activity expected in the sector, highlights the importance of ensuring there are sufficient construction workers with the right skills to deliver.

UK construction output (£ billion, 2019 prices), and growth in construction output (year-on-year growth, %)



UK construction employment (millions) and growth in construction employment (year-on-year, %)



Sources: Capital Economics and historical data from the Office for National Statistics output and labour data

The growth of the green economy will significantly increase demand for certain jobs and skills across the economy, with the greatest need for upskilling in the construction sector

Almost 30% of construction jobs need re-skilling for transitioning to net zero

To support the UK economy to achieve net zero, there will need to be significant growth in the low carbon or 'green' economy. Ricardo Energy & Environment estimate that the low carbon economy could rise from around two per cent of UK GDP in 2015 to eight per cent in 2030.[42]

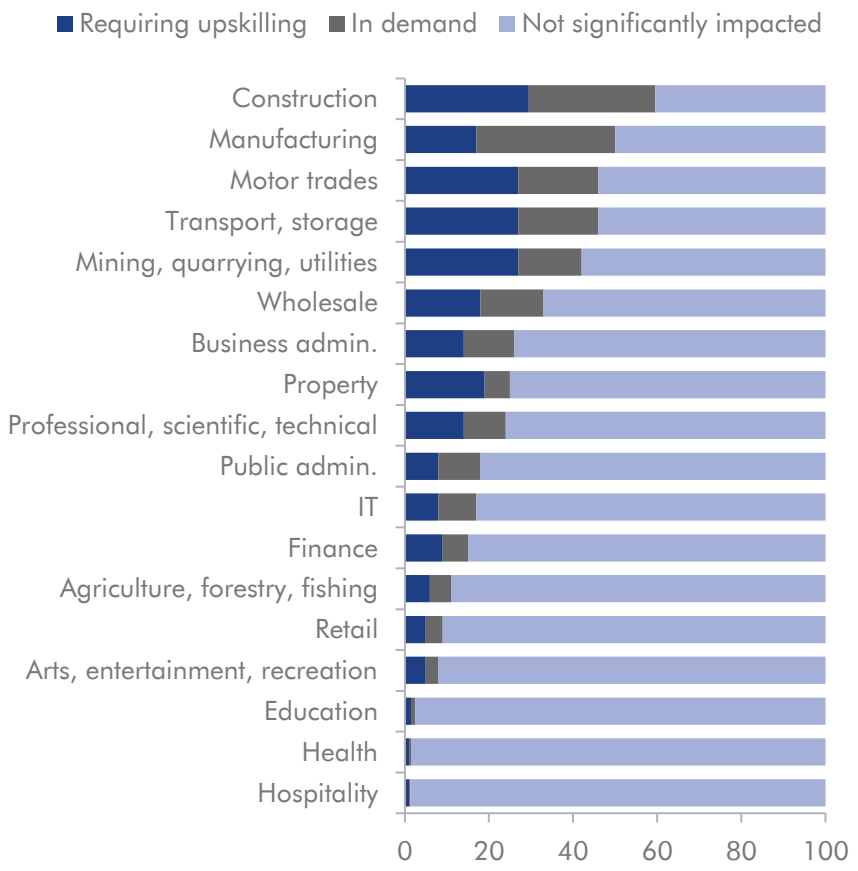
This growth will bring with it an increased demand for people in 'green jobs', which will require a range of skills.

- The LSE's Grantham Institute on Climate Change and the Environment (ICCE) and the Place-Based Climate Action Network (PCAN) have estimated the proportion of jobs that will *need upskilling* and those that will be *in demand* as a result of transitioning to net zero. Jobs that *require upskilling* are those that will need major changes in skills and knowledge, such as specialised manufacturing jobs.
- Jobs that will be *in demand* are existing jobs that will likely be in high demand due to playing a key role in the net-zero economy, such as wind turbine installers.

They estimate that around ten per cent of jobs in Great Britain have skills that will experience demand growth from the green transition, whilst eleven per cent will need to be re-skilled for the green economy.[43]

When breaking this down by sector, they identified that around 29% of construction sector jobs would require upskilling as a result of the transition to net zero and around 30% would be in demand. This was the highest proportion of jobs being impacted in a sector across the economy.

Share of jobs impacted by the transition to net zero in the UK economy, by sector*



Sources: Capital Economics and Place-Based Climate Action Network
*Figures in the chart are not exact, for full chart go to: https://pcancities.org.uk/tracking-local-employment-green-economy-pcan-just-transition-jobs-tracker

3. UK traditional building retrofit sector

- A 2021 Construction Industry Training Board (CITB) study estimated that reaching net zero in Great Britain, largely through retrofit, would require around 350,000 more construction workers than in 2019, of which 250,000 are retrofit coordinators and designers.
- Retrofit guidelines have been set by The British Standards Institution (BSI), ensuring that workers hold National Vocational Qualifications (NVQs) and retrofit professionals follow the dual-mandate of preserving significance and improving energy efficiency when retrofitting traditional properties.
- A 2019 CEBR report estimates that in the heritage sector overall, about half of which relates to construction, eleven per cent of employers reported a skills gap and six per cent reported a skills shortage.
- By combining various data sources and approaches we estimate there to be somewhere in the range of 67,000 to 148,000 people currently working with traditional buildings, in occupations relevant to retrofit.

There are shortfalls in skills needed to retrofit traditional buildings

Skills shortages and gaps will be major obstacles to UK retrofit

The importance of retrofit for reducing carbon emissions and helping to achieve net zero means there will be strong demand for skills related to retrofitting buildings.

In their 2021 paper, the Construction Industry Training Board (CITB) constructed a model to estimate the number of additional construction workers needed to achieve net zero carbon emissions in buildings through various interventions (including retrofit). They estimated that the number of additional workers (above the 2019 baseline) needed to conduct retrofits peaked at around 350,000 in the late 2020s. Within that, they find there will need to be around 250,000 additional workers with specialist skills such as Retrofit Co-ordinators and Retrofit Designers. The model estimated worker demand for the construction sector overall and the results illustrate the sheer magnitude of the challenge ahead of ensuring there are enough trained, skilled workers to achieve net zero.[44]

Skills gaps are particularly acute in traditional building retrofit

Retrofitting traditional buildings requires a different approach than for newer buildings. One reason for this is the dual mandates of protecting heritage significance, whilst also improving energy and carbon performance. Traditional buildings can have unique characteristics, meaning there is no "one-size fits all". Workers therefore must have certain training, qualifications and experience.

Research conducted in 2013 by English Heritage, Historic Scotland and the CITB found that 75% of contractors surveyed in England (72% in Scotland) had not undertaken any training for pre-1919 building work in the past 4-5 years. These results, although a few years old, illustrate the potential shortfall of skilled workers for retrofitting traditional buildings.[45]

Summary of literature and findings

Paper	Findings
English Heritage, Historic Scotland and CITB, 2013, Skills Needs Analysis 2013	• Four per cent (two per cent) of contractors in England (Scotland) had experience in pre-1919 building retrofit work. • 63% (72%) of contractors in England (Scotland) did not have confidence that existing training would develop the necessary skills for this. • 75% (72%) of contractors in England (Scotland) had no training for pre-1919 building work in the past 4-5 years.
CITB, 2021, Building Skills for Net Zero	• Peak of around 350,000 additional workers needed in late 2020s to achieve net zero in building environment. • Of these, just over 250,000 FTE needed in specialist skills in 2028.
CLC, 2021, Greening our existing homes: National retrofit strategy	• The construction industry needs around 500,000 new professionals and trades to retrofit the entire building stock by 2040. This is based on an S-curve schedule, with a 'ramp up' period.
CEBR, 2019, Skills gap/needs in the Heritage Sector	• Estimate that in 2017, the heritage sector had a skills gap of eleven per cent (as proportion of employers) and six per cent of employers identified a skills shortage. This is for the heritage sector overall, about half of which relates to construction.

Sources: Capital Economics and sources cited in table

Retrofit frameworks have outlined requirements for workers to hold certain qualifications

Industry guidelines introduce retrofit-specific qualifications

Frameworks such as PAS 2030, PAS 2035, and PAS 2038 have been introduced by The British Standards Institution (BSI) and backed by the Department for Business, Energy and Industrial Strategy. The aim is to raise the standard of retrofit work by outlining the best practices for assessing and implementing energy retrofit measures for existing buildings. Since 2021, compliance with guidelines has been mandatory for companies installing energy efficiency measures.

For a business to gain PAS 2030 certification, installers of interventions must possess relevant qualifications and competencies, and each team requires a qualified retrofit professional holding an NVQ. The retrofit professional roles were outlined under PAS 2035 as retrofit advisors, retrofit assessors, retrofit coordinators, retrofit designers, and retrofit evaluators. Anecdotally, the PAS standards are currently mainly being applied in government funded projects and there is an opportunity to apply them more widely for private projects.[46]

Additional qualifications required for traditional properties

The PAS 2035 guidelines state that for traditional dwellings, an assessment of heritage significance must be carried out. BSI, who designed the guidelines, defines significance as the value the building has for future generations. This is split into four key values, including craftsmanship, aesthetics and historical values such as associations with key historical figures and events. Additional qualifications for this sort of work include the NOCN Level 3 Award in energy efficiency measures for traditional buildings.[47]

The nature of the work can be notably different to standard properties and require different skillsets.

The significance of traditional buildings can be assessed based on key values

Architectural and Aesthetic	• Quality of design, construction and craftmanship of building, e.g., local materials, decorative brickwork • Character of setting of building
Communal	• Many people value appearance of older buildings • Traditional buildings and streets provide sense of place and identity
Evidential	• Older buildings and their setting can inform us why they were built and how they were used
Historical	• Buildings have associations with key people or events in history, e.g., birthplace of historical figure or association with an industry

Sources: Capital Economics and BSI Group, *Retrofit of domestic buildings under PAS 2035: A guide to assessing the significance of traditionally constructed buildings that are not protected*, https://pas2030.bsigroup.com/File/Spool/1184

Between 67,000 and 148,000 workers currently working with traditional buildings, in occupations relevant to retrofit

Range of estimates for traditional building retrofit workers

There are no official estimates of the number of employees working directly or indirectly in traditional building retrofit or the value of the work carried out so far. However, quantifying the *additional* workers needed to complete an example retrofit programme on traditional properties requires an estimate of the number of workers already in the sector who could carry out the work.

To generate an estimate, we have used two approaches. First, we have used official statistics on construction output and estimates of the number of traditional properties. We estimate around 630,000 people were employed in the repair and maintenance (R&M) sector in 2021. [48] We assume that half are in roles relevant to retrofit, given that R&M includes a range of work. (See table.) With 21% of properties having been built before 1919, we estimate around 67,000 construction workers have skills relevant to retrofitting traditional buildings, or three per cent of all construction workers.[49]

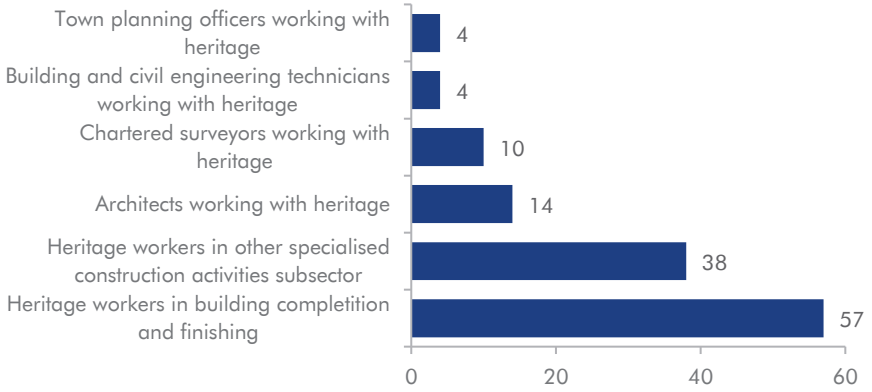
Second, we have drawn on a 2020 report by CEBR estimating the number of workers employed in England's heritage sector. Of these, we have highlighted a range of occupations we believe to be relevant for retrofitting traditional buildings. (See chart.) These sum to around 127,000 workers in England, which implies around 148,000 workers for the UK.[50] The number of workers currently retrofitting traditional properties is likely to be lower given that the the 2017 Survey of Listed Buildings Owners, conducted for Historic England, found that 22% of respondents who had applied for listed building consent in the last year, did so to carry out energy efficiency improvements.[51]

For our base case, we have assumed there are around 100,000 workers currently working with traditional buildings who are in occupations relevant to retrofit. This does not mean they are all currently engaged in retrofit work, but these workers are likely to be part of the labour pool for retrofitting traditional buildings.

Work included within Repair and Maintenance (R&M)

R&M work	Examples
Day-to-day repairs	Repairs that arise from general use, e.g., plumbing and repair of fuses
Annual repairs	Restoring aesthetics of buildings and preserving, e.g., painting and white washing
Special repairs	Replacing existing parts of buildings which deteriorate due to age
Additions & alterations	Updating facilities of buildings to improve functional efficiency
Preventative maintenance	Work to avoid problems, e.g., preventing damage from pollution and floods
Retrofit	Changes or additions to improve energy efficiency

CEBR estimates the workforce of England's heritage sector presented for occupations relevant to traditional building retrofit (2019, thousands)



Sources: Capital Economics, The Constructor: *Types of Building Repair and Maintenance Services*, CEBR 2020 *The heritage sector in England and its impact on the economy: an updated report for Historic England*

4. Future requirements for workers associated with a retrofit programme for traditional buildings

- In our base case, to help the UK reach net zero, we develop a scenario where all traditional properties receive loft insulation, window glazing, low energy lighting, heat pumps and mechanical ventilation. In the scenario, we acknowledge that not all traditional buildings will be suitable for wall insulation, so only some will have external and internal wall insulation.

- Under the base case, in which interventions are installed at a constant rate, we estimate an average of 105,000 additional full-time equivalent workers will be required each year between 2021 and 2050. The demand for the total number of workers with the appropriate retrofit skills will be greater as it is unlikely that all workers will spend all of their working hours retrofitting.

- The number of traditional properties and their unique nature means that there is significant uncertainty in our estimates. As such, we have conducted sensitivity analysis around some of the inputs to the model. Our estimates for the average need for extra workers range between 57,000 and 166,000.

- Delaying the ramp up of the retrofit programme will lead to a backlog of work and a surge in demand for workers in the 2030s.

We have constructed a bottom-up model to estimate the number of workers required to retrofit the UK's traditional properties by 2050

Our model provides estimates of the number of workers needed

We have constructed a model to estimate the number of additional full-time equivalent (FTE) workers which will be required to retrofit all traditional properties in the UK by 2050 to help reach net zero, and to provide detail at the occupation level.

The approach we have taken is similar to the one used in a 2021 CITB study which estimated the number of additional workers by occupation required for the entire UK building stock to achieve net zero emissions from the housing stock by 2050.[52]

Our model focuses on the interventions and skills required to retrofit the traditional building stock in the UK, which tends to take longer and requires a workforce with specialised skills. The model accounts for nine interventions, eight different property types and sixteen occupations, which are then scaled up to the stock of traditional buildings requiring retrofit work.

Creating a bottom-up model like this has its limitations and relies on inputs including previous literature, official statistics, data from contractors and reasoned assumptions. Given the uncertainty associated with an exercise of this nature we have conducted sensitivity analysis and presented ranges based on varying key assumptions.

See the appendix for further details on the modelling approach.

The aim of our bottom-up model and the method

Aim

Estimate the number of additional* full-time equivalent workers which will be required to retrofit all UK traditional properties by 2050

Method

For a given occupation, year, retrofit intervention, and property type, estimate the number of *occupation A* demanded:

Number of *occupation A* workers demanded = (Number of traditional properties implementing intervention per year × Number of hours of work required per intervention) / Number of hours worked per *occupation A* worker per year

Sum across all interventions and property types to find the total demand for *occupation A* each year between now and 2050.

Sum across occupations.

Subtract the number of workers we estimate are currently working with traditional buildings, in occupations relevant to retrofit.

Sources: Capital Economics. *Note: additional means above the number of workers we estimate are currently working with traditional buildings, in occupations relevant to retrofit.

Retrofitting the UK's traditional properties by 2050 could require an additional 105,000 workers on average each year

The base case of 105,000 extra workers required on average

In our base case, where the stock of UK traditional properties install retrofit interventions at a constant rate between 2021 and 2050, we estimate that an average of 105,000 additional workers will be required each year.

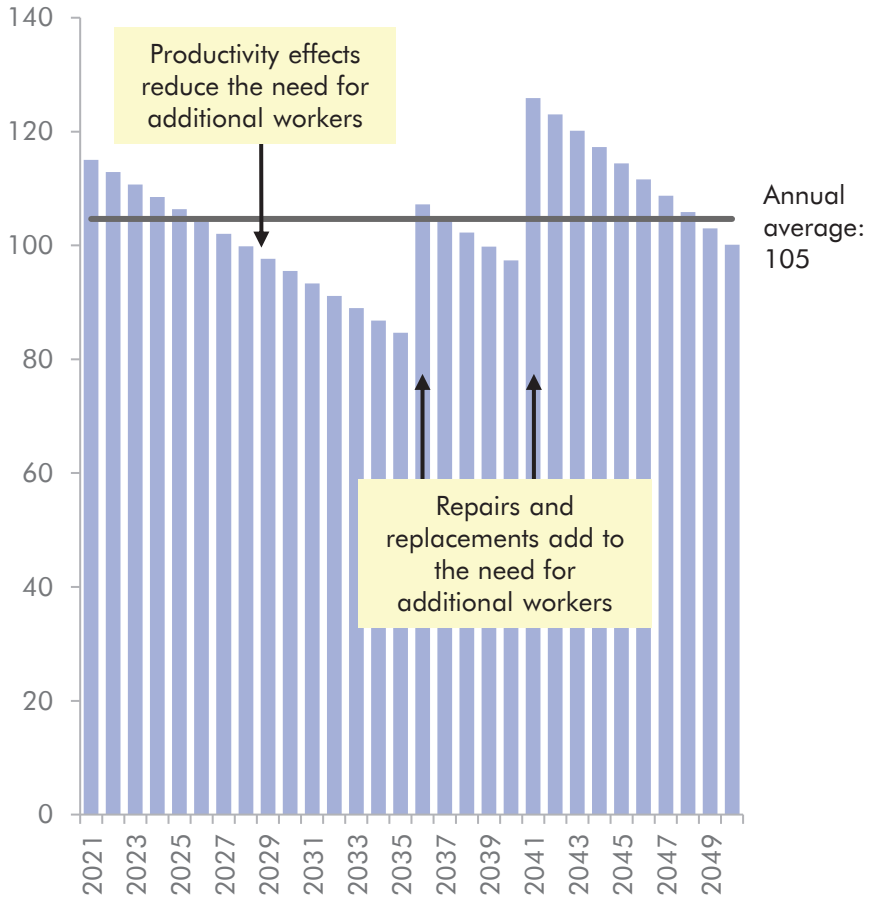
Our estimates are in FTE terms, but it is unlikely that the 100,000 workers currently working in roles relevant to retrofitting traditional buildings and the additional 105,000 workers will all spend every working hour retrofitting traditional properties. Therefore, the demand for the total number of skilled workers is likely to be even greater. This is reinforced by the fact we expect demand for construction workers to rise generally over the next few decades, which will create competition for labour. (See page 25.)

The need for workers will fluctuate over the next thirty years

Assuming that buildings are retrofitted at a constant rate, the requirement for workers will change over time. There is a requirement for 115,000 additional workers in 2021, which drops to 85,000 in 2035, rising again to a peak of 126,000 in 2041.

Productivity effects from new technologies and 'learning by doing' are likely to reduce the time taken to carry out retrofit work, therefore reducing the need for workers. A study by Currie & Brown and AECOM considers the cost-effectiveness of a package of interventions to reduce the emissions from new buildings. When projecting future costs, they assume that by 2030 the cost (in real terms, i.e., accounting for inflation) to install the measures will have fallen by the equivalent of one per cent each year. [53] We incorporated this into our model. Meanwhile, each intervention has a finite 'life' and requires repair or replacement, putting upward pressure on the need for additional workers over time.

Number of additional* full-time equivalent workers required in the UK to retrofit traditional properties per year (thousands)



Source: Capital Economics model results. *Note: additional means above the number of workers we estimate are currently working with traditional buildings, in occupations relevant to retrofit.

Several scenarios have been considered to account for uncertainties in modelling inputs

In a bottom-up modelling exercise over a long-time horizon, there are inevitable uncertainties. The base case is our view of the most likely outcome for the number of workers required given a constant number of properties retrofitted each year. However, we present a range of scenarios which account for changes to some of the key inputs:

1. **Time taken to complete work by occupation and intervention** [54]

- *High hours*: uses the mid-point between the base case estimates for the number of hours required and the maximum estimate provided by the four experts for a given intervention.
- *Low hours*: uses the mid-point between the base case and the minimum estimate for a given intervention.

2. **The time taken to complete work on bigger properties**

- *High size variation:* increases the scaling factor for larger properties by ten per cent.
- *Low size variation:* reduces the scaling factor for larger properties by ten per cent.

3. **The current number of workers***

- *High current workers*: Uses an estimate of 148,000 derived from a 2020 report by CEBR which estimates the number of workers employed in England's heritage sector broken down by occupation. Capital Economics selected the relevant occupations and scaled the England estimates up for the UK. (See page 30.)
- *Low current workers:* Use the lower estimate of 67,000 current workers derived from Capital Economics' calculations of the ONS construction industry output tables. (See page 30.)

4. **The time required to scale up the workforce**

- *S-shaped schedule:* The base case assumes that interventions are installed at a constant rate between 2021 and 2050. An S-shape schedule scenario alters this to account for the time taken to scale up the workforce and results in the need for a faster uptake between 2030 and 2040.

*Note: 'current workers' means the number of workers we estimate are currently working with traditional buildings, in occupations relevant to retrofit.

Adjusting inputs results in a range of between 57,000 and 166,000 average additional required each year to 2050.

Assumptions altered from the base case in each scenario

Issue	Scenario	**Hours of work** (average of four sources in base case)	**Property type size** (hours of work scaled by average property size in base case)	**Share installing measure by 2050** (assumptions formed using Historic England study)	**Current workers*** (100,000 in base case)	**Pace of schedule** (constant in base case)	**Average requirement for full-time equivalent workers above current workers***
Time taken to complete work by occupation and intervention	High hours	Mid-point between maximum estimate for a given intervention and base case	-	-	-	-	166,000
	Low hours	Mid-point between minimum estimate for a given intervention and base case	-	-	-	-	64,000
The time taken to complete work on bigger properties	High size variation	-	Increases scaling factor by 10%	-	-	-	115,000
	Low size variation	-	Decreases scaling factor by 10%	-	-	-	95,000
The current number of workers*	High current workers	-	-	-	148,000	-	57,000
	Low current workers	-	-	-	67,000	-	138,000
The time needed to scale up workforce	S-shaped schedule	-	-	-	-	Faster over 2030-40	95,000

Source: Capital Economics and input on assumptions for wall insulation innovation scenario from Historic England. *Note: 'current workers' means the number of workers we estimate are currently working with traditional buildings, in occupations relevant to retrofit.

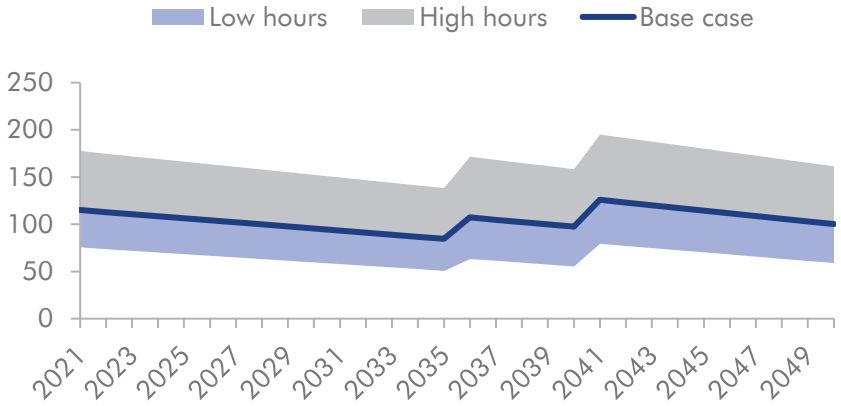
Although there is uncertainty surrounding the number of workers required for a retrofit programme for traditional buildings, the need will be significant

Adjusting the number of hours to capture the lower and upper bounds provided to us by the four sources, the average number of additional workers required per year ranges from 57,000 to 166,000. (See top right chart.)

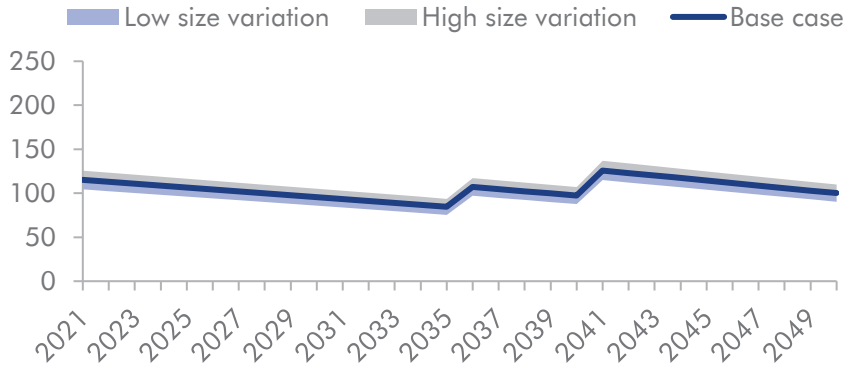
The model accounts for the eight property types by scaling the number of hours by average floorspace. Accounting for a ten per cent adjustment in the variation gives a smaller range of between 95,000 and 115,000 additional workers required per year on average. (See bottom left chart.)

Using alternative estimates for the number of workers currently working on traditional properties in occupations relevant to retrofit gives a range of between 57,000 and 138,000 additional workers needed. (See bottom right chart.)

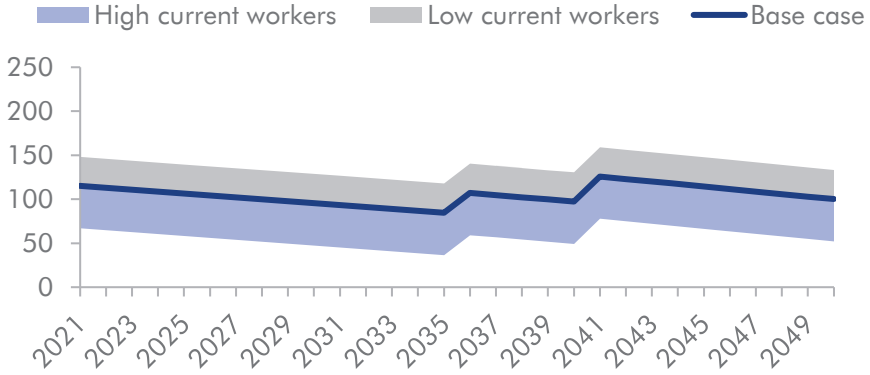
Range of number of additional* full-time equivalent workers required to retrofit traditional properties in the UK each year when adjusting hours of work per intervention (thousands)



Range of number of additional* full-time equivalent workers required to retrofit traditional properties in the UK each year when adjusting scaling factor across the eight property types (thousands)



Range of number of additional* full-time equivalent workers required to retrofit traditional properties in the UK each year when adjusting the current number of workers in the sector (thousands)



Source: Capital Economics. *Note: additional means above the number of workers we estimate are currently working with traditional buildings, in occupations relevant to retrofit.

Delaying the start of the retrofit programme could lead to a backlog of work and a surge in demand for workers

An S-shape trajectory assesses the impact of delaying the work

Our base case scenario assumes that retrofit interventions are installed at a constant rate between 2021 and 2050 until the cumulative share of traditional properties with the intervention installed by 2050 is reached.

Delays in training workers and getting started on the retrofit programme could lead to problems further down the line as there becomes a backlog of work which needs completing.

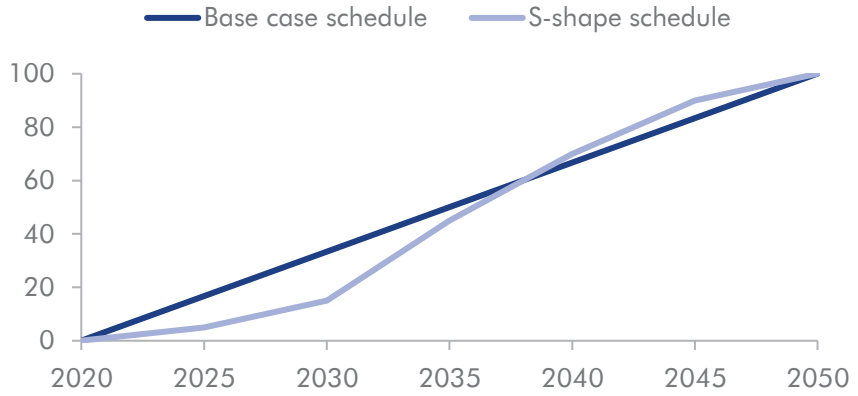
We developed a scenario to assess the impact of an S-shape trajectory, similar to that which was set out in the Construction Leadership Council's (CLC) National Retrofit Strategy.[55] In this scenario there is a slow uptake as households and industries are slow to make energy improvements and as workers are trained. This results in a much higher requirement in the later period to retrofit the traditional stock to help the UK meet net zero targets.

Delaying work will make it harder to meet demand

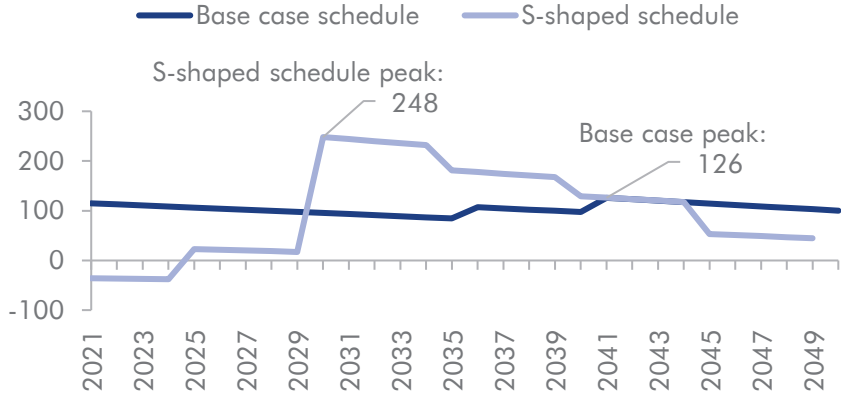
Under the S-shaped scenario, there is a peak in the number of additional workers required of 248,000 in 2031. In contrast, under the constant rate of take-up in the base case, the number of additional workers required peaks at a lower 126,000 in 2041.

These results highlight the key role government strategy could play in smoothing demand whilst supporting training for workers.

Illustrative example of the cumulative share of traditional properties in the UK with a given intervention installed between 2020 and 2050 (%)



Additional* number of full-time equivalent workers required each year to retrofit traditional properties in the UK under different retrofit schedules (thousands)



Sources: Capital Economics and the Construction Leadership Council, *National Retrofit Strategy*, 2021 *Note: additional means above the number of workers we estimate are currently working with traditional buildings, in occupations relevant to retrofit.

5. Occupational and regional breakdown of the base case

- Of the estimated 105,000 additional full-time equivalent workers required on average each year to retrofit traditional properties in the UK between 2021 and 2050 in the base case, around 77% will be needed to work on residential properties, and the remaining 23% will be required to work on non-residential properties.

- Some regions could struggle to fill the need for workers more than others as the regional requirements in the base case as a percentage of current construction employment range from around six per cent in the East of England to almost sixteen per cent in Wales.

- The occupations in highest demand are electricians, with a need of 14,500, which is equivalent to thirteen per cent of the UK's employment of electricians in 2021. This is closely followed by plumbers, heating and ventilation installers, where the need each year between 2021 and 2050 averages 14,300, equivalent to eighteen per cent of UK employment in that trade in 2021.

Around 77% of the need for workers in the base case comes from residential properties

The need for workers is substantial for all types of property

We estimate that there are around 6.7 million traditional properties in the UK. Of these, around 92% are residential properties. (See page 13.)[56] Our base case estimates that of the 105,000 additional workers required each year on average, 77% will be required to retrofit traditional residential properties. This translates to around 81,000 workers.

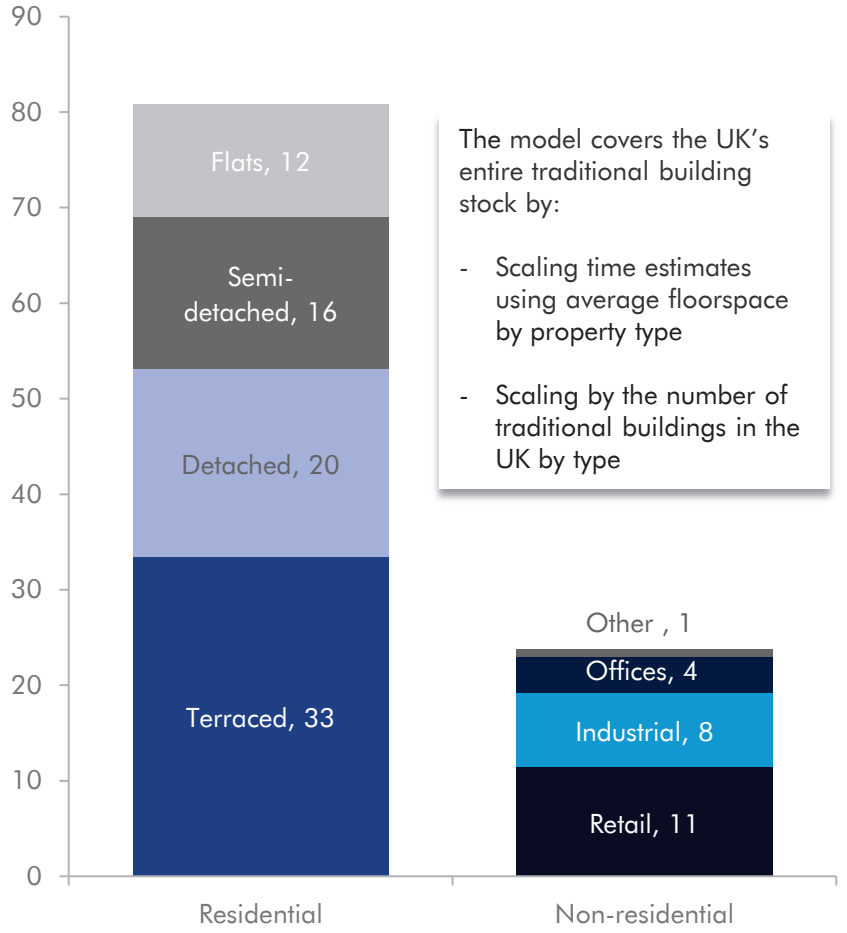
Meanwhile, the remaining eight per cent of traditional properties are non-residential but 23% of the additional workers required will be needed to retrofit these properties. This translates to 24,000 workers.

The model accounts for the fact that many non-residential properties are likely to take relatively longer to retrofit because they tend to have larger average floorspaces. For example, our estimates suggest that an industrial property built pre-1919 could be around 7.3 times the size of a terraced property built pre-1919 on average.[57] (See page 13.)

Terraced properties require the highest number of workers

The largest category of traditional buildings is terraced houses, of which we estimate that there are around 2.9 million in the UK, which is around 43% of the traditional property stock and approximately ten per cent of the entire UK residential building stock.[58] Of the 105,000 additional workers required each year, 32% will need to work on terraced properties, which equates to 33,000 workers.

Average number of additional* workers required in the UK on average each year between 2021 and 2050 to retrofit traditional properties by property type in base case (thousands)



Source: Capital Economics. *Note: additional means above the number of workers we estimate are currently working with traditional buildings, in occupations relevant to retrofit.

The need for workers is more acute in certain regions of the country

The highest number of workers will be required in London

We have used our estimates of the number of traditional properties by type and region to estimate the need for additional workers in the UK's nations and regions.

Our modelling suggests that the need for workers to retrofit traditional properties will be largest in London, with an annual average of 19,000 workers required between 2021 and 2050. Of these, around a third will need to work on terraced houses.

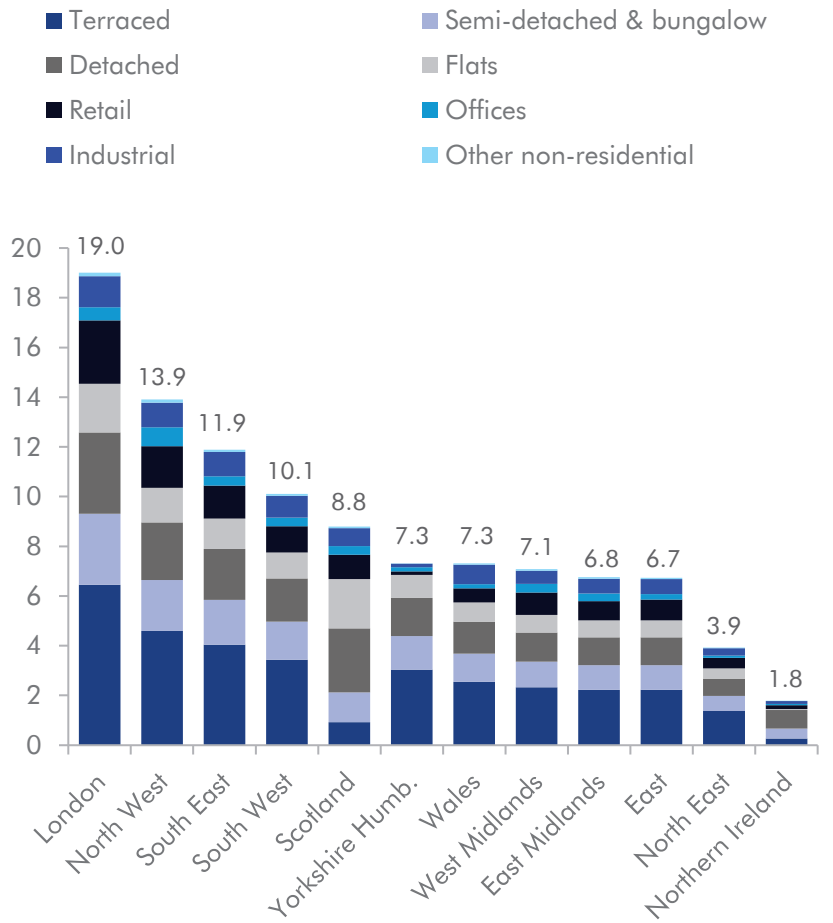
In Scotland, around 8,800 additional workers will be required on average each year compared to today's level. In Wales, the comparable figure is 7,300 while in Northern Ireland it is 1,800.

Challenges in filling skills shortages will vary by region

To provide an indication of where the need for workers is more acute, we have compared the need for workers from the model to official statistics of current employment.

In Wales, the average number of workers required each year between 2021 and 2050 is equivalent to 15.8% of construction sector employment in the region in 2021. (See page 41.) This figure is 14.2% in London, but a smaller 5.8% in the East of England, where the need is less acute.

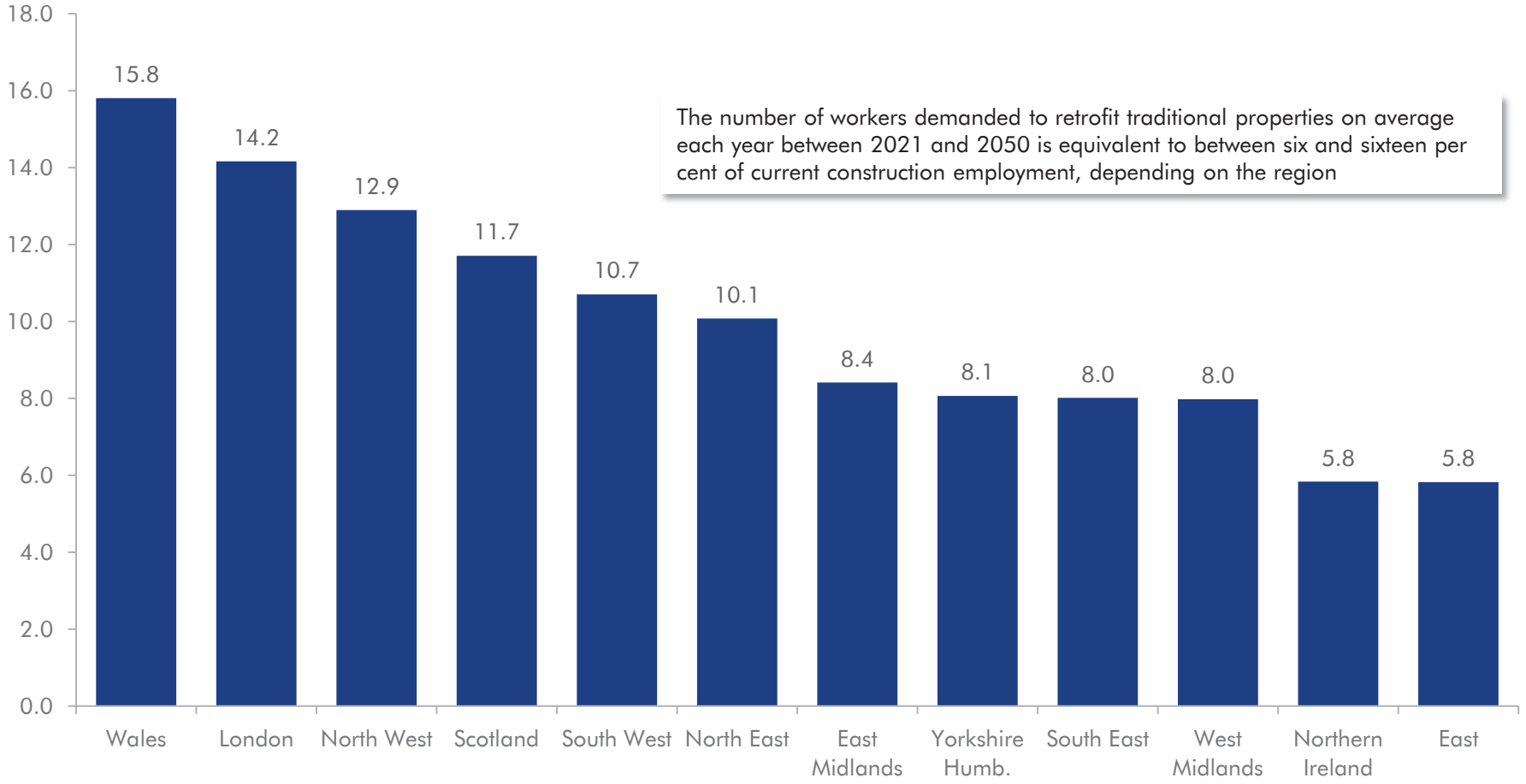
Additional* number of workers required on average each year between 2021 and 2050 to retrofit traditional properties by region and property type in the base case (thousands)



Sources: Capital Economics. *Note: additional means above the number of workers we estimate are currently working with traditional buildings, in occupations relevant to retrofit.

Comparing the model results with employment statistics points to the need for workers being particularly acute in Wales and London

Total number of workers required in the UK on average each year between 2021 and 2050 to retrofit traditional properties by region as a share of regional employment in the construction sector in 2021 (%)



The number of workers demanded to retrofit traditional properties on average each year between 2021 and 2050 is equivalent to between six and sixteen per cent of current construction employment, depending on the region

Sources: Capital Economics modelling results and Office for National Statistics Annual Population Survey 2021. Note: This calculation takes the annual average demand from the model for workers to retrofit traditional properties and divides the estimate by total employment in construction in that region in 2021. The occupations used in our model do not directly correspond to the SIC construction sector employment statistics used for this chart. The purpose of this chart is to offer some insight into where the need might be more acute.

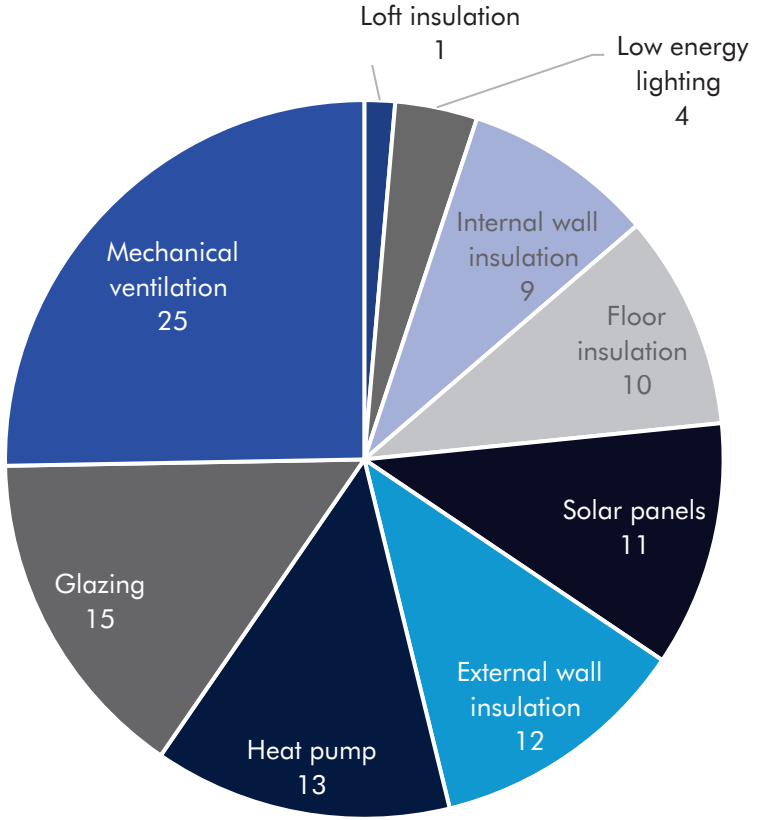
Mechanical ventilation, glazing and heat pumps require the biggest uplift in workers

Skills in installing mechanical ventilation most in demand

Breaking the need for additional workers down by intervention, the highest demand will come from the work installing and repairing/ replacing mechanical ventilation, which around a quarter of these workers will need to focus on. Meanwhile, fifteen per cent of the additional demand for workers is coming from glazing windows, and an additional thirteen per cent is in the demand for heat pump work.

These three interventions also have relatively shorter lifespans, with mechanical ventilation estimated to last fifteen years, glazing twenty years, and heat pumps twenty years. The need to repair or replace these interventions over the thirty-year horizon is accounted for in the model and therefore partly explains why the need for workers is higher for these interventions.

The average number of additional* workers per year required to retrofit traditional properties by intervention in the base case, share by intervention (%)



Source: Capital Economics. *Note: additional means above the number of workers we estimate are currently working with traditional buildings, in occupations relevant to retrofit.

A broad range of skilled tradespeople will be required, many of whom must hold qualifications specific to retrofitting traditional properties

Electricians and plumbers will be in high demand

Of the additional 105,000 workers required for traditional property retrofit each year, our model suggests around fourteen per cent should be electricians and a further fourteen per cent should be plumbers, heating and ventilation installers. This translates to 14,500 and 14,300 workers, respectively.

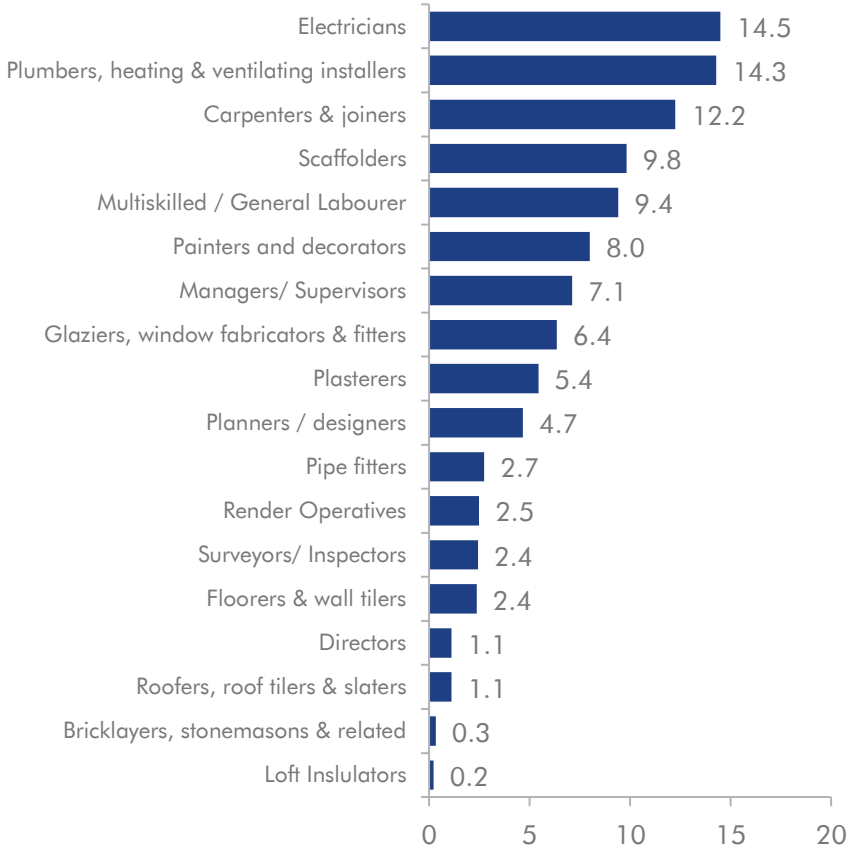
In 2021, there were 221,100 electricians in the UK, which means to retrofit traditional properties, thirteen per cent of these tradespeople would have to work solely on these retrofit projects in a given year. For plumbers and related trades, the comparable figure is eighteen per cent.[59] (See page 44.)

However, this means that essentially this share of workers must forgo their usual work to complete this retrofit to traditional properties. But they might be reluctant to do so, given the lack of skills and age of existing systems in traditional properties. It also seems unlikely that new workers entering the workforce via apprenticeships will be able to provide much of a boost to the number of tradespeople available. Apprenticeship starts in England in plumbing subjects have fallen each year since 2016/17. [60]

Finding surveyors and project managers could be challenging

The PAS 2035 retrofit guidelines require traditional and protected buildings to have an 'assessment of significance' carried out by an assessor qualified in traditional buildings.[61] A qualified retrofit designer and coordinator must then account for the building's significance in retrofit plans. If there are risks to a 'significant' aspect of the building, a Heritage Impact Assessment should be carried out. The additional 2,400 surveyors required each year, and the 7,100 managers/ supervisors must possess the relevant qualifications.

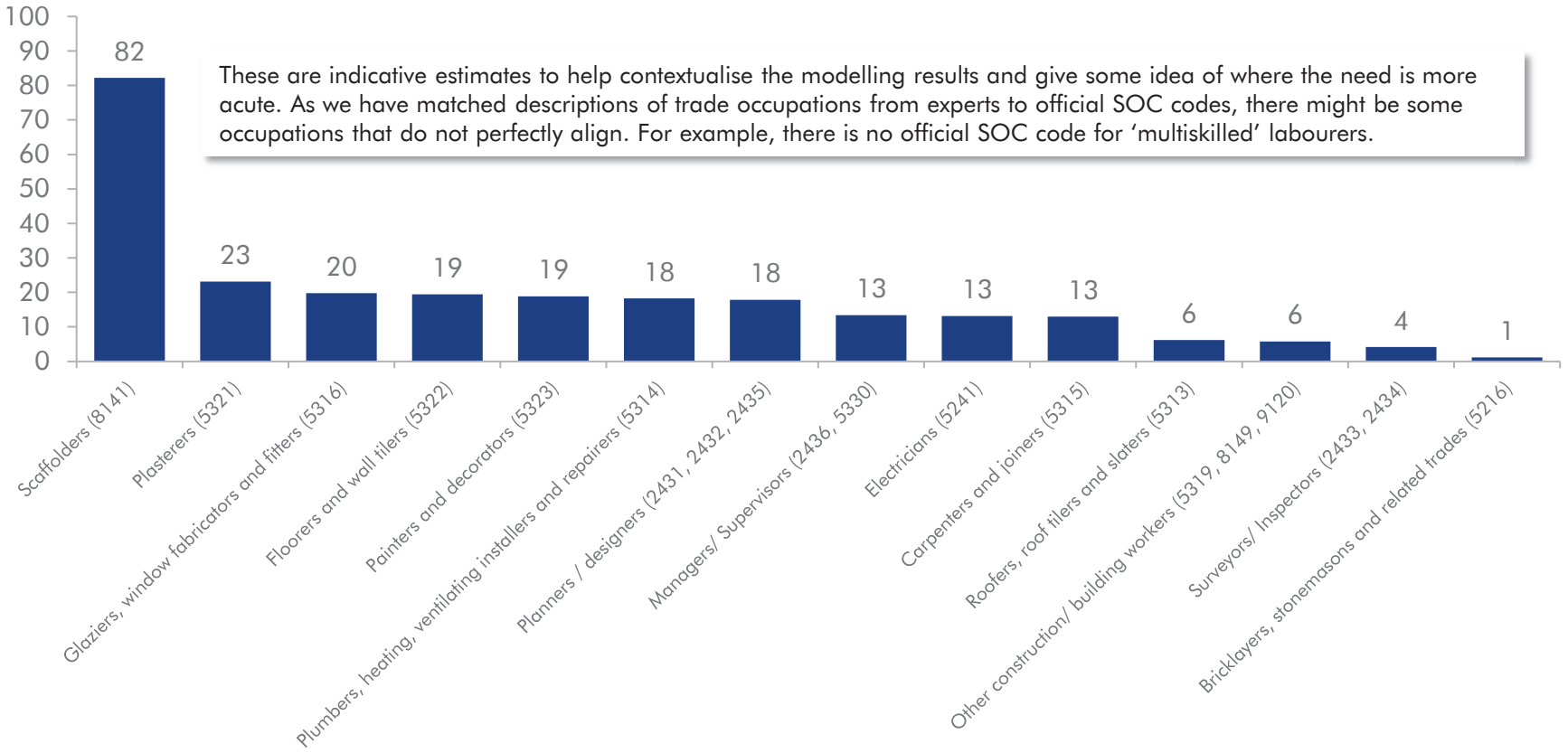
Additional* number of workers required in the UK on average each year between 2021 and 2050 to retrofit traditional properties by job occupation in the base case (thousands)



Sources: Capital Economics. *Note: additional means above the number of workers we estimate are currently working with traditional buildings, in occupations relevant to retrofit. For individual occupations, this is estimated using shares of workers required by occupation under the base case for 2021

A sizeable share of the current workforce would have to dedicate their time to retrofitting traditional buildings which is likely to require mass retraining

Number of workers required to retrofit traditional properties in the base case in the UK, annual average between 2021 and 2050, as a share of the workers in each occupation in 2021 in the UK (%) (SOC codes in parenthesis)



These are indicative estimates to help contextualise the modelling results and give some idea of where the need is more acute. As we have matched descriptions of trade occupations from experts to official SOC codes, there might be some occupations that do not perfectly align. For example, there is no official SOC code for 'multiskilled' labourers.

Sources: Capital Economics modelling and The Office for National Statistics, Annual Population Survey - employment by occupation (SOC) statistics. *Note: because there is no official SOC category for these roles, we have combined render operatives, loft insulators and multiskilled/ general labourers and compared these workers to the sum of employment in 5319 Construction and building trades n.e.c., 9149 Construction operatives n.e.c., and 9120 Elementary construction occupations

6. Impact on the wider economy

- Ensuring that the workforce has the skills to retrofit traditional properties will have knock-on benefits on the rest of the economy. Output from retrofitting traditional properties will stimulate spending in firms' supply chains and generate revenues for other businesses in both construction and other sectors of the economy.

- In total, £35 billion of output will be supported annually under our base case scenario, which in turn supports around 290,000 jobs.

Filling traditional building retrofitting skills gaps will support £35 billion in economic output

Ensuring that the workforce has the skills to retrofit traditional properties will have knock-on benefits on the rest of the economy. Additional output from retrofitting traditional properties will stimulate spending in firms' supply chains and generate revenues for other businesses in both construction and other sectors of the economy. Meanwhile, additional workers retrofitting traditional properties will spend their incomes across the economy.

If our base case scenario for the number of additional workers is achieved, there will be an average of 105,000 extra workers in a given year. Using average productivity in the construction sector we estimate that this will generate £14.2 billion of output in 2018 prices.[62]

Of this, we estimate that £8.1 billion will be spent on domestic suppliers, who in turn will then spend a portion of that income on their suppliers. Altogether, the additional retrofitting work to traditional properties will support £15.1 billion of economic output through supply chain spending. Around £8.8 billion of this will be in the construction sector, while the manufacturing and high value service sectors are the next biggest beneficiaries.

Using an average wage of just under £35,000, we estimate that the additional workers retrofitting traditional properties will spend £2.7 billion annually on goods and services.[63] In turn, this will support £5.4 billion of output across the economy. This will benefit all sectors of the economy, with the retail sector being the largest at £1.7 billion.

Annual economic activity supported in the UK with 105,000 additional full-time equivalent workers retrofitting traditional properties, constant 2018 prices

	Direct output	Output supported through supply chains	Output supported through employee spending	Total output supported
Primary activities and energy	0.0	0.5	0.4	1.0
Manufacturing	0.0	2.8	0.5	3.3
Construction	14.2	8.8	0.1	23.2
Wholesale and retail	0.0	0.9	1.7	2.6
Professional services, finance and IT	0.0	1.2	1.2	2.4
Other services	0.0	0.8	1.4	2.3
Total	**14.2**	**15.1**	**5.4**	**34.8**

Source: Capital Economics

Filling skills gaps in traditional building retrofitting will support around 290,000 jobs

If our base case scenario for the number of additional workers is achieved, there will be an average of 105,000 extra workers in a given year. On top of this, activity will be stimulated through supply chain spending and the spending of those employees.

In total, we estimate that 287,000 jobs will be supported annually if the retrofitting work to traditional properties is carried out as in our base case scenario.

Supply chain spending will support in the region of 121,000 jobs. Over half of these will be in the construction sector, while 19,000 will be supported in manufacturing firms and 35,000 overall in service sectors.

Meanwhile, the induced effect of employee spending will support a further 61,000 jobs. These will be primarily in wholesale, retail and other service sectors. [64]

Annual economic activity supported in the UK with 105,000 additional full-time equivalent retrofitting traditional properties, thousands

	Direct jobs	Jobs supported through supply chains	Jobs supported through employee spending	Total Jobs supported
Primary activities and energy	0	2	1	3
Manufacturing	0	19	3	22
Construction	105	65	1	171
Wholesale and retail	0	11	24	35
Professional services, finance and IT	0	9	6	16
Other services	0	14	25	40
Total	**105**	**121**	**61**	**287**

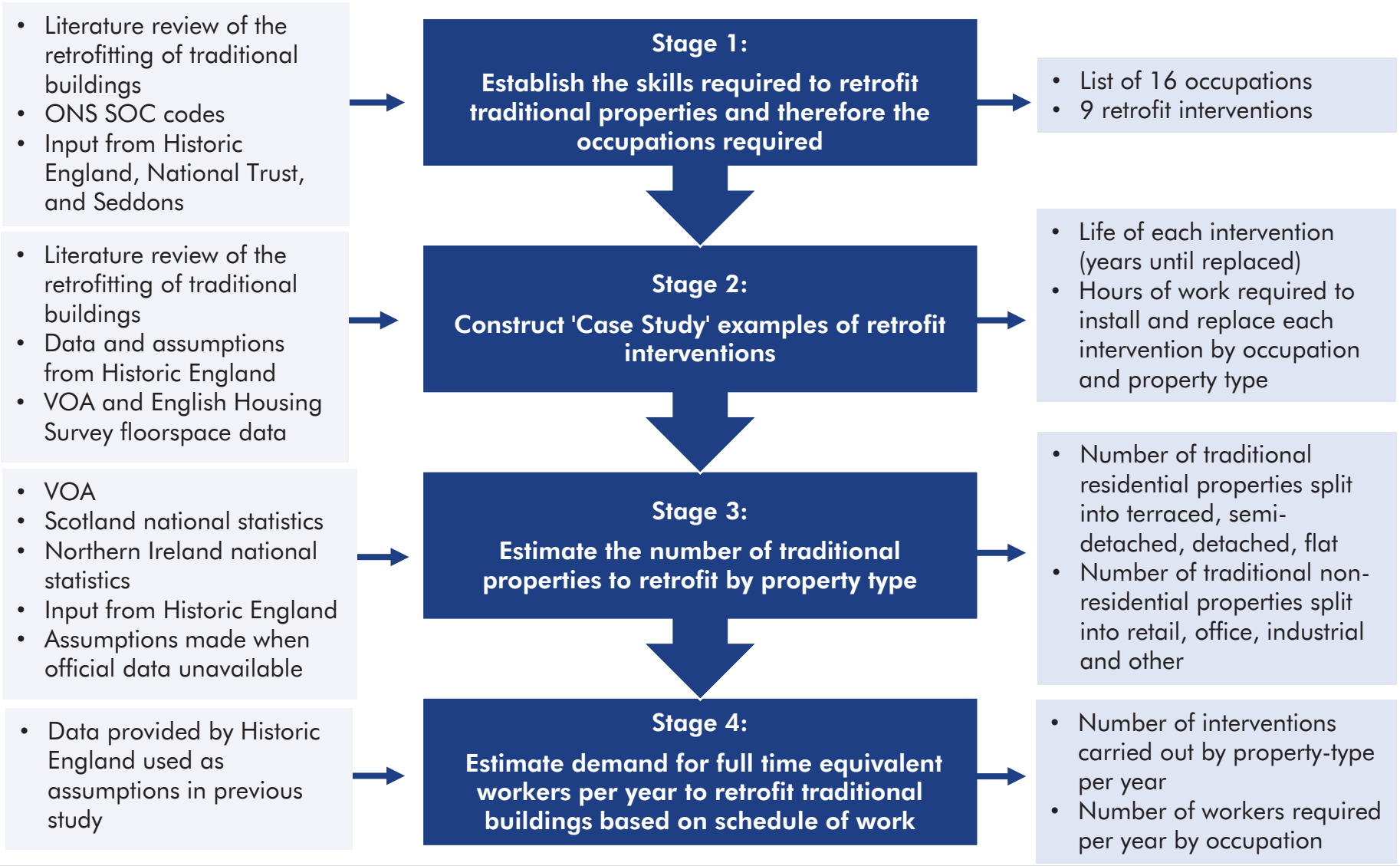
Source: Capital Economics

7. Appendix

Estimating the stock of traditional properties in the UK

Region	Variable	Source
England (by region) and Wales	Total number of residential properties and the total number built pre-1919 in regions of England and Wales	Valuation Office Agency, *Council Tax: stock of properties, 2022.* Available from https://www.gov.uk/government/statistics/council-tax-stock-of-properties-2022
	Total number of non-residential properties built pre-1919 by type in regions of England and Wales	Valuation Office Agency, *2010 Local Rating List: stock of property by region, sector and building age as at 31 March 2015.* Available from https://www.gov.uk/government/publications/non-domestic-rating-stock-of-properties-by-sector-in-england-and-wales-on-the-2010-rating-list
	Breakdown of pre-1919 residential properties in England by type	Historic England, *Know your home know your carbon* (Historic England: Kent), 2020, 15. Available from https://historicengland.org.uk/content/heritage-counts/pub/2020/hc2020-know-your-home-know-your-carbon/
Scotland	Total number of residential properties in Scotland	Scottish Government, *Housing Statistics: Stock by tenure 2020*. Available from https://www.gov.scot/publications/housing-statistics-stock-by-tenure/
	Share of residential properties built pre-1919 in Scotland	Scottish Government, *Scottish house condition survey: 2017 key findings.* Available from https://www.gov.scot/publications/scottish-house-condition-survey-2017-key-findings/
	Total number of non-residential properties built pre-1919 in Scotland	Historic Scotland, English Heritage and CITB, *Skills needs analysis 2013: repair, maintenance and energy efficiency retrofit of traditional (pre-1919) buildings in England and Scotland*
	Breakdown of pre-1919 non-residential properties built pre-1919 in Scotland	Assumptions based on England and Wales shares
Northern Ireland	Total number of residential properties in Northern Ireland	Open Data Northern Ireland, *NI Housing Stock by LGD 2008-2022.* Available from https://www.opendatani.gov.uk/dataset/ni-housing-stock
	Share of residential properties built pre-1919 in Northern Ireland	Northern Ireland Housing Executive, *Northern Ireland Housing Market: Review & Perspectives 2015-2018*. Available from https://www.nihe.gov.uk/Documents/Research/Housing-Market-Review-CURRENT/housing-market-review-2015-2018.aspx?ext=.
	Total number of non-residential properties built pre-1919 in Northern Ireland and breakdown by type	Assumptions based on England, Wales and Scotland shares and ratios of residential to non-residential traditional properties
UK	The average floorspace of residential properties built pre-1919 by property type	Ministry of Housing, Communities & Local Government, *Floor space in English homes,* July 2018.
	The average floorspace of non-residential properties built pre-1919 by property type	Valuation Office Agency, *Business Floorspace 2000/01-2020/21* and *2017 Local Rating List: Number of rateable properties 2021.* Average non-residential floorspace (all property ages) in a given region adjusted based on the ratio of average residential property floorspace (all ages) relative to average residential property floorspace (pre-1919).

Modelling approach: overview



Modelling approach: skills required

A wide range of skills are needed to retrofit traditional buildings

Retrofitting traditional buildings requires a different approach, and different materials and skills, compared to modern buildings. This can mean additional training is required and that the work takes longer than on the average property. After carrying out a literature review, we narrowed down a list of sixteen occupation categories.

For example, a planner and surveyor will be required on most retrofit projects to ensure the interventions, materials and construction processes chosen are best suited to that specific older building. If the wrong materials or processes are used, the retrofit work can jeopardise the character of the building, cause severe damage, and lead to damp and condensation. Tradespeople then require additional training and experience to complete the work.[65]

Given the different approaches associated with retrofit work, we consulted experts with experience in retrofitting traditional properties to estimate the expected number of hours of work associated with our list of interventions. The Crown Estate, National Trust and contractors PJ Harte and Seddons provided us with estimates for a pre-1919 terraced property of 93 square-metres. We took a simple average of the four for our base case model scenario, excluding one major outlier for energy efficient lighting. These experts advised us that there are likely to be notable savings in the hours required of manager and surveyors, and some savings for tradespeople, when packaging up as 'whole house' retrofits. This was accounted for in the model.

Our model considers the entire stock of the estimated 6.7 million traditional properties in the UK, both residential and non-residential. To account for the eight property archetypes outlined on page 13, we scaled the estimates of the time taken to retrofit a terraced property by the average floorspace by property type.

Skills and occupations required to retrofit traditional properties

Occupation	Skills required for
Surveyors/ inspectors	• Plans most suitable retrofit for property • Insulation requires surveys to avoid issues with ventilation, damp, condensation • Knowledge of physics and hydraulics often required to plan full retrofit
Planners/ designers	
Managers/ supervisors	• Project managers ensure systems work together, e.g., insulation works with the new heat pump
Bricklayers/ stonemasons	• Insulating walls, both internal and external, floors, and lofts • Installing solar panels • Additional glazing to windows
Carpenters/ joiners	
Render operatives	
Roofers, tilers, slaters	
Loft insulators	
Window glaziers/ fitters	
Floorers/ wall tilers	
Scaffolders	
Electricians	• Heat pumps, mechanical ventilation, low energy lighting, solar panels
Plumbers, heating, ventilating installers	
Plasterers	• Finishing jobs and input to most retrofit interventions
Painters/ decorators	
Multiskilled/ general labourer	

Sources: Capital Economics, CITB *Net Zero and Construction: Perspective and pathways*, 2021

Modelling approach: interventions

We formed assumptions for the interventions installed

Many interventions can be included in a retrofit and there is no "one-size fits all" approach. Our model aims to estimate the additional workers that would be required to complete an example retrofit programme which would help the traditional building stock meet net zero by 2050.

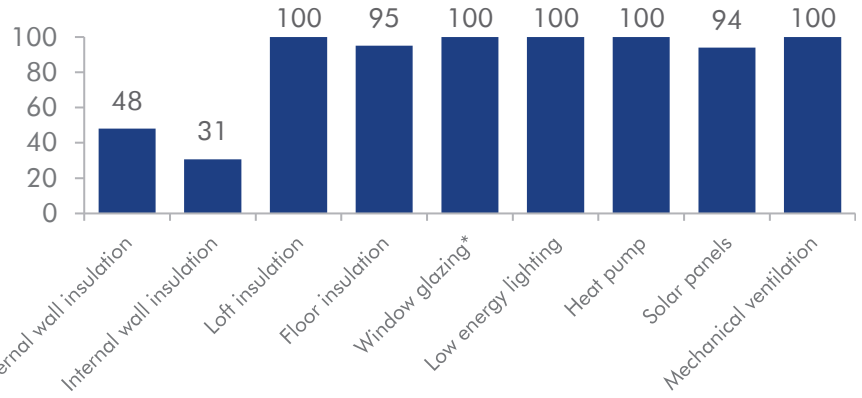
To estimate the work required on the 6.7 million traditional buildings in the UK, we have drawn upon research commissioned by Historic England which estimated carbon savings from retrofitting traditional properties in England.[66] Their research looked at eleven retrofit interventions and five property types representing 74% of England's traditional property stock. We applied the share of these five archetypes adopting a given intervention to the total stock of traditional properties in the UK.

The resulting assumptions on the number of properties that need each intervention in our base case are presented in the top chart of this page. For example, under this retrofit programme scenario, 31% of the 6.7 million traditional properties will have installed internal wall insulation by 2050, while 100% will have loft insulation work carried out. This is a scenario which enables us to quantify a need for workers to respond to net zero, rather than a forecast or an advocation for specific interventions.

Workers will need to install and repair/replace these measures

In addition to installing the measures, the technologies and materials have a finite 'life'. This means that workers' time will also be required to re-install, repair and maintain these interventions. We have drawn from a variety of sources for our assumptions of the life of interventions.[67] For example, a heat pump might need to be replaced after twenty years. This has been accounted for in our analysis.

Base case share of traditional properties with retrofit intervention installed by 2050 (%)



Life of intervention (number of years until repair or re-installation required)

Intervention	Life (years)	Intervention	Life (years)
External wall insulation	36	Low energy lighting	n/a**
Internal wall insulation	36	Heat pump	20
Loft insulation	42	Solar panels	30
Floor insulation	42	Mechanical ventilation	15
Window glazing	20		

Sources: Capital Economics, Historic England, Mission New Energy, and the Climate Change Committee.

*Note: Historic England listed three types of window glazing. We grouped these together.**Assumed that changing light bulbs will require minimal effort once the initial installation has been carried out.

Modelling approach: time estimates

Hours of work by occupation to carry out each given retrofit intervention on a terraced pre-1919 residential property of 93 square metres (hours per property)

	External wall insulation	Internal wall insulation	Loft insulation	Floor insulation	Window glazing	Low energy lighting	Heat pump	Solar panels	Mechanical ventilation
Directors	3.0	5.0	1.3	3.0	2.0	1.0	3.0	1.8	5.0
Surveyors/ Inspectors	12.8	10.0	3.1	7.8	3.9	2.7	5.8	8.5	6.8
Managers/ Supervisors	22.3	28.8	2.9	20.3	13.9	6.0	19.5	17.3	29.5
Electricians	5.3	38.3	-	3.0	-	44.3	16.4	42.8	47.9
Pipefitters	-	-	-	2.0	-	-	30.0	-	3.8
Bricklayers/ stonemasons	4.9	4.0	-	-	1.9	-	-	-	-
Roofers/ tilers/ slaters	17.5	-	-	-	-	-	-	13.9	-
Plumbers, heating & ventilating installer	12.0	37.3	-	-	-	-	71.3	-	87.5
Carpenters and joiners	10.5	111.6	2.0	79.5	20.0	2.7	6.0	2.0	43.0
Glaziers, window fabricators & fitters	1.9	-	-	-	82.3	-	-	-	-
Plasterers	117.5	103.8	-	-	5.9	-	1.9	-	2.9
Floorers and wall tilers	-	7.9	-	42.5	-	-	2.0	-	-
Painters and decorators	74.8	123.8	-	8.0	7.9	3.8	11.4	0.5	22.9
Scaffolders	90.3	-	-	-	59.0	-	-	59.0	2.0
Planners/ designers	14.0	17.3	8.4	9.3	7.4	7.9	12.8	12.8	16.8
Render operatives	99.5	-	-	-	-	-	-	-	-
Loft insulators	-	-	3.2	-	-		-	-	-
Multiskilled/ general labourers	14.5	91.5	6.4	37.3	6.9	9.5	9.9	11.1	33.3

Sources: Capital Economics, National Trust, and Seddons. Note: the National Trust provided us with estimates for 'other tradespeople', while Seddons provided three more specific 'other' categories. We applied these three categories to the National Trust estimates and took a simple average across both sources.

Modelling approach: key assumptions

	Base case
Hours of work by occupation and intervention	Average from a variety of sources provided to us
Productivity improvement	Fall in hours of work required of one per cent each year, which we have incorporated into our model. This means that by 2050, the time taken to install an intervention could take 70% of the time it took in 2020.[68]
Whole house efficiency	Notable savings in the hours required of a range of occupations when packaging up intervention measures. Hours of work required for the following occupations were reduced by 25%: directors, surveyors/inspectors, managers/supervisors, planners/designers. The remaining occupations were scaled down by 10%.
Scale for property types	Mean floorspace
Hours of work for re-installations once intervention life has expired	75% of the time it took to install in that same property type
The cumulative share of properties with intervention installed by 2050	Average of 'low' and 'high' energy efficiency scenarios used by Historic England in carbon saving model
	The assumptions used in the Historic England study stated whether an intervention would be carried out on the front, back, or extension of a property. Converted this to hours of work by assuming the front, back, and extension would take 40%, 40%, and 20% of the time it would take to install into a whole property
	Interventions installed at a constant pace between now and 2050
Number of construction workers currently working with traditional buildings who are in occupations relevant to retrofit	Assumed to be 100,000 in the base case

8. Bibliography

Bibliography (1)

[1] Construction Industry Training Board, *Building Skills for Net Zero* (Eunomia: Bristol), 2021.

[2] Capital Economics' analysis of Climate Change Committee, *The Sixth Carbon Budget Dataset*, 2021.

[3] Capital Economics' analysis of UK Green Building Council, *Net Zero Whole Life Carbon Roadmap for the Built Environment*, 2021. Available from: https://www.ukgbc.org/ukgbc-work/net-zero-whole-life-roadmap-for-the-built-environment/#:~:text=UKGBC%20have%20launched%20the%20Whole,demolition%20of%20buildings%20and%20infrastructure

[4] HM Government, *Net Zero Strategy: Build Back Greener* (HH Associated Ltd: London), October 2021.

[5] HM Government, *Heat and Buildings Strategy* (HH Associated Ltd: London), October 2021.

[6] Business, Energy, & Industrial Strategy, *Clean Growth Strategy*, October 2017.

[7] Climate Change Committee, *The Sixth Carbon Budget: Buildings* (Climate Change Committee: London), 2020.

[8] Capital Economics' analysis of Climate Change Committee, *'Sector explorer'* in *The Sixth Carbon Budget Dataset*, 2021. Available from https://www.theccc.org.uk/2021/02/01/the-numbers-behind-the-budget-six-ways-to-explore-the-sixth-carbon-budget-dataset/

[9] Construction Industry Training Board, *Net zero and construction: perspective and pathways*, 2021.

[10] Historic England, *Know your home, know your carbon: reducing carbon emissions in traditional homes*, 2020.

[11] Constructive Leadership Council, *National Retrofit Strategy*, 2021.

[12] Capital Economics' analysis of a range of sources including: Valuation Office Agency, *Council Tax: stock of properties*, 2022; Scottish Government, *Scottish house condition survey: 2017 key findings*; Northern Ireland Housing Executive, *Northern Ireland Housing Market: Review & Perspectives 2015-2018.*

[13] Capital Economics' analysis of Valuation Office Agency, *2010 Local Rating List: stock of property by region, sector and building age as at 31 March 2015.*

[14] Capital Economics' analysis of Valuation Office Agency, *2010 Local Rating List: stock of property by region, sector and building age as at 31 March 2015.*

Bibliography (2)

[15] Capital Economics' analysis of a range of sources including: Ministry of Housing, Communities & Local Government, *Floor space in English homes*, July 2018; and Valuation Office Agency, *Business Floorspace 2000/01-2020/21* and *2017 Local Rating List: Number of rateable properties 2021*. Note: Average non-residential floorspace (all property ages) adjusted based on average residential floorspace (all ages) relative to average residential floorspace (pre-1919) in a given region.

[16] Department for Levelling Up, Housing and Communities and Ministry of Housing, Communities & Local Government, *English Housing Survey Energy Report 2019-20: Energy efficiency profile,* 2021.

[17] Historic England, *Environmental Audit Committee: Energy Efficiency of Existing Homes Inquiry,* July 2020. Historic England notes that EPCs were devised as a compliance tool but are often used as a retrofit design tool. Additionally, research has demonstrated that actual energy use is often much less (<40%) than the predicted EPC rating. Furthermore, the assessment model used to generate EPCs - Reduced data SAP (RdSAP) - has been shown to predict higher energy demand than the 'full SAP' model used for new buildings (Better Buildings Partnership, 2018). Historic England concludes that this disadvantages existing buildings disproportionately, particularly older ones.

[18] Historic England, *Know your home, know your carbon: reducing carbon emissions in traditional homes,* 2020.

[19] CEBR, *The heritage sector in England and its impact on the economy*, 2020.

[20] Historic England, *Heritage Counts: There's no place like old homes, 2019.*

[21] CEBR, *The heritage sector in England and its impact on the economy*, 2020.

[19] Historic England, *Heritage Counts: There's no place like old homes, 2019.*

[21] CEBR, *The heritage sector in England and its impact on the economy*, 2020.

[22] Capital Economics' analysis of The Office for National Statistics, *GDP output approach UK Quarter 1 2022.*

[23] Capital Economics' analysis of The Office for National Statistics, *GDP output approach UK Quarter 1 2022.*

[24] Capital Economics' analysis of The Office for National Statistics, *GDP output approach UK Quarter 1 2022.*

[25] Capital Economics' analysis of The Office for National Statistics, *Output in the construction industry reference tables March 2022.*

[26] Capital Economics' analysis of The Office for National Statistics, *Output in the construction industry reference tables March 2022.*

Bibliography (3)

[27] Capital Economics' analysis of The Office for National Statistics, *Output in the construction industry reference tables March 2022.*

[28] Capital Economics' analysis of The Office for National Statistics, *Jobs by Industry.*

[29] Capital Economics' analysis of The Office for National Statistics, *Jobs by Industry.*

[30] Capital Economics' analysis of *RICS skills shortage survey results datasets* sourced from Refinitiv.

[31] Capital Economics' analysis of The Office for National Statistics, *Vacancies by Industry.*

[32] Capital Economics' analysis of Office for National Statistics, *Population projections United Kingdom 2020-based.*

[33] Capital Economics' analysis of Eurostat, *Employment by sex, age and detailed economic activity.*

[34] Construction Industry Training Board, *Fuller Working Lives in Construction*, (United Kingdom), October 2018.

[35] Capital Economics' analysis of Office for National Statistics, *Long-term international migration UK.*

[36] Capital Economics' analysis of Office for National Statistics, *Annual Population Survey UK.*

[37] Capital Economics' analysis of Office for National Statistics, *Long-term international migration UK.*

[38] Capital Economics

[39] Capital Economics' analysis of a range of sources including: Office for National Statistics, *2018-based household projections for England;* Stats Wales, *2018-based household projections;* Northern Ireland Statistics and Research Agency, *Population statistics household projections for Northern Ireland;* National Records of Scotland, *Household projections for Scotland (2018-based).*

[40] Capital Economics

[41] Capital Economics

[42] Ricardo Energy & Environment, *UK business opportunities of moving to a low carbon economy*, 2017.

[43] Place-Based Climate Action Network, *Tracking local employment in the Green Economy: The PCAN Just Transition Jobs Tracker*, https://pcancities.org.uk/tracking-local-employment-green-economy-pcan-just-transition-jobs-tracker

Bibliography (4)

[44] Construction Industry Training Board, *Building Skills for Net Zero* (Eunomia: Bristol), 2021.

[45] English Heritage, Historic Scotland and CITB, *Skills Needs Analysis 2013*, 2013.

[46] Retrofit Academy CIC, *Raising the Standards of Retrofit*, https://retrofitacademy.org/what-is-pas-2035/

[47] BSI Group, *Retrofit of domestic buildings under PAS 2035: A guide to assessing the significance of traditionally constructed buildings that are not protected.* Available at: https://pas2030.bsigroup.com/File/Spool/1184

[48] Capital Economics' analysis of The Office for National Statistics, *Output in the construction industry reference tables March 2022.* Repair and maintenance (R&M) is a sub-sector of construction output. In 2021, output in R&M (excluding infrastructure) was £50 billion. The average output per worker in the construction sector was around £82,000 in 2021, which implies that 630,000 people were employed in R&M in 2021.

[49] Capital Economics' calculations using own estimates of the number of traditional properties in the UK. See bibliography references 12,13, and 14.

[50] Capital Economics' analysis of CEBR, The heritage sector in England and its impact on the economy: an updated report for Historic England, 2020.

[51] Ecorys and Alastair Coey Architects, *Survey of Listed Building Owners (2017): a final report submitted to Historic England,* 2017. Available from https://historicengland.org.uk/content/docs/research/survey-listed-building-owners-2017-pdf/

[52] Construction Industry Training Board, *Building Skills for Net Zero* (Eunomia: Bristol), 2021.

[53] Currie & Brown and AECOM, *The costs and benefits of tighter standards for new buildings*, (Currie & Brown, London), July 2019. Study assumes that by 2030 the cost (in real terms, i.e., accounting for inflation) to install the measures will have fallen to around 89% of 2017 prices. This translates to a fall of nearly one per cent each year.

[54] Capital Economics' analysis of estimates of the number of hours of work required by occupation for each intervention for an exemplar pre-1919 terraced property of 93 square metres. These estimates were provided by the following four sources: The Crown Estate, National Trust, PJ Harte, and Seddons.

[55] Construction Leadership Council, *National Retrofit Strategy,* 2021.

Bibliography (5)

[56] Capital Economics' analysis of a range of sources including: Valuation Office Agency, *Council Tax: stock of properties*, 2022; Valuation Office Agency, *2010 Local Rating List: stock of property by region, sector and building age as at 31 March 2015;* Scottish Government, *Scottish house condition survey: 2017 key findings*; Scottish Government, *Housing Statistics: Stock by tenure 2020*; Northern Ireland Housing Executive, *Northern Ireland Housing Market: Review & Perspectives 2015-2018;* Open Data Northern Ireland, *NI Housing Stock by LGD 2008-2022;* Historic Scotland, English Heritage and CITB, *Skills needs analysis 2013: repair, maintenance and energy efficiency retrofit of traditional (pre-1919) buildings in England and Scotland .*

[57] Capital Economics' analysis of a range of sources including: Ministry of Housing, Communities & Local Government, *Floor space in English homes*, July 2018; and Valuation Office Agency, *Business Floorspace 2000/01-2020/21* and *2017 Local Rating List: Number of rateable properties 2021*. Note: Average non-residential floorspace (all property ages) adjusted based on average residential floorspace (all ages) relative to average residential floorspace (pre-1919) in a given region.

[58] Capital Economics' analysis of a range of sources including: Valuation Office Agency, *Council Tax: stock of properties*, 2022; Valuation Office Agency, *2010 Local Rating List: stock of property by region, sector and building age as at 31 March 2015;* Scottish Government, *Scottish house condition survey: 2017 key findings*; Scottish Government, *Housing Statistics: Stock by tenure 2020*; Northern Ireland Housing Executive, *Northern Ireland Housing Market: Review & Perspectives 2015-2018;* Open Data Northern Ireland, *NI Housing Stock by LGD 2008-2022;* Historic Scotland, English Heritage and CITB, *Skills needs analysis 2013: repair, maintenance and energy efficiency retrofit of traditional (pre-1919) buildings in England and Scotland .*

[59] Capital Economics' analysis of Capital Economics modelling results and Office for National Statistics, *Annual Population Survey employment by occupation (SOC).*

[60] Capital Economics' analysis of Office for National Statistics, *Apprenticeship subject standards 2021 Q4*

[61] BSI Group, *Retrofit of domestic buildings under PAS 2035: A guide to assessing the significance of traditionally constructed buildings that are not protected.* Available at: https://pas2030.bsigroup.com/File/Spool/1184

[62] Capital Economics' analysis of Capital Economics modelling results and Office for National Statistics, *Real GVA output tables and labour market data.*

[63] Capital Economics' analysis of Capital Economics modelling results and Office for National Statistics, *Annual survey of hours and earnings.*

[64] Capital Economics' analysis of Capital Economics modelling results and Office for National Statistics, *Real GVA output tables and labour market data.*

Bibliography (6)

[65] Construction Industry Training Board, *Net Zero and Construction: Perspective and pathways*, 2021.

[66] Capital Economics' analysis of data provided directly by Historic England which was used in the following study: Historic England, *Carbon reduction scenarios in the built historic environment: Final Report*, 2020.

[67] Life of external wall insulation, internal wall insulation, loft insulation, floor insulation and glazing: Climate Change Committee and UCL, *Analysis work to refine fabric energy efficiency assumptions for use in developing the Sixth Carbon Budget,* February 2020. Life of heat pumps uses input from Historic England and Grosvenor. Life of mechanical ventilation from Historic England, *Carbon reduction scenarios in the built historic environment: Final Report*, 2020, p.44.

[68] Currie & Brown and AECOM, *The costs and benefits of tighter standards for new buildings*, (Currie & Brown, London), July 2019. Study assumes that by 2030 the cost (in real terms, i.e., accounting for inflation) to install the measures will have fallen to around 89% of 2017 prices. This translates to a fall of nearly one per cent each year.