Net Zero Whole Life Carbon Roadmap

A Pathway to Net Zero for the UK Built Environment

November 2021

UK GBC

WORLD GREEN BUILDING COUNCIL

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Laudes Foundation

IKEA Foundation

The **Net Zero Whole Life Carbon Roadmap** project aims to outline a common vision and agree upon industry-wide actions for achieving net zero carbon in the construction, operation, and demolition of buildings and infrastructure in the UK.

The main areas of discussion include the carbon footprint for the UK built environment, the Net Zero Carbon trajectory to 2050, and policy recommendations with industry action plans to deliver the 2050 scenario. These outputs are published in an initial series of four reports:

A Pathway for the UK Built Environment - aimed at stakeholders from across the built environment value chain who need an overview of the Roadmap findings and its implications for the sector. The report provides context for why the Roadmap exercise is critical to delivering the UK net zero goal, while also detailing the necessary technological shifts, policies and industry actions that can help deliver decarbonisation.

Technical Report - provides detail on the project structure, the process for data collection, the key features of the calculation methodology and concludes with a description of the net zero scenario definition and results.

Summary for Policy-Makers - aimed at central government, local authorities, and anyone interested in built environment policies. The Summary provides an overview of the relevant Roadmap findings and policy recommendations for central government to deliver a net zero built environment by 2050.

Stakeholder Action Plans – sets out specific recommended actions for 14 key industry stakeholders, enabling them to play their part in achieving the Roadmap's goals.

Context

UKGBC is one of several European GBCs developing national Whole Life Carbon Roadmaps under the WorldGBC #BuildingLife project, funded by Laudes and the Ikea Foundation. In the runup to COP26, WorldGBC has convened ten European Green Building Councils to galvanise climate action in the built environment through national and regional decarbonisation roadmaps. The Green Building Councils spearheading the project are Croatia, Finland, France, Germany, Ireland, Italy, the Netherlands, Poland, Spain and the UK. BuildingLife is accelerating ambitions in the building sector by creating the first region-wide response to the vision of a net-zero whole-life carbon-built environment as set out in WorldGBC's 2019 report.

The project acknowledges support from UK Research and Innovation through the Centre for Research into Energy Demand Solutions, grant reference number EP/R035288/1

Citation

Net Zero Whole Life Carbon Roadmap: A Pathway for the UK Built Environment. UK Green Building Council, 2021, London, UK.

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Nigel Topping

COP26 High Level Climate Action Champion

2021 HAS BEEN A MONUMENTAL YEAR FOR ACTION ON CLIMATE CHANGE.

The latest assessment reports from the Intergovernmental Panel on Climate Change have provided the starkest warning yet that immediate action at scale is needed to mitigate against the most extreme impacts of climate change. This warning has not fallen on deaf ears. Numerous companies, countries, cities and regions have stepped up with immediate action plans to deliver net zero, many through joining the UN Race to Zero.

This global momentum has certainly been felt in the built environment. With the built environment responsible for 38% of global emissions, concerted effort is now being placed on delivering credible pathways to net zero for individual markets. One of the key outcomes of this process has been the recognition that the industry must take meaningful actions to measure and reduce embodied carbon emissions alongside its operational ones.

In this context, this Roadmap report provides a much-needed clarification on what a whole life carbon pathway entails for the UK built environment. It lays out the necessary steps for the industry and government to deliver a net zero built environment, and the timeframes in which they need to be taken. Collaboration will be key to it all.

The Roadmap and its targets are aligned with the UK's carbon budget and the trajectory they set aims to provide clarity and coherence around the journey to hit these ambitious UK commitments. The targets will be challenging to achieve, especially given the complex and interdependent nature of the built environment's many sectors and disciplines. To overcome these challenges, innovative financing solutions, renewed stakeholder engagement, and unprecedented levels of investment into net zero skills will be needed. These elements will be essential throughout the built environment's intricate supply chains to ensure the incentives exist on both the supply and demand side, and that smaller UK businesses are supported in the transition. While this report will provide valuable guidance for the direction of travel on whole life carbon, business and government leadership will be necessary to drive innovation and investment to where it is most needed.

With over 20 percent of the largest property companies and real estate investment managers committed to achieving net zero carbon in the built environment globally, the intention to drive this transition is evident and increasing. We are close to reaching a breakthrough tipping point in the sector in which it will be easier to continue towards a net zero carbon future than to adopt any other approach. I call therefore on everyone with a stake in the UK built environment to continue to demonstrate this leadership, join the Race to Zero, and align your action plans with this Whole Life Carbon Roadmap. This is a systemic issue and we must engage with other businesses, governments, municipalities, and civil society organisations so that we can drive this transition together.

As we start a critical decade for climate action, the United Kingdom can and should take a leadership role. This report epitomises leadership and establishes that the UK built environment has a comprehensive and rigorous plan for abating its emissions across the construction, operation, and demolition of buildings and infrastructure. I invite you all to use this Roadmap for delivering a net zero future.

Mark Allan

Chief Executive, Landsec

IF WE ARE TO MEET THE UK'S TARGETS ON CLIMATE, OUR SECTOR MUST ACT AND IT MUST ACT NOW.

When it comes to action on climate change, we all want to go as far, and as fast as we can. The evidence is clear that action in this decade will be absolutely critical in order to achieve the emission reductions required to limit global warming to 1.5ºC.

As a sector, the real estate industry has a significant environmental impact. With building and construction estimated to be responsible for 25% of the UKs total carbon footprint, we have a significant role to play in the national transition to Net Zero.

In 2016 Landsec was the first commercial real estate company in the world to set science-based carbon reduction targets. Only by aligning our ambitions with the latest climate evidence can we determine credible mitigation strategies and clearly identify actions.

This landmark report, created in partnership with industry, provides our sector with a detailed carbon pathway to net zero, in line with the UK's national carbon budgets and targets. By establishing a carbon budget for the UK built environment, the Roadmap clearly articulates the emissions reductions required.

However, targets alone will not deliver the outcomes needed, our sector has to act and it has to act now. The UK Built Environment's current carbon footprint indicates that while there has been progress, widescale, transformative shifts in practice have not yet occurred. We must challenge ourselves to move further and faster. The answer, I believe, is likely to be a combination of factors. Industry collaboration, innovation and government support among them.

There are many examples of what is possible across our sector, we now need to find more ways to tip the scales, unlock new ways of doing things, and bring new innovations and learnings into the mainstream to become the market standard. That might be with funding from public or private sources or through collaboration and innovation.

Our industry has set out some bold ambitions on climate change but we're only going to meet them by finding ways to unlock new thinking. As a sector we need to come together to share best practice and demonstrate the art of the possible. We all have a role to play, embedding net zero skills throughout our business and supply chains, and across all types of buildings and infrastructure.

The Whole Life Carbon Roadmap provides a common vision for industry. It provides consensus on the key interventions and milestones and lays out the steps necessary for decarbonisation. By having a common language, common principles and a common roadmap, collaboration is within reach. I have every confidence that as a sector we can tip the scales and achieve what is needed for the future of our planet and for the future of our sector.

Executive Summary

Introduction to the Roadmap

The Net Zero Whole Life Carbon Roadmap for the Built Environment (The Roadmap) provides a shared vision and set of actions for achieving a net zero carbon UK built environment by 2050, in relation to the construction, operation, and demolition of buildings and infrastructure.

The Roadmap consists of four elements:

- A carbon footprint of the UK built environment, defined on a consumption basis (i.e. including emissions from imported construction products and materials)
- A net zero emissions budget and trajectory to 2050 for the UK built environment
- Recommended policy interventions for central and local government
- Recommended actions for industry stakeholders

This Pathway report includes the carbon footprint and the trajectory to 2050, together with an overview of the methodology used to create them. The report then focuses on the actions required to achieve the net zero trajectory, explaining them via a timeline and then in terms of the nature of the emissions (operational and embodied) and the primary asset types (domestic, non-domestic, infrastructure).

Methodology

A key aspect of the project approach was to ensure that The Roadmap was co-created by the industry. To facilitate this engagement, UKGBC convened a project Steering Group and four Task Groups, who focused on New Build, Domestic Retrofit, Non-Domestic Retrofit and Infrastructure. All the groups were comprised of representatives from commercial organisations, professional institutions and other key sector bodies. Acknowledgements of the approximately 100 individuals and organisations involved can be found at the end of this report.

The Task Groups developed the carbon trajectory, and the policy and industry proposals, through a series of workshops, working collaboratively with project technical partners. A formal industry consultation was undertaken on the draft proposals, alongside dialogue and engagement with government, local authorities, key industry stakeholders and the Climate Change Committee (CCC).

The Roadmap was also planned to be consistent with wider UK carbon targets and budgets. These include the UK government's 2050 net zero target and the 2035 interim target for emissions to be 78% lower than in 1990. To ensure alignment, the Roadmap uses the CCC 6th Carbon Budget this as an overarching reference, with additional datasets and feedback provided by the CCC.

Emissions attributable to the UK built environment cut across several of the CCC emission categories, and the 6th Carbon Budget therefore does not provide a clearly defined quantum of emissions for the built environment. Consumption emissions (i.e. emissions related to imported construction materials and products) are not considered within CCC analysis of UK domestic emissions (i.e. emissions arising in the UK) but are a significant element of the built environment's carbon footprint.

The Roadmap's approach, therefore, was to capture all of the emissions related to the built environment under one sectoral umbrella. The Roadmap trajectory can thus be seen as compatible with the CCC's balanced pathway and national carbon budget, as near identical end points are reached - albeit with some differences in the approaches taken to drive decarbonisation.

Impact of the Built Environment

The Roadmap created a carbon footprint of the UK built environment based on the most up-to-date emissions data. Figure 1 illustrates that the UK Built Environment is currently responsible for (i.e., has direct control over), 25% of total UK greenhouse gas emissions (buildings and infrastructure). If surface transport (vehicle emissions) is included within the scope of the built environment, the total share of UK emissions increases to 42%.

Figure 2 shows that over the last two decades, built environment emissions (excluding surface transport) have reduced by c.30%. Most of this decrease occurred after 2010 and is largely due to a reduction in operational emissions, most of which are attributable to rapid decarbonisation of the electricity grid in recent years, rather than improvements in the energy efficiency of buildings.

Embodied carbon emissions over the period have reduced by almost 20% and are driven by two factors - decreasing carbon intensity of construction and increasing construction growth. The former declined by 40% in the period 2000-2018, while the latter only paused between 2007 and 2012 as a result of the financial crisis.

Business as usual (BAU) projections[1], informed by the existing government policy framework, indicate that the sector will fall well short of 2050 net zero targets. Only a 60% reduction will be achieved compared to 1990 emission levels, which will leave 115 MtCO2e of residual emissions that will need to be offset. This is above the CCC's projected 97 MtCO2e offset capacity for the entire UK in 2050 via land use and greenhouse gas removals.

These projections highlight the scale of transformation required across the built environment, with systemic interventions needed to incentivise change across the design, construction, operation, and demolition of buildings and infrastructure.

Figure 1: Total UK GHG emissions (2018 CCC Data) showing proportion of Built Environment emissions

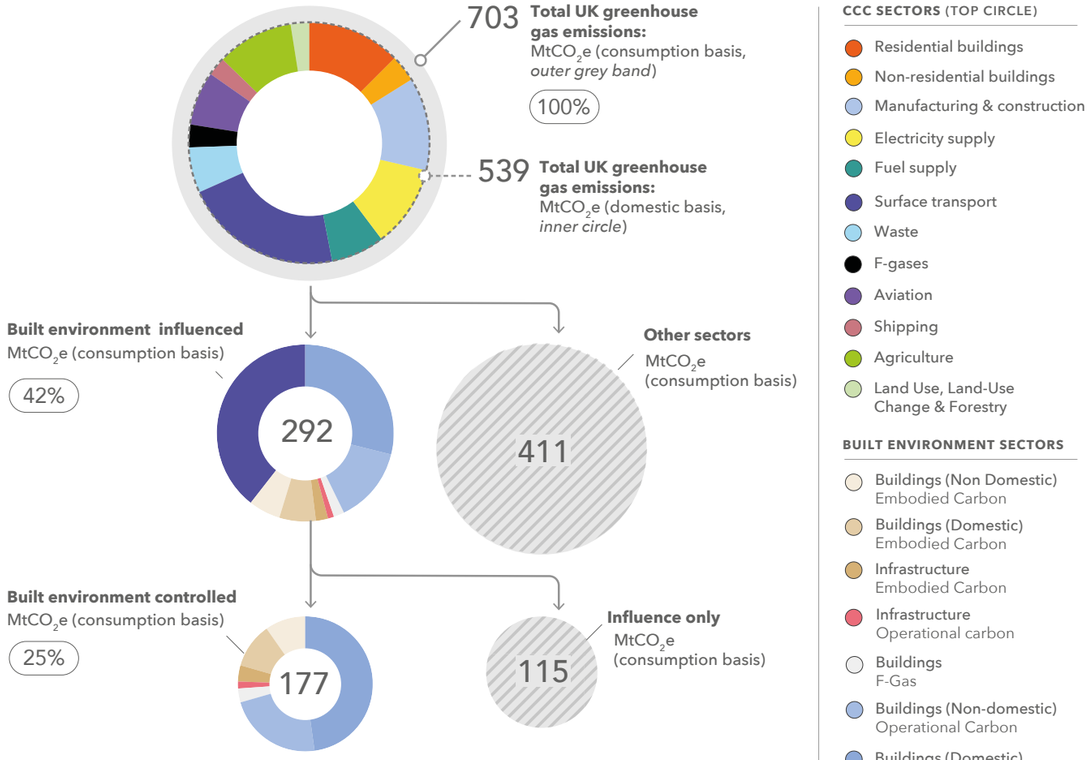
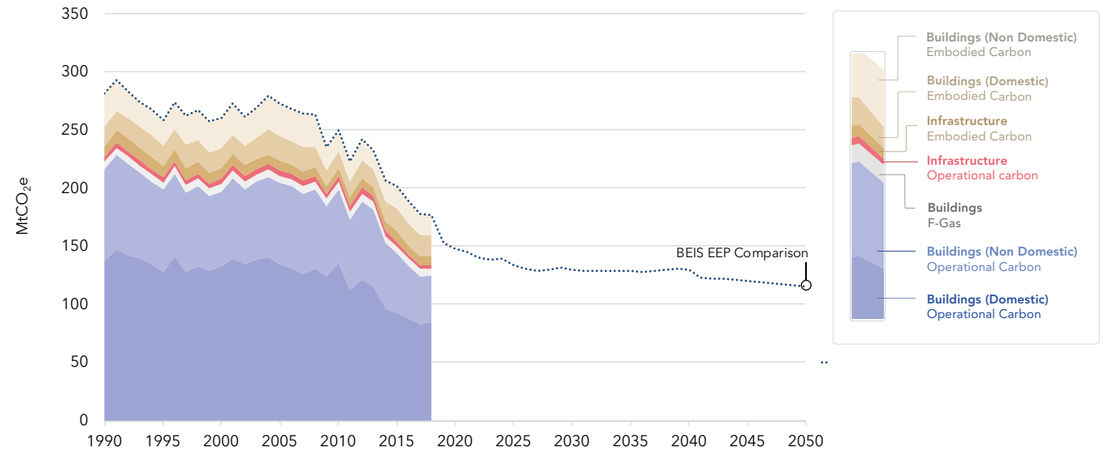


Figure 2: Historic (1990-2018) Built Environment emissions (excluding transport), with business as usual projections applied (BEIS EEP to 2040, with trendline extended to 2050)



Net Zero Trajectory

2018 - 2050

The Net Zero trajectory shows projected emissions from the Built Environment through to 2050. The baseline year is 2018 as this is the most recent year for which full emission datasets are available.

The trajectory was informed by data inputs from the project team, setting out the required pace and scale of mitigation measures across the Built Environment.

Policy recommendations to drive and enable the transition were developed collaboratively, building on recent industry guidance and research.

A summary of recommended interventions is shown for the 2020s, 2030s and 2040s, for both operational emissions (blue) and embodied emissions (gold).

Key milestones and policy timelines are mapped on top of the trajectory, as per the legend below.

Key milestones and policy interventions

Operational Carbon

- (A) End of sales of gas / oil boilers (domestic & non-domestic)
- (B) Mandatory minimum EPC "C" required at point-of-sale for owner-occupied homes and domestic rented sector (MEES)
- (C) Mandatory Energy Disclosure introduced for non-domestic buildings via Performance Rating Schemes
- (D) Performance Rating Schemes introduce minimum standards
- (E) Building Regulations Part L adopts Energy Use Intensity (EUI) compliance approach

Embodied Carbon

- (F) Building Regulations introduce mandatory measurement of Whole Life Carbon
- (G) Building Regulations introduces limits on Upfront Embodied Carbon
- (H) Carbon pricing and anti-carbon leakage policies

2020s

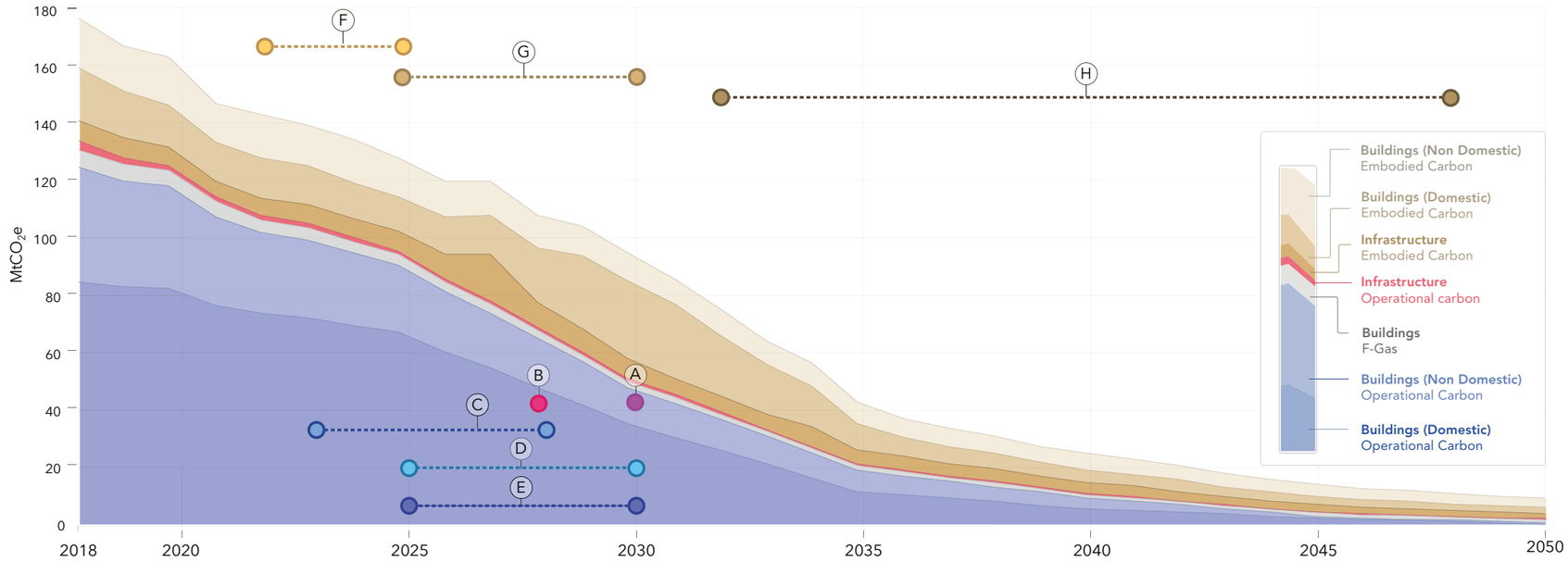
- Mandatory measurement of Whole Life Carbon introduced into Building Regulations.
- Building Regulations introduce initial limits on Upfront Embodied Carbon once sufficient datasets established to inform targets across sectors.
- Planning and VAT reforms prioritise the reuse of existing buildings and assets while disincentivising demolition and new builds.
- Commitment and investment in industrial decarbonisation strategies including delivery of first CCS clusters.

2030s

- Progressive tightening of Building Regulation limits on embodied carbon as measurement and mitigation via design efficiency and optimised material selection becomes standard practice.
- Upturn in embodied carbon as a result of home retrofit programme.
- Embodied carbon represents c.50% of Built Environment emissions by 2035 due to steeper reductions in buildings operational emissions.
- Industrial decarbonisation accelerates, supported by robust carbon pricing and anti-carbon leakage policy framework. Delivery of additional CCS clusters.

2040s

- Carbon pricing and anti-carbon leakage policies evolve to drive final phases of industrial decarbonisation programmes, including solutions for dispersed and smaller sites.
- Carbon intensity of construction significantly reduced through improved design efficiency, optimised material selection, and decarbonised supply chains, alongside a maturing circular economy.



2020s

- National domestic retrofit strategy established, setting out a UK homes upgrade programme to 2040, fully coordinated with local government, industry, and relevant stakeholders via a Central Retrofit Agency. Phase 1 (capacity building) commences.
- Timelines confirmed for phase-out of gas & oil boilers (no further sales from 2030)
- Domestic EPCs reformed to better reflect energy performance.
- Net Zero energy performance standards confirmed, with suitable triggers such as minimum EPCs at point-of-sale for owner-occupied homes (EPC "C" by 2028).
- Mandatory energy disclosure for non-domestic buildings introduced via Performance Rating Schemes, followed by minimum standards per sector to drive sectoral performance.
- Low carbon heating for all new buildings and Building Regulations Part L transitions to Energy Use Intensity (EUI) compliance approach in line with energy disclosure timeline per sector. Low carbon heating for all new buildings and Building Regulations Part L transitions to Energy Use Intensity (EUI) compliance approach in line with energy disclosure timeline per sector.

2030s

- Domestic retrofit strategy accelerates the integrated deployment of fabric improvements and low carbon heating technologies to millions of homes, using digital building renovation plans/passports to accurately describe Net Zero pathway(s) for individual homes.
- A range of funding mechanisms and fiscal policies utilised to enable and incentivise widespread domestic retrofit for all, including variable stamp duty (adjusted in line with energy performance), VAT reductions on retrofit works, and direct government grantsfor low-income households.
- Progressive tightening of minimum standards for non-domestic energy performance in line with sectoral carbon budgets.
- Building Regulations introduces peak load limits for new buildings. Building Regulations introduce peak load limits for new buildings.

2040s

- Final phase of domestic retrofit strategy completes, tackling harder-to-treat homes.
- Last remaining fossil fuel boilers are replaced ahead of 2050.
- Some residual F-gas emissions due to widespread heat pump usage, to be minimised via rigorous F-Gas policy framework and enforcement regime which meets or exceeds EU policy on refrigerants.
- Progressive tightening of minimum standards for non-domestic energy performance in line with sectoral carbon budgets.

Key Messages

The built environment is directly responsible for 25% of UK emissions. The urgency to act on climate change has never been greater, and the built environment sector has a moral and legal responsibility to address the climate emergency and accelerate sector decarbonisation.

Five Key Priorities

The Roadmap has identified five key priorities which government and industry need to support and implement across the sector in order to deliver Net Zero for the built environment:

1. **Nation-wide retrofitting of existing homes.**

   To transform UK housing so it is efficient, warm, and cheaper to heat, whilst phasing out fossil fuel heating.

2. **Energy performance disclosure for non-domestic buildings.**

   To ensure that real-world performance of assets is visible to the market, and can influence asset valuation, market transactions, and management decisions.

3. **Adoption of a design for performance approach.**

   To shift away from the theoretical "notional building" approach and to focus on how energy intensive buildings will be built in practice, alongside other key net zero enablers such as peak demand limits.

4. **Whole life carbon measurements and agreed limits.**

   To start with mandatory measurement, followed by the phased introduction of embodied carbon limits for new buildings to reduce demand, alongside changes to planning and VAT to incentivise the re-use of existing buildings.

5. **National infrastructure investment based on the net emissions impact.**

   To consider all forms of carbon, alongside a policy framework and investment to drive industrial decarbonisation of key construction supply chains.

Future of the Roadmap

Updates and Ownership

The intention of this project is to create and share a resource of lasting value and impact to both Government and industry. The carbon trajectory data published in this report is available online for download and review by stakeholders across the industry.

Tracking sector progress against the trajectory will be crucial, and UKGBC is committed to refreshing the datasets on an annual or biennial basis to provide progress updates to the sector.

Progress updates will enable the industry to track carbon reduction progress and identify sub-sectors which are not moving fast enough.

There is also potential to undertake periodic updates and recasting of the trajectory, to identify the impact of updates in national policy or strategy.

Ongoing Roadmap Development

Sub-Sector Roadmaps

The carbon trajectory provides an overarching carbon budget which will inform sub-sectors' emission reduction plans and identification of interim targets. The roadmap trajectory forms a consistent umbrella dataset, complimenting detailed pathways for sub-sectors or industry stakeholder groups, ensuring a consistent sector approach while accounting for unique challenges and opportunities at a more granular level.

Asset Level Targets

The Roadmap carbon budget and sub-sector trajectories provide an invaluable resource to inform the development of standards and targets to underpin the definition of net zero carbon at an asset level, ensuring that targets are consistent with the sectoral Net Zero pathway.

The Roadmap datasets should inform the following workstreams:

- Identifying Energy Use Intensity (EUI) target pathways to 2050 within the Government's Performance-Based Policy Framework for non-domestic buildings.
- New Building EUI targets (industry targets and future regulatory standards).
- Developing science-based pathways for asset level embodied carbon targets (industry targets in support of future regulatory limits).
- Domestic retrofit stock modelling of different house architypes to identify cost-optimal levels of fabric upgrades.
- Asset level Net Zero Carbon standards and any verification scheme requirements.

Call to Action

The Roadmap is a resource for the sector that establishes urgent priorities and actions for decarbonisation. Achieving the net zero 2050 target is feasible, but will require a transformative shift in industry practices, as well as Government policy and investment into key delivery programmes and technologies.

A new context for addressing the climate emergency has emerged that is moving radically faster than previous years, with drivers towards net zero increasingly being put into place by Government, industry, financiers, occupiers, and wider society.

Extensive collaboration and efforts will be required to deliver the net zero scenario, but the science is clear on the dangers of failing to act. Everyone must play their part, and while the work is only beginning, the path forward is clearer than ever before.

Methodology

The following section describes the approach to establishing the scope, the concept of a carbon budget for the Built Environment, and the methodology and approach adopted.

Purpose

The Net Zero Whole Life Carbon Roadmap for the Built Environment (The Roadmap) aims to build a common vision and agreed actions for achieving net zero carbon in the construction, operation and demolition of buildings and infrastructure in the UK.

The UK has a legal commitment to achieve Net Zero by 2050, with pathways and recommendations for how this could be achieved set out by the Climate Change Committee (CCC) through their UK Carbon Budget analysis and reports.

The Roadmap highlights and provides focus to the emissions footprint specific to the UK Built Environment and presents a view of the specific actions and steps needed throughout the sector to reduce emissions, through the lens of whole-life carbon (i.e. construction, operation, end-of-life stages).

Key Project Objectives

- Build consensus on a pathway to net zero carbon for the built environment among businesses and industry bodies.
- Identify key interventions required and any critical interdependencies.
- Develop sectoral carbon targets.
- Set out actions, owners and processes to achieve these targets.
- Identify a range of policy recommendations to support, incentivise, and where necessary, regulate carbon reduction measures.
- Highlight the role of industry.
- Encourage and enable greater consistency between sector-based action plans that are published or in development.

Approach

A key aspect of the project approach was that the proposals would be co-created with industry. To deliver the objectives, four project Task Groups were established, with representatives and expertise from across the industry. The task groups developed the carbon trajectory, and policy and industry proposals, through a series of workshops, working collaboratively with project technical partners.

The industry-wide Steering Group provided strategic input throughout the process and acted as a reviewing body for the Task Group outputs. A formal industry consultation was undertaken on the draft proposals, alongside dialogue and engagement with government, local authorities, key industry stakeholders and the Climate Change Committee.

Roadmap Overview

The Roadmap consists of four elements:

- **A CARBON FOOTPRINT FOR THE UK BUILT ENVIRONMENT**, defined on a consumption basis
- **A NET ZERO SCENARIO** calculating an emissions budget and trajectory to 2050 for the UK Built Environment.
- A suite of **POLICY RECOMMENDATIONS** for central and local government
- **A STAKEHOLDER ACTION PLAN** describing the specific actions for key stakeholder groups in support of the Net Zero Scenario.

The Net Zero Scenario methodology builds on the work of the Green Construction Board 2013 Low Carbon Route-map for the Built Environment. The 2013 Route-map analysis carbon model has been utilised and updated to incorporate key changes.

The Net Zero trajectory was informed by data inputs from the Steering Group and Task Groups, setting out the required pace and scale of mitigation measures. Policy recommendations and stakeholder actions were informed by recent industry guidance and research, and further refined by the project team.

Scope of UK Built Environment Emissions

Within its analysis and reporting, the CCC splits UK emissions into the categories or 'sectors' shown in Figure 3 below, with associated mitigation measures and recommended actions per sector.

Emissions related to the UK Built Environment cut across several of these CCC sectors, most obviously Buildings, but also elements of Manufacturing and Construction, Waste, Surface Transport, F-Gases (i.e. fugitive emissions from refrigerants), and others. Furthermore, although a proportion of embodied carbon emissions from construction are captured within UK Manufacturing and Construction, a significant proportion (c.30%) relate to non-territorial 'consumption' emissions, i.e., construction materials and products produced overseas and imported to the UK.

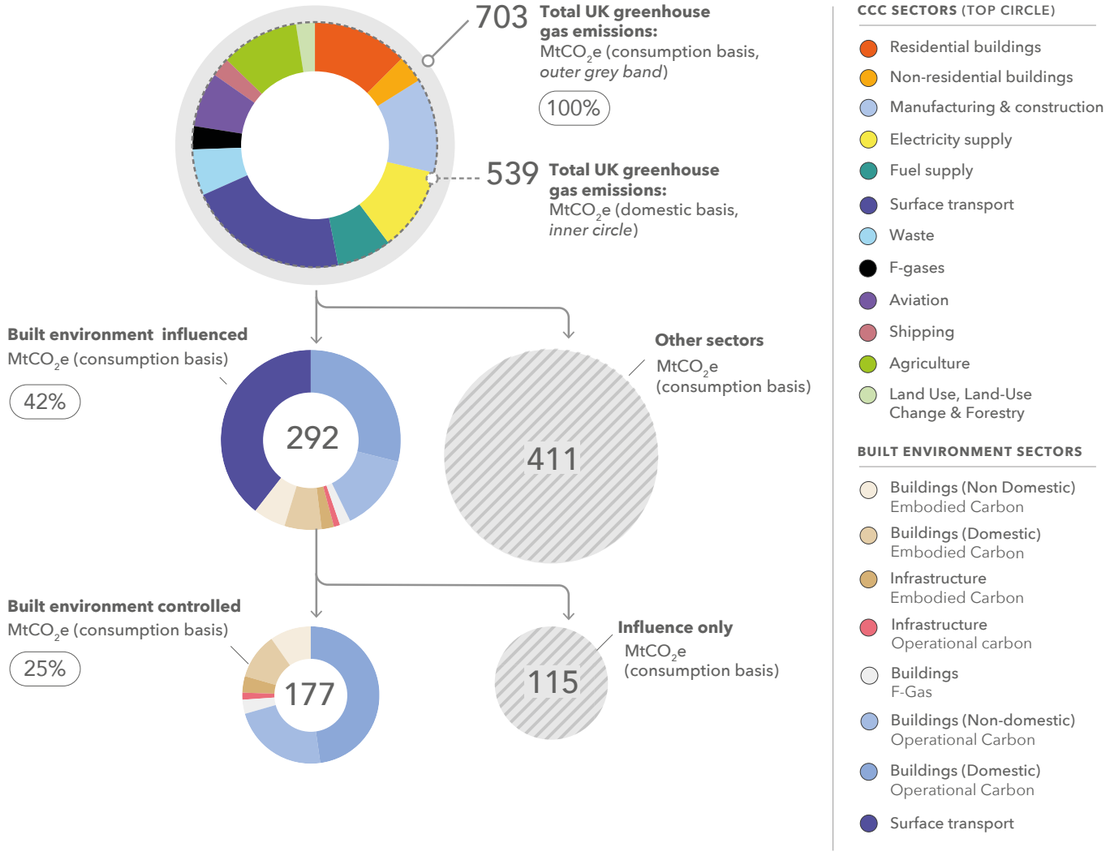
In order to accurately determine a carbon footprint for the UK Built Environment and identify tailored stakeholder actions, an appropriate system boundary and sub-categories are required. The Roadmap scope attempts to capture all the emissions related to the built environment under one sectoral umbrella, including consumption emissions.

Sub-sector categories provide increased visibility in relation to the degree of control or influence of each stakeholder group, which allows for a more consistent roadmap of actions to be developed with the end goal in mind.

In first principle terms, the built environment encompasses all elements of man-made infrastructure and buildings. If the construction, operation and use of all these elements are included for scoping purposes, such as the supply and distribution of fuel and power, and all vehicle usage on our transport networks, the resultant quantum of emissions is approximately 75% of the UK emissions total.

A significant proportion of this is from the transport (vehicle usage), and energy (supply) sectors, and decarbonising these sectors is clearly critical in the context of the UK's Net Zero 2050 commitment. They are also integral parts of the wider Built Environment, and ultimately a systems viewpoint is required to evaluate the wider interconnected carbon impacts and reduction opportunities.

Figure 3: Total UK GHG emissions (2018 CCC Data) showing proportion of Built Environment emissions



However, in order to provide adequate focus and depth to the industry, the focus of this report is on embodied and operational carbon of buildings and infrastructure, and excludes emissions related to surface transport (i.e. "tailpipe" emissions from vehicles) and energy distribution.

For the purposes of this exercise the following scope of emissions and sub-categories have been established to represent the UK Built Environment.

Table 1: Scope of Built Environment Emissions

	Embodied Carbon	Operational Carbon (Regulated)	Operational Carbon (Unregulated)	F-Gas
Domestic Buildings	Embodied carbon from Construction, Maintenance & Demolition. Both domestic and consumption (imported) emissions.	Carbon from regulated energy uses: - Heating - Cooling - Ventilation & Pumps - Lighting - Hot Water	Carbon emission from unregulated energy uses: - Cooking - Appliances - Lifts - Small power / plug loads - IT servers	F-Gas leakage from refrigeration, heat pumps and air conditioning plant within buildings.
Non-Domestic Buildings				
Infrastructure		Carbon from the operation of infrastructure: - Street & public realm lighting - Communication networks - Water supply & treatment - Waste treatment	Not in scope (i.e. "User Carbon")	Not in scope

UK Built Environment Emission Reductions

Using the established emissions scope, historical emissions within the Built Environment can be reviewed to understand the specifics of where progress is being made, and where further efforts are required.

Figure 4 shows that over the last two decades, built environment emissions (excluding surface transport) have reduced by 30%. Most of this decrease occurred after 2010 and is largely due to a reduction in operational emissions, most of which is attributable to rapid decarbonisation of the electricity grid in recent years, rather than improvements in the energy efficiency of buildings.

Business as usual (BAU) projections, informed by the existing government policy outlook, indicate that the sector will fall well short of 2050 net zero targets.

Only a 60% reduction will be achieved compared to 1990 emission levels, which will leave 115 MtCO2e of residual emissions that will need to be offset. This is above the CCC's projected 97 MtCO2e offset capacity for the entire UK in 2050 via land use and greenhouse gas removals.

Embodied carbon emissions over the period have reduced by almost 20% and are driven by two factors - decreasing carbon intensity of construction and increasing construction growth. The former declined by 40% in the period 2000-2018, while the latter only paused between 2007 and 2012 as a result of the financial crisis.

The net result is an overall reduction in emissions, but the data demonstrates the challenge of decoupling embodied emissions

Figure 4: Historic (1990-2018) Built Environment emissions (excluding transport), with business-as-usual projections applied (BEIS EEP to 2040, with trendline extended to 2050).

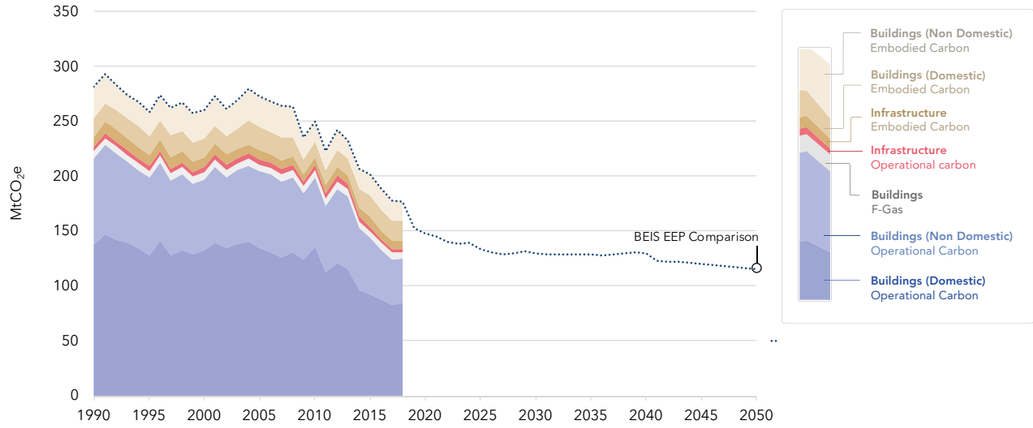


Figure 5: Total UK building energy usage, related carbon emissions, and grid electricity carbon intensity, expressed as a percentage against a 2000 baseline

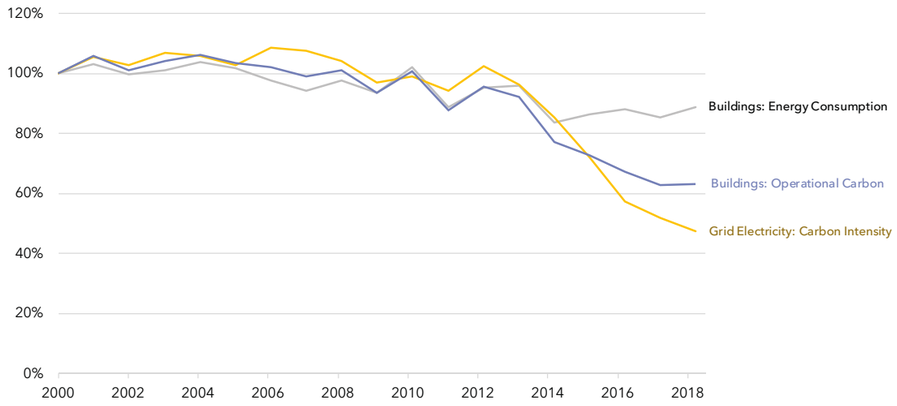
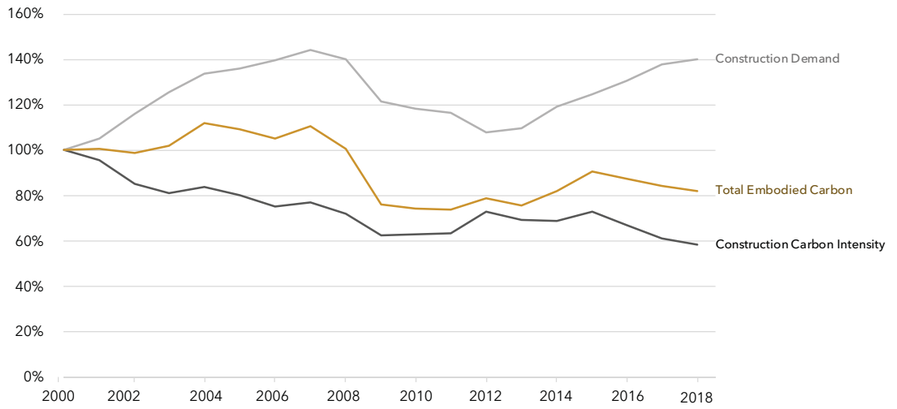


Figure 6: Total Built Environment embodied carbon emissions, carbon intensity of construction, and construction economic growth, expressed as a percentage against a 2000 baseline.



A Carbon Budget for the UK Built Environment

One of the overarching objectives of the Roadmap is to identify and set out a forward emissions budget to 2050 for the built environment, consistent with the wider UK carbon budget, and with a suitable system boundary.

The CCC recommends emission reduction targets aligned with the UK's 2050 net zero goal, as defined by the 2015 Paris Agreement. In 2020, the CCC proposed a legally binding emission target for the period of 2033-37, known as the 'Sixth Carbon Budget,' which would commit the UK to lowering its emissions to 78% below a 1990 baseline by 2035. In April 2021 the UK adopted the CCC's recommendation as a legally binding target.

The benefit of identifying carbon budgets is that they provide a ceiling for allowable emissions, whilst enabling choices within that budget around how emissions are allocated between sub-categories and different carbon emitting activities. Value judgements may be made around competing priorities and preferred pathways based on economic or technical considerations.

Determining and agreeing an overarching consumption-based carbon budget for the Built Environment creates a top-down dataset that can be used to support the evolution of asset and project level targets.

To determine a carbon budget for the Built Environment, once boundary conditions have been established to identify the starting position, projections can then be made for the pace and scale of required carbon reduction interventions over time. The resultant projected emissions form the pathway, or emission trajectory, with the interventions forming the projected scenario.

Net Zero 2050 Target

The CCC 6th Carbon budget sets out a balanced pathway for carbon reduction towards Net Zero across all sectors. Some sectors, such as Buildings, are projected to decarbonise completely, whereas other sectors, such as Manufacturing and Construction (which includes embodied carbon emissions from buildings), are not projected to reach full decarbonisation, and are left with a degree of residual emissions.

Total residual emissions across all UK sectors are then proposed to be offset via both nature-based removals (i.e., land-use change, increased forestation, peatland restoration), and engineered greenhouse gas removals (i.e., Bioenergy with carbon capture and storage (BECCS), Direct Air Capture of CO2 with storage (DACCS) across multiple sectors, and increased use of timber in construction) to permanently remove carbon from the atmosphere and achieve the UK's Net Zero target by 2050.

To align with the UK's Net Zero 2050 target, the Built Environment is therefore required to deliver the full decarbonisation of direct emissions from buildings (energy usage).

Any residual emissions related to the Built Environment must be limited to embodied carbon (manufacturing and construction). They will also need to sit within the available total UK removals budget as defined by CCC and not exceed the sector proportion of UK-wide natural and engineered carbon removals.

The UK Built Environment Net Zero target therefore takes the form of a sector emissions budget, which aligns with the UK's Net Zero 2050 strategy and identifies the lowest possible residual emissions.

Identifying the Pathway

Project team members considered which measures, interventions and solutions should be implemented in the drive towards Net Zero and in the context of the climate crisis, with consideration of the following criteria:

- **Technological feasibility:** Solutions and measures reflect what is currently considered to be *technically feasible*, as we look to the future. Technical feasibility of implementation is referenced through technical studies and background evidence, with the quality, transparency, objectivity, scalability, and applicability of different resources considered throughout the process.
- **Economic viability:** The scenario includes measures which may not be currently viewed as economically viable, or do not have a positive return on investment (i.e. large scale retrofit of hard to treat domestic properties) and which would therefore require financial mechanisms, incentives or alternatively regulation to encourage or mandate adoption.
- **Market viability:** Measures proposed for implementation in the short and medium-term are cognizant of current market position and enabling actions required, (unrealistic step changes were avoided). Measures proposed further into the future are likely to increasingly rely on positive progressions in policy and market landscapes. .

The project team worked on the following basis for the direction of travel over the 30-year period from 2020-2050 for the Net Zero Scenario, Policy Recommendations and Stakeholder Action Plan:

- An overarching shift in the national and local policy landscape towards Net Zero as part of a green recovery strategy.
- Increasing urgency for the implementation of Net Zero solutions, including fundamental changes in approach where necessary.
- Strong drivers toward Net Zero from both the investment community and occupiers.
- A responsibility, ownership and drive from within the construction industry and supply chains to accelerate change.
- Increasing consumer and societal pressure and appetite for climate action, and higher acceptance of disruption.

Carbon Modelling Methodology

The objective of the Net Zero Whole Life Carbon Roadmap model is to provide a calculation platform that can be used to develop an emissions profile, setting out the pace and scale of actions across the sector to support it to achieve net zero by 2050. This has been delivered by updates to the 2013 Low Carbon Routemap model for the UK Built Environment.

The emissions model is based around a key number of calculation modules covering aspects such as historical outturn emissions, embodied carbon via the use of the UKMRIO model, and building energy models for domestic and non-domestic buildings operational carbon. The calculation modules are driven by a wide range of specific datasets. In the cases of the baseline year and historical emissions these are authoritative national sources (DUKEs, ECUK, etc).

The model provides a timeseries approach to its calculations including historical outturn emissions from 1990 to a baseline calculation year of 2018 (the most recent year in which full emissions datasets are available); and then the ability to apply projected emissions scenarios to 2050.

The full details of the modelling approach can be found in the technical report.

Final Residual Position

In the Roadmap carbon trajectory, operational emissions from buildings are effectively reduced to zero by 2050, however, a small level of embodied and F-gas emissions remain. The final residual emissions for the built environment resulting from the trajectory detailed in this report equate to 6.9MtCO2e considering domestic (territorial) emissions, and 9.1MtCO2e including all consumption emissions (i.e., imported materials).

The CCC projection for total UK removals by 2050 is 97 MtCO2e (territorial). Therefore, the built environment's residual domestic emissions equate to approximately 7% of the estimated total. Figure 7 shows the CCC Balanced Pathway in comparison to the Roadmap Net Zero Scenario. For the purposes of comparison, the final Roadmap position is shown for domestic emissions only, i.e., with imported emissions excluded.

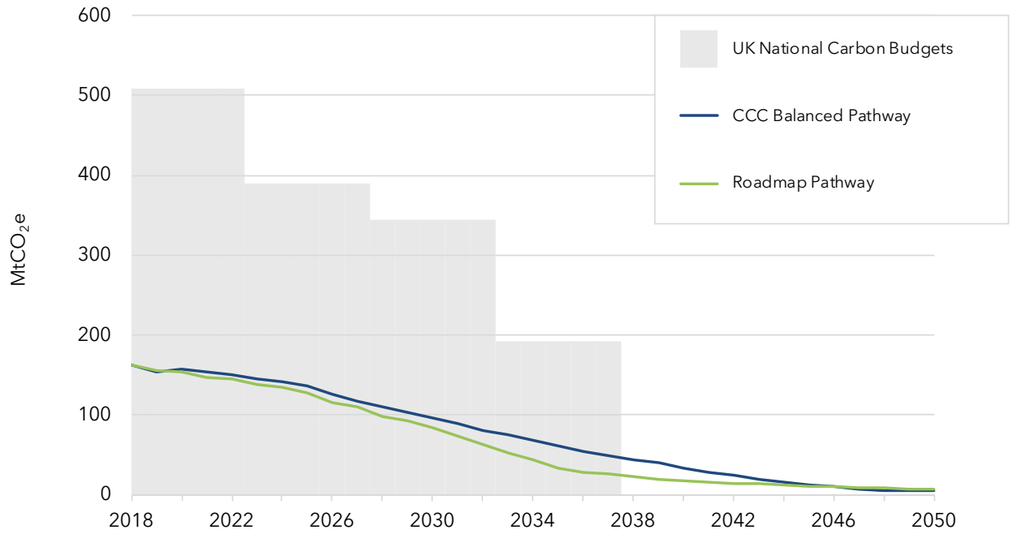
CCC Engagement

The Roadmap trajectory has been developed in dialogue and engagement with the CCC, benefiting from additional data breakdowns provided by CCC specific to the Built Environment.

This engagement process has enabled the Roadmap project team to effectively translate the CCC analysis and targets into a dataset and forward trajectory aligned with built environment sub-sectors, mapping out the decarbonisation pathway into a recognisable landscape for industry stakeholders.

The Roadmap trajectory can be seen as compatible with the CCC's balanced pathway trajectory, as near identical end points are reached, albeit with some differences in the choices taken to drive decarbonisation.

Figure 7: CCC balanced pathway and Roadmap Net Zero trajectory comparison



Net Zero Trajectory
2018 – 2050

Approach to evaluating UK Built Environment Greenhouse Gas (GHG) emissions (referred to as 'carbon emissions' or 'emissions' in this report):

As the trajectory estimates sectoral emissions over a finite time period (2018 - 2050), by definition, full whole life carbon emissions are not captured in their entirety for any particular asset.

Instead the trajectory quantifies total sector emissions on an annual basis, from all buildings and infrastructure, in their various life-cycle stages. I.e. each year the trajectory estimates all operational emissions from energy usage within buildings, and all embodied carbon emissions from construction, maintenance and refurbishment activity, per sub-sector, per year.

Emissions are categorised within the trajectory as follows:

Embodied Carbon (Domestic and Non-Domestic Buildings, and Infrastructure)

Total GHG emissions associated with materials and construction processes across all life cycle stages of assets (Lifecycle Assessment Modules A1-A5, B1-B5, C1-C4).

This includes total annual sectoral emissions relating to material extraction and product manufacture, transport to site and construction processes, in-use maintenance, repair and refurbishment, and end-of-life processes.

Infrastructure Operational Carbon

Total GHG emissions arising from energy consumed, water supply and wastewater treatment, and other emissions associated with the operation of infrastructure required to enable it to operate and deliver its service (Lifecycle Assessment Modules B6, B7, B8).

This includes total annual emissions from street & public realm lighting, communications networks, water supply and treatment, and waste treatment.

Buildings F-Gas

Although part of wider embodied carbon emissions, fugitive (F-gas) emissions from domestic and commercial refrigeration, air conditioning plant and heat-pumps have been split out as a separate category, primarily to identify the potential impact of increased usage of heat-pump technology within the built environment.

Buildings Operational Carbon

GHG emissions arising from all energy consumed by assets in-use (Lifecycle Assessment Module B6), but with data estimated on an annual basis for each sector (using annual average carbon factors per fuel type).

For further information please refer to "Carbon Definitions for the Built Environment, Buildings and Infrastructure" published by the Whole Life Carbon Network (https://www.leti.london/carbonalignment)

	Category	2018	2025	2030	2035	2040	2045	2050
Carbon	Built Environment (Total - MtCO2e)	176.5	128.2	94.8	42.7	24,2	14.3	9.1
	% Reduction vs **2018** Baseline	0%	-27%	-46%	-76%	-86%	-92%	-95%
	% Reduction vs **1990** Baseline	-37%	-54%	-66%	-85%	-91%	-95%	-97%
	Buildings (Non-domestic) - Embodied Carbon	Baseline 16.9	-17% 14.0	-44% 9.5	-57% 7.2	-67% 5.5	-75% 4.2	-82% 3.0
	Buildings (Domestic) - Embodied Carbon	Baseline 18.8	-37% 11.7	46% 27.4	-50% 9.4	-76% 4.5	-84% 3.1	-90% 2.0
	Infrastructure - Embodied Carbon	Baseline 7.1	0% 7.1	-3% 6.9	-31% 4.9	-47% 3.7	-63% 2.6	-70% 2.1
	Infrastructure - Operational Carbon	Baseline 2.9	-62% 1.1	-71% 0.9	-82% 0.5	-87% 0.4	-91% 0.3	-93% 0.2
	Buildings - F-gas	Baseline 6.4	-43% 3.6	-63% 2.3	-77% 1.5	-81% 1.2	-82% 1.2	-81% 1.2
	Buildings (Non-domestic) - Operational Carbon	Baseline 39.7	-41% 23.5	-68% 12.8	-81% 7.5	-90% 3.8	-99% 0.5	-99% 0.3
	Buildings (Domestic) - Operational Carbon	Baseline 84.8	-21% 67.2	-59% 35.1	-86% 11.7	-93% 5.7	-97% 2.6	-99.6% 0.3
Energy	Total Energy Usage - Non-Domestic Buildings (TWh/year)	Baseline 198.0	-8% 181.4	-29% 139.6	-40% 118.5	-49% 100.9	-57% 85.0	-59% 81.5
	Total Energy Usage - Domestic Buildings (TWh/year)	Baseline 458.4	-3% 443.7	-31% 317.4	-56% 203.1	-61% 179.2	-63% 171.3	-64% 162.9
Domestic Retrofit	No. Heat-pump installations in existing homes (millions)	0.2	1.4	9.0	18.3	20.7	21.9	23.0
	No. Existing Homes Retrofitted (millions)	0.1	1.5	12.3	25.2	27.3	27.3	27.3

Net Zero Scenario

The following section describes how the Net Zero Scenario is defined and outlines the recommended policies and industry actions needed to deliver the scenario. The analysis is split into the following sections:

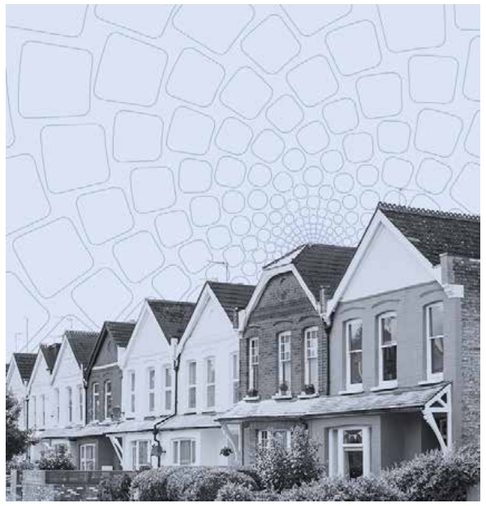
- Operational Carbon: Existing Homes
- Operational Carbon: Non-Domestic Existing Buildings
- Operational Carbon: New Buildings
- Embodied Carbon: All Buildings
- Embodied and Operational Carbon: Infrastructure

Operational Carbon:
Existing Homes

48% of emissions from the UK built environment are produced by energy usage within the existing housing stock. This represents 16% of total UK domestic emissions. Of this, 62% are produced by heating, predominantly via fossil fuel boilers.

This situation is incompatible with the UK target of Net Zero 2050 and improving domestic energy efficiency and enabling a transition away from fossil fuel heating must therefore form a fundamental element of the UKs Net Zero pathway.

With this in mind, there can be no further delay in embarking on a national programme of home retrofitting, which will transform UK housing, creating warm and cheaper to heat homes while bringing health and wider societal benefits. This process will eradicate fuel poverty, create 500,000 green jobs, and positively contribute to the national levelling up agenda.



NATIONAL RETROFIT PROGRAMME

The UK housing stock is one of the oldest in Europe (potentially in the world[2]) with 20% of homes built pre-1919, influenced by housing growth during the industrial revolution. 85% of homes in the UK use a gas boiler for heating[3], and approximately 50% have uninsulated walls[4].

Our Net Zero 2050 target is in part influenced by the UK's role in historical emissions, and the moral imperative to demonstrate global leadership in emission reductions. Upgrading our housing stock to create safe, healthy and zero carbon homes must be a central element of the UK's net zero future.

Achieving transformational change across UK homes will only be possible with a coordinated national strategy which enables and supports all facets of delivery, including costs, capacity, quality, standards, consumer protection and public engagement.

The Construction Leadership Council (CLC) National Retrofit Strategy[5] (NRS) sets this out in a clear and compelling vision for the retrofit of almost all UK homes over the next 20 years. It highlights that successful delivery of the programme is dependent on a suite of interdependent modules, and if any are left out, the whole ceases to function. Local engagement will also be critical, with significant work currently underway in the devolved nations and across many local authorities.

The Roadmap trajectory for existing homes adopts and builds on the proposals and vision set out in the NRS, which is also embedded within CLC Construct Zero.

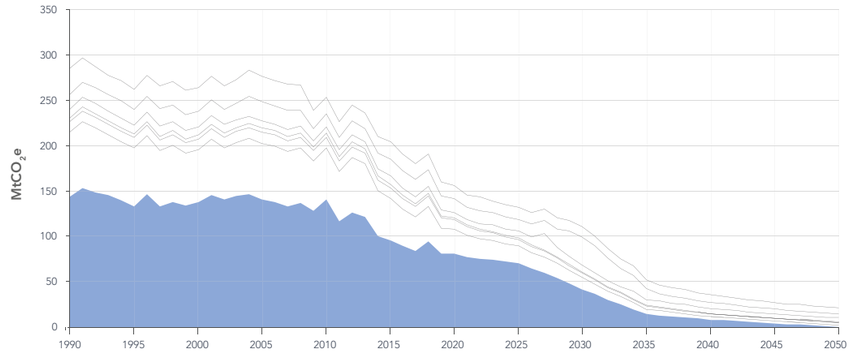
BENEFITS TO SOCIETY

Upgrading our homes will also bring multiple benefits to wider society, as set out by the CLC NRS:

- Up to 500,000 new, higher skilled jobs across the country
- Significant economic boost for existing Repair, Maintenance and Improvement (RMI) firms & supply chains
- Lower energy bills for consumers (£430 average energy bill savings per home, 2% increase in household disposable income)
- £56bn health benefits linked to improved air quality and thermal comfort, with 6,000 avoided deaths per year.
- Accelerated progress towards statutory fuel poverty targets

OPERATIONAL CARBON: EXISTING HOMES

Other categories have been greyed out



DELIVERY PLAN

The ambitious home retrofit target will require an unprecedented pace and scale of investment to enable capacity building and delivery. The NRS proposes a partnership approach to funding, with both government and private investment. A progressive policy framework will be essential in building market confidence and incentivising consumers, alongside reliable and clear information for the public.

Initial investment to create a secure retrofit pipeline will enable capacity building within the workforce, which can then be scaled up to deliver the skills, material and local partnerships needed to drive retrofit.

The CLC NRS sets out four clear phases for delivery, with the initial focus on capacity building, supply chain readiness, and skills and training, building towards an accelerated deployment of retrofit from the late 2020s to the mid-2030s:

- **Phase 1 (2020–2025):** Underpin capability, including Government endorsement of the NRS strategy.
- **Phase 2 (2025–2030):** A slower start focussing on education of householders and wider industry through a clear communications campaign, as well as an intensive training programme for new entrants to the industry. Piloting and field trials would also be taking place.
- **Phase 3 (2030–2035):** A 'quick' middle period based on a mature supply chain eco-system and strong customer protection.
- **Phase 4 (2035–2040):** A ramp down of pace towards the end, focussing on hard-to-treat properties, and a phased redeployment of resources to alternate sectors.

FABRIC FIRST

The Roadmap pathway for existing homes builds on the 'fabric first' approach set out in the CLC NRS, as a 'no regrets' strategy in reducing energy demand and a fundamental step in eradicating fuel poverty.

It is also paramount that approaches to heating systems and building fabric improvements are treated as interdependent. For example, it is crucial that heat pumps are deployed in tandem with sufficient home insulation to avoid poor system performance, higher running costs, and associated risks to consumer confidence).

Integrated and holistic performance standards will be key in this regard, whilst also mitigating risks to consumers around poor-quality building works. Improved building fabric also results in higher internal surface temperatures within dwellings and reduced cold draughts. This helps occupants to turn down room heating thermostats, or use lower temperature heating systems, whilst still feeling comfortable.

There should be caution around expectations that occupants will be able to simply turn down heating thermostats and maintain comfort without any upgrades to the fabric of their homes.

The Roadmap home retrofit roll-out is based on a stock average target for space heating demand (energy output of the heating appliance) of 50 kWh/m^2/year, in alignment with CLC NRS, the AECB retrofit standard target, and LETI retrofit guidance. Further work will be required to identify cost-optimal approaches across different housing architypes.

Additional 'performance gap' factors are included within the modelled pathway on the basis that targets are rarely fully realised in operation. These factors start at 20% in 2020, but are projected to decrease to 5% by 2050, due to a clear focus on skills, quality and continuous improvement within the retrofit programme.

HEATING TECHNOLOGY MIX

The wholesale transition from a dependence on fossil fuel domestic heating to zero carbon technologies is one of the fundamental challenges the UK faces in its path to Net Zero by 2050, with a significant role for heat pump technologies. The starting point for the Roadmap domestic heating pathway is that there must be no gas boilers in operation by 2050.

There is also increasing consensus that although there is a clear role for hydrogen within sectors such as industry and transport, there is limited rationale for the use of hydrogen to heat buildings.

Hydrogen usage is therefore limited to only those homes in the vicinity of industrial clusters, from the late 2030s onwards (12% of all UK homes by 2050, aligned with CCC 6th Carbon Budget 'Balanced Pathway').

The phase-out of gas boilers is driven by a clearly signalled ban on sales of all gas boilers by 2030, providing sufficient time to build heat pump supply chain readiness, develop consumer planning, and ensure that some headroom exists for replacement of the last remaining gas boilers between 2045-50.

The pathway sees 10% of homes served by district heating by 2050, with electric resistive heating or storage heaters replaced by heat pumps by 2050.

Heat pump deployment is linked to the wider retrofit programme, with 80% of homes using a heat pump system by 2050, representing c.23m domestic installations over the next 30 years. The ratio of air source to ground source systems is fixed at the current proportions.

Heat pump seasonal efficiencies are projected to improve (300% in 2020, 380% by 2030, 420% by 2040) due to investment, R&D, and system optimisation throughout the retrofit programme.

HOME APPLIANCES

Fossil fuel usage within cooking appliances must also be ended by 2050, and the pathway aligns the phase-out of gas cooking with gas boilers, as households convert to electric heat pumps (except those homes identified for future hydrogen usage).

The widespread uptake of more efficient induction cooking hobs by 2045 reduces cooking energy usage, with continued improvement in the efficiency of other appliances.

BEHAVIOUR CHANGE

The opportunity for widespread behaviour change has been considered, with a cautious approach to expectations that occupants will be able to reduce thermostats without improvements to building fabric - one of the supporting arguments for the fabric first retrofit programme.

The UK's aging population may also be a factor which leads to an increasing proportion of the population preferring higher room temperatures. Evidence also suggests that occupants in low energy homes tend to set higher than average room temperatures.

ON-SITE RENEWABLES

To support the necessary level of grid decarbonisation as projected by the National Grid in their Future Energy Scenarios (FES2021[4]), 30,000MW of PV capacity will be required on domestic buildings by 2050. This is the equivalent of a typical domestic PV system installed on 1 in every 4 homes in the UK.

Financial incentives for consumers to store and trade energy flexibly, and pricing solutions such as flexible tariffs (e.g., Time-of-Use) will be key in enabling this.

Figure 8: Heating technology mix - existing dwellings

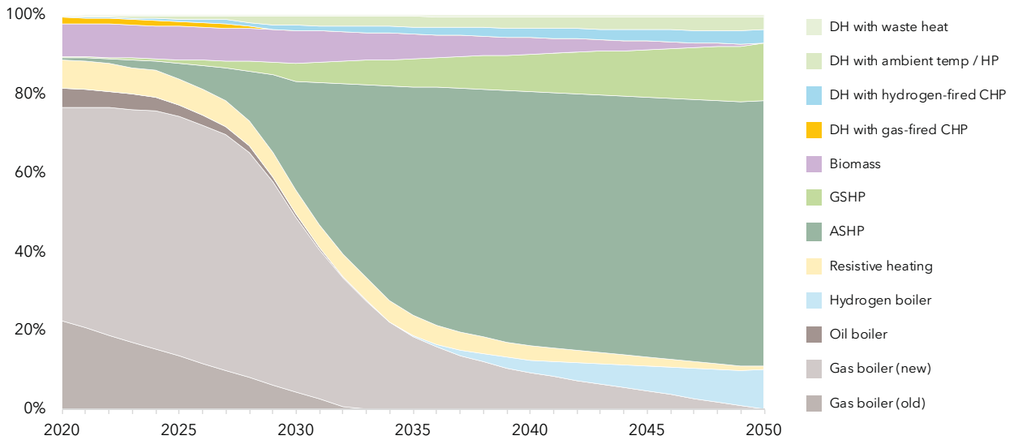
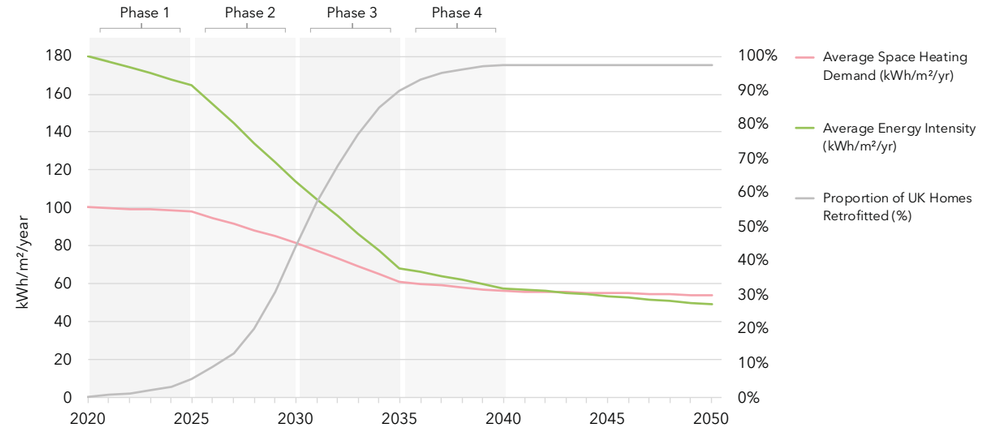


Figure 9: Existing homes national retrofit strategy



EXISTING HOMES: PATHWAY

RETROFIT ROLL-OUT

- 97% of existing UK homes retrofitted by 2040

BUILDING PERFORMANCE TARGETS

- 50kWh/m²/year average space heating demand by 2040
- Average dwelling energy intensity reduces by 30% by 2030, 60% by 2040.

FOSSIL FUEL BOILERS

- End of sales of gas boilers in 2030
- End of Sales of oil boilers in 2030

HYDROGEN

- Hydrogen boilers used in homes near industrial clusters from 2040, reaching 12% of homes by 2050.

HEAT PUMPS

- 80% of all homes utilise heat-pumps by 2040 (c.23m new domestic installations)
- Peak of 1.5m heat-pumps installed per year between 2030-2035 (c.29,000 installations per week)
- Average heat-pump efficiencies of 380% by 2030, 420% by 2040

PV

- 30,000MW PV installed on domestic properties by 2050 (i.e., a typical c.4kW domestic system installed on 1 in 4 homes across the UK)

LIGHTING

- 5% reduction in domestic lighting usage by 2035, 10% by 2050.

UNREGULATED ENERGY

- Domestic gas cooking phased out by 2040 with all households using high efficiency electric induction cooking hobs by 2045.

Policy Recommendations

The large-scale, transformative domestic retrofit strategy set out here is deliverable - but only if Government and industry work closely in partnership.

It is critical that the Government commits to and supports the programme with a long-term policy framework and sufficient investment to build market confidence, incentivise and protect consumers, and unlock private investment.

A range of policy levers and interventions will be required, including incentives and enablers prioritising building fabric upgrades to ensure effective deployment of domestic heat pumps.

The approach must be fully coordinated with local authorities, consumers, communities and other relevant stakeholders, and must not disadvantage lower-income households.

Key Policy Recommendations for Government

Adopt a National Retrofit Strategy by 2022, setting out a clear national homes upgrade programme, fully coordinated with local government, industry, and relevant stakeholders:

STRATEGY & ENGAGEMENT

- Establish a **Central Retrofit Agency** – to coordinate policy makers, local authorities, housing associations, community groups, local advocates, green finance and funding experts, industry bodies and regulators, private sector partners, and existing and future retrofit customers - to fund projects, track progress, share learnings, promote innovation, and broker partnerships.
- Develop a **comprehensive engagement plan**, providing clear and reliable information to the public to ensure all households are aware of funding and incentive mechanisms, and the full benefits of taking action.

POLICY

- Introduce and clearly signpost a **cut-off date of 2030 for sales of gas and oil boilers**.
- A clear trajectory and regulatory framework to introduce **mandatory minimum EPC rating of C** (or equivalent under updated EPC methodology), for **owner-occupied homes at the point of sale** (with suitable caveats e.g., historic building considerations) by 2028.
- A clear trajectory for improving the **MEES for domestic rented sector to EPC C** (or equivalent under updated EPC methodology) by **2028**.
- Tightening of **Building Regulations requirements** for **works to existing dwellings** (with suitable enforcement), with consequential improvements and clear triggers for energy improvement requirements.
- Introduce and clearly signpost a cut-off date of 2030 for sales of gas and oil boilers.

FISCAL INCENTIVES

- **Variable stamp duty** rates adjusted in line with the energy performance of a property. House buyers would receive a lower rate discount if a property is above a certain energy efficiency rating, and an increased rate for less efficient properties, designed to be fiscally neutral.
- **Remove VAT on refurbishment work** (i.e., 0% VAT) where energy performance improvement targets are met (to incentivise energy efficiency improvements whilst retaining VAT revenue from general improvement works).
- **Council tax reform** considering variable rates / rebates dependent on energy performance.
- **Direct government grants** for low-income households to support both energy efficiency improvements and the installation of low carbon heating.
- Incentivise banks and lenders to offer **low interest mortgage extensions and loans** for retrofit for landlords and homeowners, where energy performance improvement targets are met.
- **Adjust the gas and electricity tax regime** (which currently strongly favours gas) for domestic customers, to incentivise the shift to heat pump technology, whilst mitigating risks to those in fuel poverty.

ENABLERS

- **Reform EPCs** to establish in-use energy performance as the rating metric (as opposed to cost), reducing the performance gap and disincentivising gas usage, and enabling EPC ratings to be used as a meaningful regulatory driver in reducing emissions by 2023. Link to updated sizing and installation guidance (i.e., MCS) for heat pumps to optimise performance.
- **Accelerate SMETERS project** working towards incorporation of actual measured energy data into the EPC methodology.
- **Support the development of digital building renovation plans or 'passports'** (in conjunction with industry) that inform evidence-based retrofit pathways for existing building stock varieties and are held within a central property database.
- Develop **standard package solutions** to achieve required energy performance standards for **main house architypes**, indicating preferred cost-effective fabric measures and minimum sized heat pumps.
- Support the development of the right market framework to enable financial incentives for individual consumers to trade energy flexibly and improve the route to market for pricing solutions such as **flexible tariffs** (e.g. Time of Use (ToU)).

SKILLS & BUSINESS

- Create a **national retrofit training and skills strategy**, scaling up rapidly to meet emerging demand, working with trade associations within the home repair, maintenance and improvements (RMI) market, local skills partnerships, and will be informed by the Government's Green Jobs Taskforce and the CITB work on Building Skills for Net Zero.
- **Promote** throughout the country with **communications campaigns** to inspire and recruit, targeting school leavers, those reskilling for career change in declining sectors, and existing construction workers in need of upskilling.
- **Leverage public procurement** to build demand for skills and supply chains by providing a guaranteed pipeline to enable the transition away from traditional approaches and rapid expansion of market delivery capability. **Incentivise and support** firms to take on new apprentices.
- **Update apprenticeship and training standards** to align with the required the retrofit delivery programme, optimising digital skills.

Key Policy Recommendations for Local Authorities

Important domestic retrofit work is already being undertaken by many local authorities and it is critical that national and local strategies are complementary. There are also many resources for local authorities to deliver mass retrofit, including the UKGBC Retrofit Playbook.

Local authorities can support the net zero trajectory and align with the National Retrofit Strategy by:

- Publishing comprehensive local retrofit strategies that include local retrofit targets
- Initiating retrofit delivery programmes that develop area-based approaches for building retrofit capacity in a locally relevant way.
- Undertaking local area-based retrofit pathfinder projects to de-risk investment
- Developing strategies to engage with civil society to deliver retrofit
- Developing regional upskilling programmes
- Delivering deep social housing retrofit

Industry Role

Unparalleled coordination between Government, local authorities, communities, and the Repair, Maintenance, and Improvement (RMI) industry will be needed to successfully deliver the domestic retrofit strategy.

The CLC estimates that an additional 500,000 trade positions and 50,000 Retrofit Coordinator roles will be needed - more than double the existing workforce.

The strategy to deliver this transformational workforce expansion will need to consider the variety of pathways in the construction industry, both skilled and unskilled, and the range of employment opportunities that they could match to.

Upskilling and training will be critical, alongside building robust supply chains and developing innovative funding and investment mechanisms and products.

SKILLS AND TRAINING

- The scale of the retrofit challenge requires a significant expansion of the **RMI sector**. Skills and competency levels must be an integral part of the capacity building strategy to ensure quality standards and performance outcomes are achieved, and that wider issues such as moisture and overheating risk are managed appropriately.
- **Training providers, colleges and universities, professional institutions**, and **trade associations** will need to work with local authorities to build capacity and meet the demand for high-quality retrofits.
- Local delivery programmes will play a key role in bringing together relevant local stakeholders to identify the skills and partnerships needed to deliver an area's retrofit needs. An agreed upon skills base by **industry bodies** will help inform these programmes, as well as company recruitment strategies, retraining programmes, and CPD and trade programmes.
- A secure initial pipeline of works will enable **contractors** and **installers** to review their retrofit capabilities and scale up via both workforce training and recruitment.
- Personnel from non-traditional disciplines and training backgrounds will need to be attracted to the retrofitting industry. A variety of built environment sector specialisms are suited to the Retrofit Coordinator role, and recruits will also need to be attracted from outside the construction industry, creating far-reaching opportunities.
- A recruitment campaign will be a priority for the Retrofit Agency. Local partnerships to highlight routes to work for the unemployed and offer training and apprenticeships for those with transferrable skills will be essential.
- Training (and re-training) programmes should be coordinated with **trade associations**, with a specific focus on trades and technologies impacted by the national strategy, e.g., gas and heat pump installers.
- Sizing and installation guidance (i.e., MCS) for heat pumps should be updated to optimise performance.
- Skills and training programmes should be informed by the Government's Green Jobs Taskforce and the CITB work on Building Skills for Net Zero.
- The provision of clear and reliable information to **homeowners** and **occupants** as part of the handover process must form an integral part of programme delivery, particularly for new, less familiar technologies, to ensure public understanding on how to operate new technologies most effectively.

SUPPLY CHAIN MATERIAL CAPACITY

- Retrofitting products and materials must also be delivered at scales that can sustain the pace of retrofits. Key **manufacturer supply chains** for domestic retrofit (i.e., heat pumps, insulation) will need to conduct market analysis (with the support of a newly formed Retrofit Agency and local delivery programmes) to better understand demand and forecast long term material and product needs.
- Government research[7] indicates that the international heat pump industry does not foresee significant manufacturing capacity difficulties in meeting the UK's increased retrofit heat pump needs. There is also opportunity for increased domestic manufacture of heat pumps and investment in the UK, if market confidence can be built through a clear government strategy and long-term policy direction.
- The retrofit programme is projected to have a knock-on increase in embodied carbon emissions, as can be seen in the trajectory results between 2028-2035.
- Further research (coordinated by the National Retrofit Agency, supported by **NGOs, trade associations, supply chains, professional institutions, academia**) should focus on identifying ways to minimise this impact, by reducing embodied carbon of key retrofit products and materials (i.e., insulation, heat pumps) through material and specification choices.
- This work should be undertaken during Phase 1 of the retrofit programme in order to mitigate and minimise embodied carbon impacts ahead of the wider roll-out in Phases 2-3.

INVESTMENT AND FINANCING

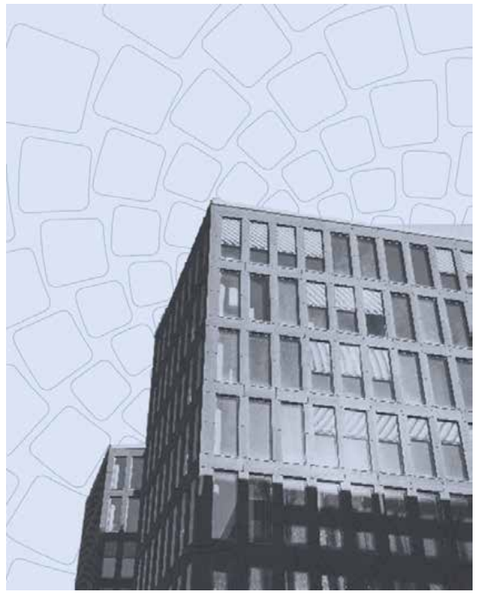
- **Financial institutions** will need to enable retrofit financing through innovative lending solutions, developed in coordination with Government. Millions of households in the UK are likely to require some form of assistance, making financing collaboration between Government and the financial sector essential.
- A range of finance solutions for domestic retrofit will need to be developed, suitable for different domestic tenures including 'blended finance packages' which combine funding from private and public sector. Investors and Local Authorities will need to work together to develop packages for accelerating domestic retrofit.
- **Banks** and **lenders** can increase the availability and promotion of lower interest mortgage extensions and loans for highly efficient properties, and predicate home repair loans on wider energy efficiency improvements.
- Clear and reliable information on funding opportunities should be provided to the public as part of the comprehensive engagement plan, explaining how wider energy efficiency works can be included within other home improvement works such as loft conversions.
- **Commercial landlords** can also set out financial provisions and funding mechanisms for retrofits in their decarbonisation strategies.
- **Financial institutions**, with Government support, will also need to invest into supply chain capacity for SMEs. Recent research[8] from The Green Finance Institute and Bankers for Net Zero looks at how retrofit supply chains can be financed to scale up their delivery capacities. In many cases, the organisations needing support will be SME's who cannot upskill otherwise.
- Headline proposals include increasing access to sustainability-linked loans for SMEs, creating dedicated 'Green' or 'Transition' SME funds, and adding green criteria to existing public finance schemes and using guarantees to 'crowd in' private capital.

Operational Carbon:
Existing Non-Domestic Buildings

The non-domestic building stock currently represents 23% of built environment carbon emissions. Significant improvements in energy efficiency must be accelerated across all sectors. Mandatory energy disclosure and performance-based rating systems are required to stimulate markets.

The currently proposed introduction of a performance-based rating system for large office buildings represents a critical opportunity to demonstrate the benefits of mandatory energy performance disclosure, followed by a rollout to other non-domestic sectors.

66% of commercial building emissions are currently caused by heating - predominantly via fossil fuel heating systems. A managed transition away from gas heating is therefore essential.



SECTOR SNAPSHOT

- The BEIS Building Energy Efficiency Survey (BEES, 2016)[9] provides a snapshot of non-domestic building energy usage in England and Wales.
- The study identified that the top five energy consuming non-domestic sectors were offices, retail, industrial, health and hospitality. These sectors accounted for 71% of total non-domestic energy consumption.
- The highest end uses were space heating, internal lighting, catering and cooled storage. The study concluded that the potential exists for a 39% reduction in aggregate energy usage, with over a third of measures offering a simple payback of <3 years.
- Key interventions identified were carbon & energy management, lighting replacement & control, and building services optimisation, together representing 55% of the total reduction potential.
- Perceived barriers to energy efficiency implementation included economic, organisational, competency and behavioural issues.

DYSFUNCTIONAL MARKET DRIVERS

The 2020 Better Building Partnerships (BBP) Real Estate Environmental Benchmark (REEB)[10] for commercial buildings shows that market leaders are making progress, achieving a 27% improvement in energy efficiency over the past 10 years, and 4% from 2019-20.

However, the data also clearly shows that there is no correlation between the legal energy efficiency indicator used in market transactions, Energy Performance Certificates (EPCs), and how much energy buildings actually use in operation.

This leads to a lack of visibility of actual energy performance for buildings in many of the highest energy consuming sectors at the point of sale or lease. Actual energy performance is therefore underrepresented and undervalued within commercial markets as there is no requirement to disclose this information. The lack of correlation between EPC ratings and in-use performance also undermines their credibility as analysis tools to evaluate energy efficiency retrofit measures, or their adoption as effective metrics for policy drivers.

OPERATIONAL CARBON: EXISTING NON DOMESTIC BUILDINGS

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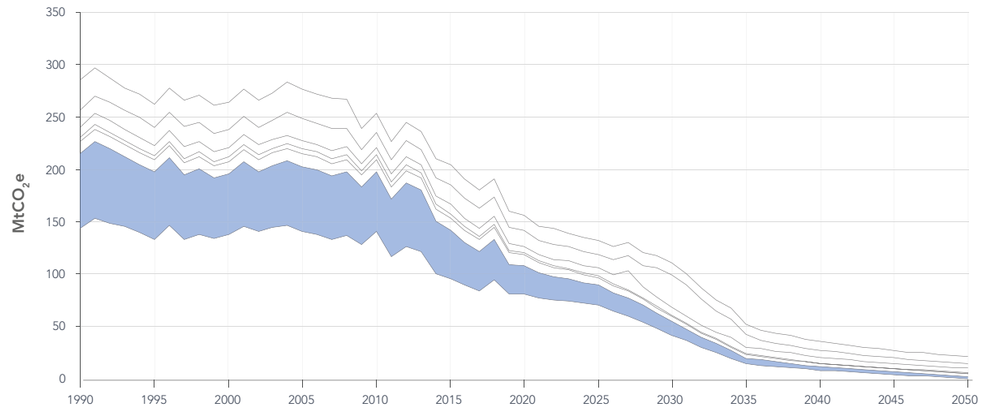


UNLOCKING POTENTIAL

Alternative approaches can be found outside the UK, for example, in Sweden where EPCs are based on real energy consumption from smart meter data, or Australia whose NABERS energy rating system has led to more than 30% real-world energy reductions within the office sector.

The potential to adopt a performance-based approach for UK commercial buildings has been explored over several years through the work of the BBP Design for Performance initiative, culminating in the recent launch of the NABERS UK scheme for office buildings.

The scheme will bring to the market a simple yet credible rating system providing visibility on the actual energy performance of office buildings. The scheme will benefit investors, developers, owners, and occupiers, by providing transparency on which buildings are performing well, and which are not.

The BEES statistics show that a significant proportion of total energy usage is from large buildings in certain key sectors, and that there is high potential for energy savings from interventions which do not require high capital investment, such as improved energy management and building services optimisation.

The implementation of performance-rating schemes which require mandatory disclosure of energy usage is therefore seen as the critical market driver to galvanise action in the non-domestic sector.

The UK government recently consulted on proposals for a performance-rating system for landlord energy usage in large (>1,000m^2) office buildings, to be launched in 2022 with mandatory energy disclosure (public reporting) by 2023. The successful implementation of this scheme to these timescales is a critical first step. This will, for the first time, make the actual energy performance of all large office buildings publicly available for scrutiny. The approach can then be rolled out to include tenant energy usage and other key sectors as quickly as possible.

Both minimum standards & incentives can then be introduced as policy levers to ensure sufficient sectoral progress, reviewed on a periodic basis to ensure they align with carbon budgets.

The Roadmap identifies sectoral average EUI trajectories for non-domestic buildings, derived from current aggregate energy usage data per sector. These indicate the projected levels of sectoral energy efficiency progress required within the wider Net Zero trajectory.

However, behind the aggregate or average data, each sector will contain a range of building typologies and use-types, and a wide range of performance. Future performance rating schemes and associated minimum standards and incentivisation policies will need to take this into account. In simple terms, the trajectories represent sector targets rather than targets for all individual buildings within that sector.

FOSSIL FUEL TRANSITION

Performance rating schemes can disincentivise the use of fossil fuels by including weighting factors which penalise their use and lead to lower building ratings. Over time this is likely to drive fuel switching, due to the detrimental impact on ratings. However, given the timescales for the introduction of these schemes, it is unlikely that this approach will be sufficient as the only driver for phasing out our reliance on gas heating systems given the need to eliminate gas usage in buildings ahead of 2050.

HEATING TECHNOLOGY MIX

Building owners and landlords require certainty and clear timescales to plan and make investment decisions for replacement of gas boilers, which may be expanded into wider refurbishment activities.

The Roadmap pathway for existing non-domestic buildings therefore includes a clearly signalled end date for sales of gas and oil boilers of 2030. Assuming a typical 15-year boiler lifespan, the last remaining gas boilers are assumed to be decommissioned in 2045-2050.

The projected heating technology mix for the existing non-domestic building stock was derived with reference to the Building Energy Efficiency Survey (BEES) research, based on the percentage coverage by total non-domestic stock floor area.

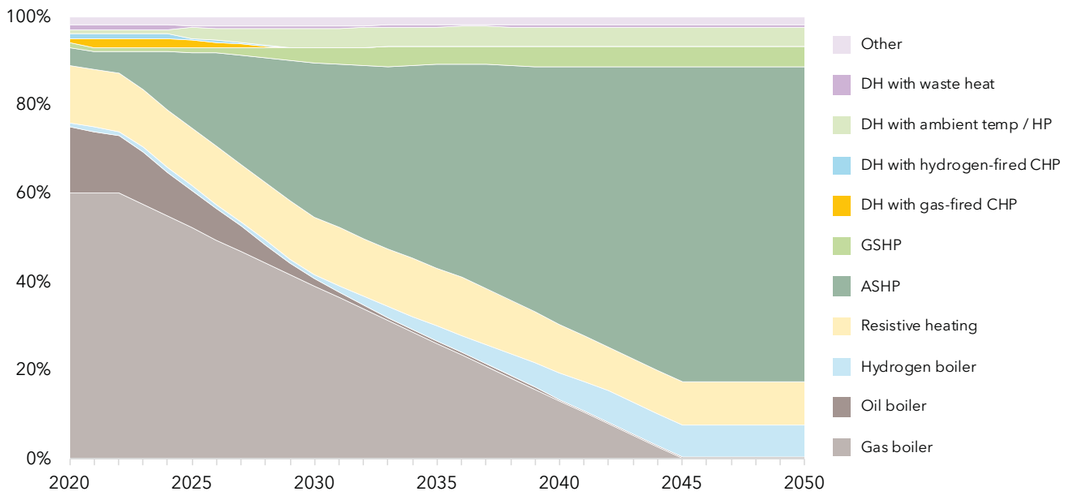
Use of hydrogen boilers increases from 2030, with 7.5% of non-domestic buildings on hydrogen heating by 2050. District heating with gas-fired CHP is phased out by 2030, with these networks converting to low carbon alternatives. The proportion of existing district heating with other fuel types is assumed to remain constant. The pathway sees 10% of buildings served by district heating by 2050.

The remaining demand is met by heat pumps (with the ratio of air source to ground source systems fixed as per current proportions). Heat pump seasonal efficiencies are projected to improve (from 300% in 2021, to 380% by 2030, and 420% by 2040) due to investment, R&D and system optimisation. Less pronounced improvements are anticipated for cooling plant, as these are more established technologies.

RETROFIT & OPTIMISATION

Driven by mandatory energy performance disclosure and an increasing relationship between energy performance and asset value, a range of building retrofit and optimisation measures are deployed to non-domestic buildings, linked to accelerated asset replacement cycles. The most effective of these are fabric enhancements (façade upgrades or replacement, and replacement glazing) and lighting and controls upgrades. Improved sub-metering, recommissioning and building performance optimisation is another significant and effective intervention.

Figure 10: Heating technology mix - existing non-domestic buildings



APPLIANCES & UNREGULATED ENERGY

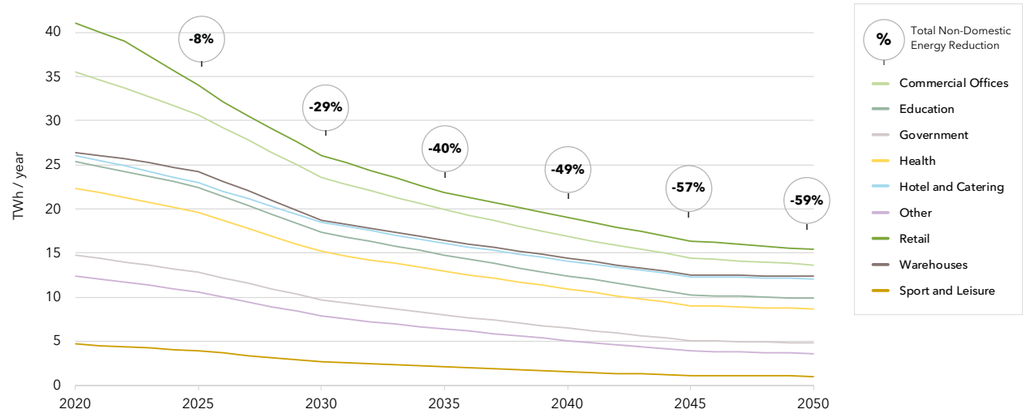
Improvements in the efficiency of appliances and unregulated energy usage are projected to continue in line with recent trends.

Fossil fuel usage within cooking appliances is also phased out ahead of 2050, alongside heating systems. The pathway aligns the phaseout of gas cooking with the phaseout of gas boilers, as buildings convert to electric heat pumps and other low carbon technologies. The widespread uptake of more efficient induction cooking hobs by 2045 also reduces cooking energy usage.

ON-SITE RENEWABLES

Projections for onsite renewables reflect a continuation of current trends, with a 6% annual increase in photovoltaic (PV) capacity on non-domestic buildings. Modest improvements in PV system efficiency are expected.

Figure 11: Non-domestic buildings sectoral energy use



EXISTING NON-DOMESTIC BUILDINGS: PATHWAY

BUILDING PERFORMANCE TARGETS

- 29% average non-domestic building energy intensity reduction by 2030 (49% by 2040)

BOILERS

- End of sales of gas boilers in 2030
- End of Sales of oil boilers in 2030
- 7.5% of non-domestic buildings have hydrogen boilers by 2038

HEAT PUMPS

- 70% of all non-domestic buildings benefit from heat-pumps by 2045

PV

- 6.7% annual increase in PV installations on non-domestic building (existing trend)

UNREGULATED ENERGY

- Continued trend of 1% PA reduction across all sectors.
- Gas cooking phase out in 2030-2040

Policy Recommendations

Evidence demonstrates that there is significant energy efficiency potential within non-domestic buildings. Mandatory energy disclosure as part of performance-based rating systems across multiple sectors is needed to stimulate markets to realise this potential.

Once established, additional policy levers such as minimum standards and fiscal incentives (in the form of penalties or rebates linked to existing or new taxation mechanisms) can be introduced in order to accelerate stock average energy performance as required, maintaining alignment with overarching carbon budgets.

Clarity and sufficient forewarning on phaseout dates for gas and oil heating systems must also be provided to enable building owners and landlords to plan

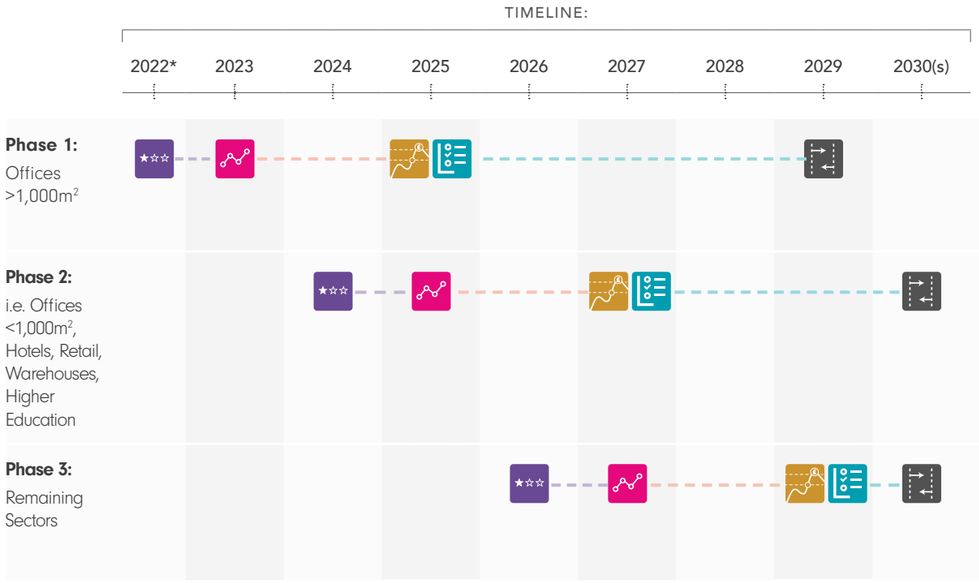
Key Policy Recommendations for Government

Introduce performance-based rating schemes for existing non-domestic buildings via a phased approach:

- Introduce the planned **performance-based rating system** for **large office buildings (>1,000m²) by May 2022,** including **mandatory energy performance disclosure.**
- Introduce **minimum standards** and **fiscal incentives for large office buildings** by **2025,** including **separate minimum standards for new buildings** (with suitable transitional arrangements).
- Fiscal incentives could take the form of penalties or discounts linked to existing or new taxation mechanisms.
- Introduce performance-based rating systems in **other non-domestic sectors (and small office buildings)** by **2025,** followed by minimum standards and fiscal incentives for both new and existing buildings.
- By 2028, establish performance-based rating systems in remaining non-domestic sectors (see suggested timeline below).

Wider Policy

- Introduce and clearly signpost a **cut-off date of 2030 for the sale of gas and oil boilers.**
- Review Landlord & Tenant Act 1954 to require by law that all new business leases include green lease clauses, the standards of which should be developed with industry.
- Remove VAT on refurbishment work (i.e., 0% VAT) where energy performance targets are met (to incentivise energy efficiency works whilst retaining VAT revenue from general improvement works).
- Retain proposals for use of MEES in the non-domestic sector in the short to medium term. Review the need for MEES as a policy lever in the medium-long term as performance rating schemes become established.



Reading this timeline

- Performance Rating Scheme Launch
- Minimum Standards & Fiscal Incentives introduced
- Progressive tightening of Minimum Standards & Fiscal Incentives
- Mandatory Energy Disclosure
- Part L compliance for New Buildings based on EUI
- (2021: Part L 2021 introduces mandatory EUI Forecast for all buildings >1,000m²)

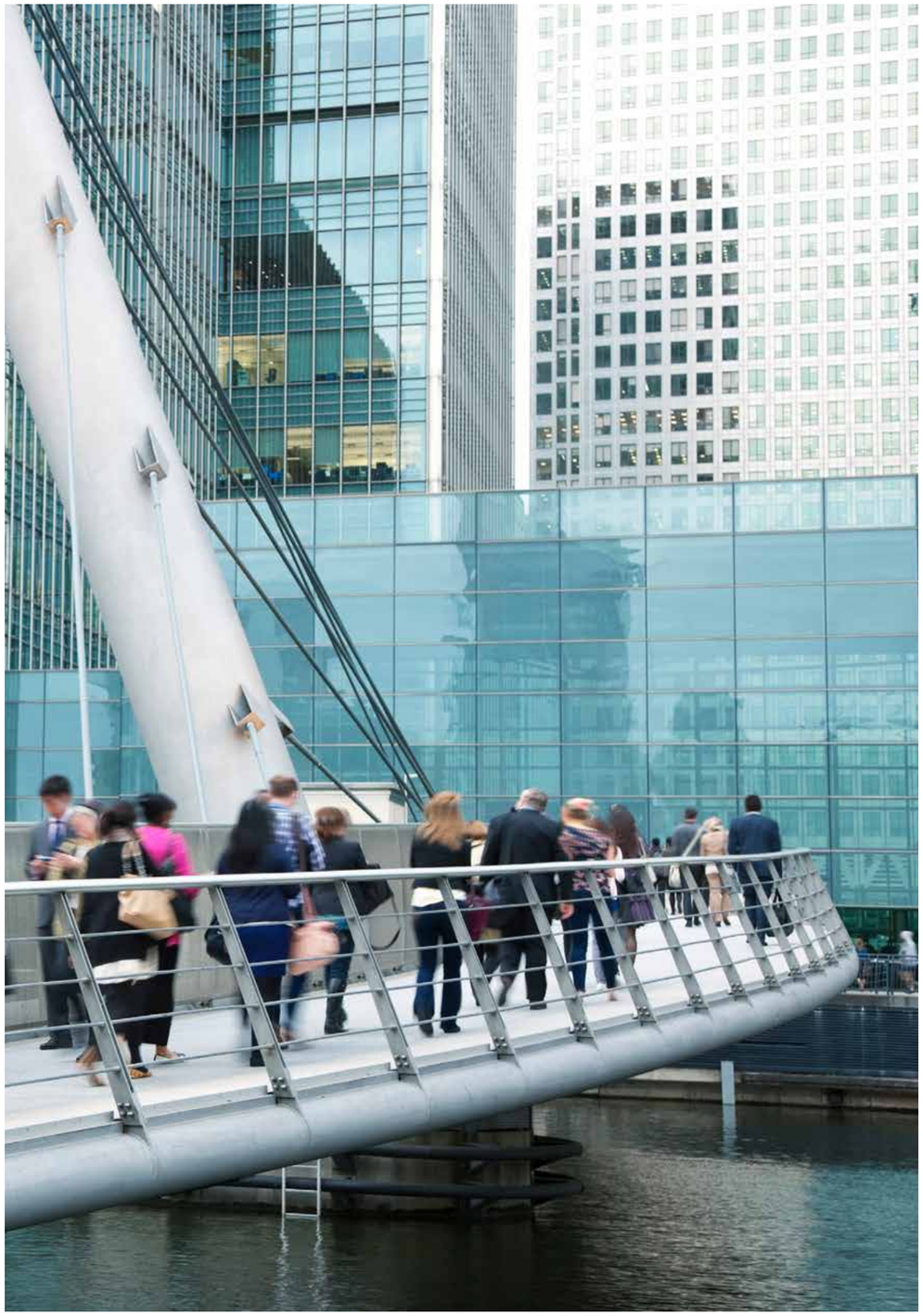
Industry Action

PORTFOLIO PATHWAYS

- All **building owners** should establish portfolio energy efficiency targets with clear milestones, with reference to the Roadmap sectoral average EUI trajectories.
- Bespoke energy performance pathways should be developed for individual buildings and portfolios, aligned with maintenance and investment plans, and lease events.
- As a first practical step, all **commercial landlords** must ensure energy monitoring and management processes are in place across their entire portfolio. **Landlords** should commit to sharing energy data regularly and transparently with all **tenants** and collaborate with tenants to minimise operational energy, with requirements clearly set out within green leases.
- **Building owners** and **landlords** must also formulate and commence portfolio-wide plans to transition away from fossil fuel heating. Heat pump supply chains will need to build capacity and support building owners in planning gas boiler replacement works.
- **Institutional investors** based in the UK should begin to disclose the operational energy and carbon performance of all held properties (at asset level) across their portfolios (funds) in annual reporting.
- **Investor** and lender evaluations and decision making are likely to evolve to focus on performance-based ratings rather than EPCs, elevating the importance of in-use performance within the valuation of buildings. **Agents** and **Surveyors** will also have a key role to play in supporting this transition from EPCs to performance rating schemes.

BUILDING OPTIMISATION

- **Building** and **Facility Managers** are critical to implementing energy efficiency in practise. Achieving energy intensity pathway targets should form a key deliverable and indicator of success requested by landlords within maintenance contracts. Other incentives for improved energy management should be included within FM contracts, with condition-based maintenance considered rather than typical planned preventative maintenance regimes.
- **Facility Management** businesses will need to review capacity, skills and training plans to prepare for the increased focus on energy performance following mandatory energy disclosure legislation. They will need to commit to and deliver on building performance plans, set against energy use reduction targets over time, including clear plans for ongoing engagement with end users and tenants.
- **Tenants** and **Occupiers** will need to take ownership for the elements of energy usage they are responsible for and have control over, with clear reduction targets aligned with sector pathways. **Occupiers** and **Tenants** should place more focus on the energy performance of fit-out projects and set targets for energy intensity, as well as collaborate with landlords to shift to low-carbon heating technologies and install on-site renewable energy solutions (where possible).
- **Building Services Engineers** and **Energy Performance** consultants will have a significant role to play in carrying out energy efficiency surveys and recommending retrofit upgrade pathways. There will be strong demand for recommissioning and building performance optimisation skills.
- Advanced building HVAC simulation will be an important tool in evaluating retrofit options in detail, and significant upskilling will be required to mainstream these skills across the building services industry.



Operational Carbon:
New Buildings

Current Building Regulations (Part L) and energy rating mechanisms (EPCs) do not adequately predict or represent the actual performance of new buildings in operation.

The 2025 Part L update must fundamentally change the way energy performance is assessed within the Building Regulations, with a decisive pivot from theoretical comparisons to real-world outcomes (Energy Intensity, i.e., kWh/m^2/year) which can be linked to the Net Zero trajectory.

New homes should deliver world-leading standards of energy efficiency for consumers, appraised via a simple real-world metric showing the amount of heat they will need in practice. They will also need to manage demand on the electricity grid by minimising peak loads.

FUTURE STANDARDS

Approximately 80% of the UK's 2050 building stock already exists, with the remaining 20% to be delivered in the intervening period.

The scale of the existing retrofit challenge is significant and continuing to deliver new buildings which fall short of net zero standards will only add to this challenge in the coming years, locking buildings into a pathway towards an unnecessary future retrofit. Considering carbon reduction as early as possible within the design process minimises cost impacts and leads to better design integration.

Today's new buildings will be less than halfway through their lifespan by 2050 and must therefore be equipped to deliver the energy performance levels required for net zero. This will avoid the need for future retrofitting and remove the risk of future occupant disruption, cost and embodied carbon emissions.

For new homes this means minimising heat demand through Net Zero building fabric standards and low carbon heating systems. Sufficient investment in the building fabric of new homes is a no regrets, "right first time" approach and fundamentally locks in the benefits for future occupants.

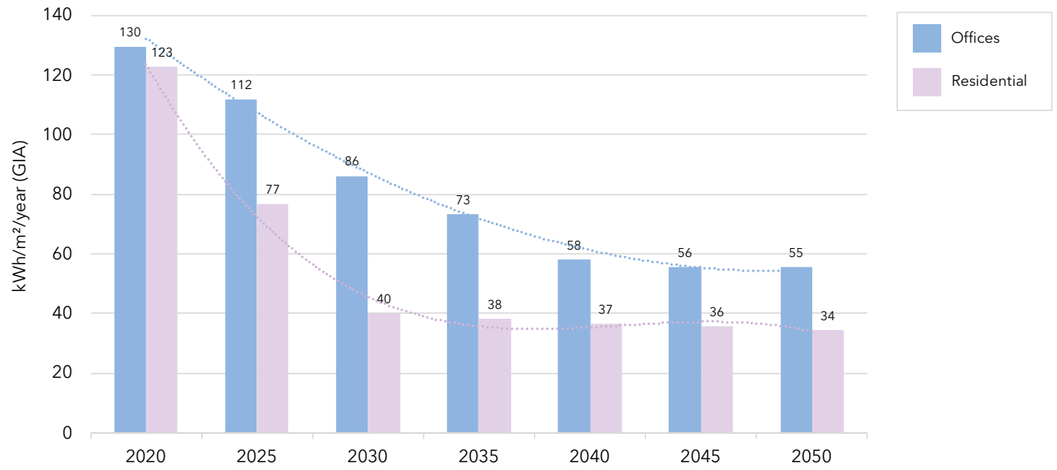
To enable the transition to net zero, additional metrics will also require focus, including measures to limit peak demand and energy storage to enable load shifting.

ENERGY INTENSITY APPROACH

In addition to the current use of compliance tools and methodologies to evaluate performance at the design stage, a significant 'performance gap' exists between design intent and building performance outcomes, due to multiple factors including insufficient attention towards building handover.

Building Regulations must therefore shift from the "notional building" (i.e., hypothetical) comparison approach to in-use energy performance metrics (Energy Use Intensity (EUI), i.e., kWh/m^2/year) to drive an industry shift towards an outcomes-led "design for performance" approach.

Figure 12: Energy intensity of new office and residential buildings within trajectory



LINK WITH PERFORMANCE RATING SYSTEMS

Adopting an EUI compliance approach within Buildings Regulations for non-domestic buildings would align metrics with in-use performance-based rating systems (which may use a star rating or similar as the primary rating scale, but with EUI embedded within the methodology).

This would create three energy performance gateways for new non-domestic buildings from design through to operation, using a consistent, outcome-focused metric (EUI):

- Design Stage (Building Regs EUI - Design forecast)
- Completion (Building Regs EUI - As Built forecast)
- In-Use (Performance Rating Systems EUI - Measured)

NEW BUILDINGS PATHWAY

The Roadmap trajectory adopts two approaches to representing EUIs for new buildings:

- For sectors where industry guidance and targets developed through asset level research is available (residential and offices), the trajectory aligns EUIs with these targets. In future these sectors would, however, benefit from further granularity for key typologies (houses, apartment blocks, dwellings connected to heat / hydrogen networks, etc).
- For sectors that cover a broader range of building types (e.g., education, healthcare), mapping specific EUI targets to the aggregate sectoral data is more challenging. Asset level EUI research data is also more limited. For these sectors, the standards for new buildings are mapped as an improvement against the sectoral average for existing buildings.

Identifying appropriate EUI standards in detail for all new building types within all sectors is beyond the scope of the current Roadmap exercise.

Future work is required to rapidly develop these standards, informed by emerging in-use data following the introduction of mandatory in-use energy disclosure. The timelines in the previous section indicate how the proposed evolution of Part L to EUI compliance approaches can be coordinated with mandatory energy disclosure per sector.

NEW BUILDINGS: PATHWAY

Following targets established through the Future Homes Standard / Future Buildings Standard (2025):

ENERGY SUPPLY

- All new buildings have low carbon heating systems from 2025
- 2.6kW PV installation on 80% of new homes from 2020-2050.

BUILDING PERFORMANCE TARGETS

- 15kWh/m^2/year space heating design limit for new homes from 2025
- 35-40kWh/m^2/yr EUI design target for new homes from 2025 (regulated and unregulated energy use)
- EUI design targets for new non-domestic buildings to be determined per sector informed by emerging in-use data following the introduction of mandatory in-use energy disclosure.

Policy Recommendations

Buildings designed from 2025 onwards must be equipped to deliver the energy performance levels required for Net Zero.

Key Policy Recommendations for Government

Update the regulatory and policy framework for new homes:

- Update the National Calculation Methodology (NCM, as underpinned by SAP) and the EPC methodology to create a fit-for-purpose predictive methodology for energy performance of dwellings, that better reflects in-use energy performance.
- 2025 Future Homes Standard and associated Building Regulations Part L 2025 update to introduce:
  - Energy Usage Intensity (EUI) targets inc. regulated and unregulated loads (kWh/m^2/yr)
  - Thermal energy demand limits (kWh/m^2/yr)
  - Low carbon heating for all new buildings (no fossil fuel combustion)
  - Measures to limit peak demand and enable load shifting (with limits on peak demand from 2030)
  - Minimum standards for currently unregulated key appliances with high influence on annual & peak demand, i.e., cooker hobs & showers

Update Building Regulations for new non-domestic buildings to include:

- Part L 2021 final statutory guidance to include mandatory provision of Energy Usage Intensity (EUI) forecasts (regulated and unregulated loads) for all buildings >1,000m^2.
- 2025 Future Buildings Standard and associated Building Regulations Part L 2025 update to introduce:
  - For office buildings >1,000m^2: EUI target (kWh/m^2/year) compliance approach in place of notional building methodology.
  - Thermal Energy Demand limits (kWh/m^2/year) for different building typologies
  - Low carbon heating for all new buildings (no fossil fuel combustion)
  - Peak Load prediction (and ability for load shifting)
- Interim amendments to 2025 Building Regulations Part L to introduce EUI target compliance approach for additional sectors, aligned with mandatory energy disclosure dates:
  - 2027 amendments: Phase 2: i.e., Offices <1,000m^2, Hotels, Retail, Warehouses, Higher Education
  - 2029 amendments: Phase 3: Remaining sectors
- 2030 Building Regulations to include:
  - Peak load limits demand limits (W/m^2) for different building typologies.
- Align the introduction of the EUI compliance approach per sector with the timings of a confirmed mandatory energy disclosure timetable (with timetable to be confirmed ahead of 2025).

Wider Policy Measures

- Stamp duty rates should be adjusted in line with the energy performance of a property (as part of wider policy across the market - see Existing Homes).
- Increased availability of green mortgages with reduced interest rates for the most efficient homes to stimulate market demand for future building efficiency standards (as part of wider housing policy - see Existing Homes).
- Enable accelerated planning approval for early adopters of future energy efficiency levels (with disclosure of performance on completion).
- Local planning authorities' ability to set more ambitious targets for new development should be retained until suitable EUI targets consistent with Net Zero are established within building regulations per sector (i.e., 2025 onwards).

Key Policy Recommendations for Local Authorities

Whilst national regulations are being updated to align with Net Zero, local authorities can use planning policy requirements to prioritise in-use energy performance.

Resources such as the UKGBC New Homes Playbook can be used to design policies focusing on:

- Requiring % reductions on Building Regulations beyond minimum standards and prioritising a fabric-first approach.
- Requiring that homes meet ambitious space heating targets and that all buildings forecast operational energy performance using suitable predictive methodologies.
- Adopting EUI targets for different building types (including regulated and unregulated demand)
- Reducing peak demand via requiring planning applicants to evaluate building peak demand and demonstrate reduction efforts.
- Measuring in-use performance through implementing monitoring regimes throughout design, construction and operation stages.

Industry Action

Achieving in-use energy targets requires an outcomes-led "design for performance" approach, forming a golden thread throughout the design, construction, and handover of buildings.

Regulation, standards, design, procurement, construction, handover and management must focus on energy performance in use.

DESIGNING FOR PERFORMANCE

- **Developers** should update their briefs to include energy intensity targets aligned with industry targets and request a Design for Performance approach from design teams and contractors, seeking to include contractual targets where possible.
- **Architects** and **Building Services Engineers** should advocate for an outcome focused Design-for Performance approach, and increasingly embed this into their own processes. This may involve awareness raising with some clients, and consistency within industry bidding processes.
- **Building Services Engineers** and **Energy Consultants** have a critical role in enhancing skills and scaling up existing capabilities in advanced building energy simulation in order to effectively evaluate energy performance during design stages. Significant upskilling will be required to mainstream these skills across the building services industry.
- A Design for Performance approach will only become the norm if embedded by stakeholders across the value chain, including **Contractors** and those involved in **Commissioning**. The measurement of in-use energy and performance must be championed early in the process, even if those initial stakeholders do not have responsibilities into handover.
- Increased focus is required from **Occupiers** and **Tenants** on reducing the energy intensity of fit outs, including the impact of tenant IT and catering.

MONITORING IN-USE PERFORMANCE

- **Developers** and **Landlords** must ensure measures are in place to enable effective in-use energy monitoring and reporting of new buildings once operational, including clear plans for ongoing engagement with **Occupiers** and **Tenants.** Energy data should be shared between **Landlords** and **Tenants** and fed into central industry databases.
- **Post Occupancy Evaluation** (POE) of completed projects is invaluable and should become standard practice, with results fed into central industry databases. **Developers** and **Tenants** should instigate POE on recent projects (i.e., delivered in last 5-years), engaging the design teams of both base builds and fit outs to evaluate performance, rapidly improve industry datasets, generate feedback loops and support the formation of new performance-based rating systems.

Embodied Carbon:
All Buildings

Embodied carbon from the construction and refurbishment of buildings makes up 20% of built environment emissions. As operational emissions from buildings decrease, the trajectory results indicate that embodied carbon will form over half of built environment emissions by 2035.

Embodied carbon emissions are currently unregulated, and measurement and mitigation within construction is typically voluntary.

This suggests that legislation to measure and limit embodied carbon must be introduced at the earliest opportunity, alongside support for industrial decarbonisation of key material supply chains and reduced demand for new construction and materials through increased design efficiency, re-use and circularity.

MEASUREMENT AND REGULATION

Embodied carbon emissions over the last two decades have reduced by almost 20% and are driven by two factors - decreasing carbon intensity of construction and increasing construction growth. The former declined by 40% in the period 2000-2018, while the latter only paused between 2007 and 2012 as a result of the financial crisis. The net result is an overall reduction in emissions, but the data demonstrates the challenge of decoupling embodied emissions from economic growth, with emissions increasing over the last decade.

Currently, the measurement and mitigation of embodied carbon at project level is typically voluntary, with no existing regulatory or statutory mechanisms in place to drive demand side efficiency.

Many leading developers and infrastructure clients now measure and optimise the embodied carbon footprint of new projects, and technical standards and guidance are available to do this, but it is far from being mainstream practice across the industry.

DECOUPLING GROWTH AND EMISSIONS

There are three main factors which influence sectoral embodied carbon emissions:

- The design efficiency of projects, i.e., the overall quantum and choice of materials used in projects
- The carbon intensity of construction material supply chains, i.e., industrial decarbonisation.
- Overall growth rates, i.e., how much we build

Investment will be required to drive decarbonisation of material production on the supply side. However, recent emissions trends demonstrate that regardless of improvements in carbon intensity, if growth rates of buildings and infrastructure continue to increase, the benefits are negated, and absolute emissions will be static or even increase.

Parallel efforts must therefore be made to both reduce demand for new buildings and materials, through improved material efficiency, material choices, re-use and circularity, and accelerate industrial decarbonisation of key construction material supply chains.

The embodied carbon results highlight the fundamental influence of construction demand. Future investment as part of a post-pandemic drive to Build Back Better must be underpinned by a full understanding of embodied carbon impacts, with a clear directive for the lowest impact form of development - prioritising re-use of existing assets wherever possible.

EMBODIED CARBON: ALL BUILDINGS

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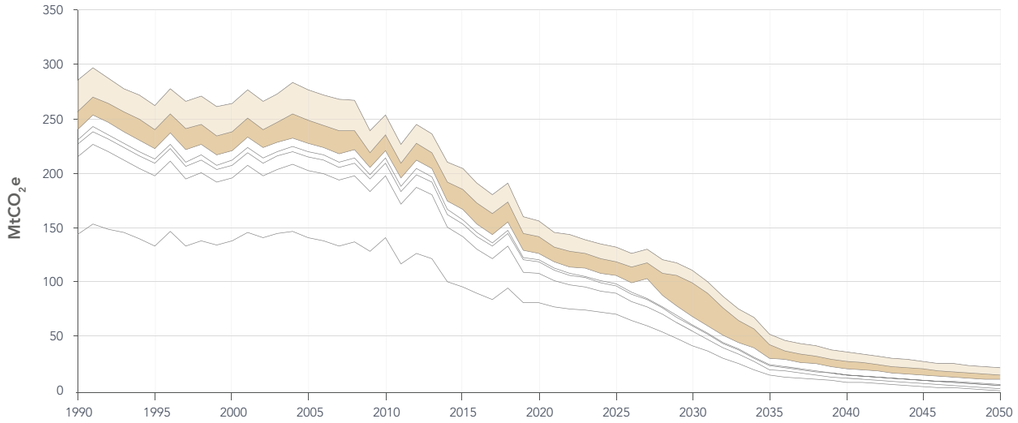


Development of the UK building stock requires a focus on driving the circular economy, developing the second-hand materials markets and increasing re-use. Strategic thinking on improved utilisation and change-of-use of the existing building stock also has the potential to reduce embodied emissions.

This is increasingly important in the short to medium term, as industrial decarbonisation of carbon intensive supply chains will not be immediate, and in many cases will require significant investment to upscale technologies such as Carbon Capture and Storage (CCS). .

RETROFIT IMPACT

The transformative national retrofit programme as set out in previous sections will also have a significant impact on demand, given the scale of ambition of the programme. This investment into insulation materials and new heating systems is unavoidable in order to tackle the current dominant source of built environment emissions – domestic fossil fuel heating. It will however generate a knock-on increase in embodied carbon emissions, the reduction of which will require new supply chain innovation and measures to reduce emission intensities. The impact of this programme can be clearly seen in the trajectory from 2028-2035.

BUILDING DEMAND REDUCTION

The Roadmap trajectory for embodied carbon adopts a lower projection for new build homes than current government targets. The trajectory derives a net demand for new homes using the ONS household statistics.

Demand for new construction is further reduced through estimates for the potential to create new dwellings through change-of-use of existing non-domestic buildings, and improved utilisation of the existing building stock more broadly.

The trajectory assumes that the number of new homes delivered through change-of-use conversions will increase, with 25,000 new homes delivered in this way each year from 2025 onwards, emitting 25% less embodied carbon than new construction.

The over-supply of space in some commercial sectors (i.e., retail) and the under-occupation of homes offers the opportunity to reduce demand for new office and residential buildings, if existing assets can be better utilised.

This wide potential for improved building utilisation has been represented in the trajectory by reducing demand for new offices and residential buildings by 10% by 2041.

MATERIAL DEMAND REDUCTION

The existing building stock is full of high value materials which have the potential to be reused in new development through a circular economy model, dampening the demand for new materials. To represent this opportunity in the trajectory, demand for virgin metal and petrochemical-based materials has been reduced by 11% across all building sectors by 2041 within the trajectory.

DESIGN EFFICIENCY

Optimising designs to be more efficient with materials is the first step in reducing embodied carbon emissions on projects. This approach should be embedded throughout the industry, considering modern methods of construction. Material quantities should be measured and tracked as part of embodied carbon reporting.

The Roadmap trajectory projects a 20% reduction in material usage by 2050, based on several reference studies that give a wide range of predictions for potential design savings across different design packages.

EMBODIED CARBON: PATHWAY

BUILDING GROWTH RATES & UTILISATION

- c.200k new homes PA
- 25k new homes PA from 2025 onwards via change-of-use conversions
- 10% reduction in new office / resi demand by 2040 through Improved utilisation of existing building stock

MATERIALS

- 20% reduction in material usage through design efficiency by 2050
- 10% reduction in material demand by 2040 through increased material reuse

SITE EMISSIONS

- 80% reduction in construction site emissions by 2050
- 50% reduction in construction material transportation emissions by 2050.

CONSTRUCTION SITE AND TRANSPORT EMISSIONS

Construction site emissions are projected to continue to decrease in line with recent progress (5% PA) as measures such as the optimisation and digitalisation of construction processes and operations, plant and equipment technologies, electrification of site power supplies and some small plants, and carbon management training and behaviours continue to be deployed.

The decarbonisation of construction transport is based on trajectories for different modes of transport, the most significant being the phase out of new petrol or diesel LGVs from 2030, and international shipping emission reduction commitments.

MATERIAL SUPPLY CHAINS

The projected decarbonisation of construction materials has been identified with reference to existing and emerging industry sources, alongside the Government Industrial Decarbonisation Strategy. As the roadmap adopts a consumption basis to emissions, the decarbonisation trajectories are based on both UK supply chains and imported materials.

Consideration of the benefits of specific material switching at asset level was beyond the scope of the study given the range of building typologies, sectors, and material options available. Materials optimisation at asset level will be driven through the introduction of policy to drive mandatory measurement and limits on embodied carbon.

SUPPLY CHAIN PRIORITY GAPS

Currently, the level of detail and certainty around decarbonisation strategies varies significantly across material supply chains. Therefore, there is a significant variation in projection confidence levels. For example, a concrete sector roadmap has been published[11], but projections for glass, brick and ceramics are less recent (derived from BEIS studies from 2016). Forward projections for the timber industry are derived from direct engagement in the absence of published decarbonisation plans.

INFRASTRUCTURE DEPLOYMENT

Many of the material supply chains will be reliant on the deployment of CCS and / or Hydrogen in order to decarbonise hard-to-abate emissions (i.e., high temperature processes, or chemical process emissions such as cement production).

These projections are therefore reliant on Government and industry commitment to delivering these technologies as an integral part of UK infrastructure. If supply chain decarbonisation investments such as CCS are not planned for and delivered as projected, then other areas of the built environment will be required to deliver reductions to keep total emissions within budget.

Figure 13: Improvements in design material efficiency, transportation of materials and construction site practices.

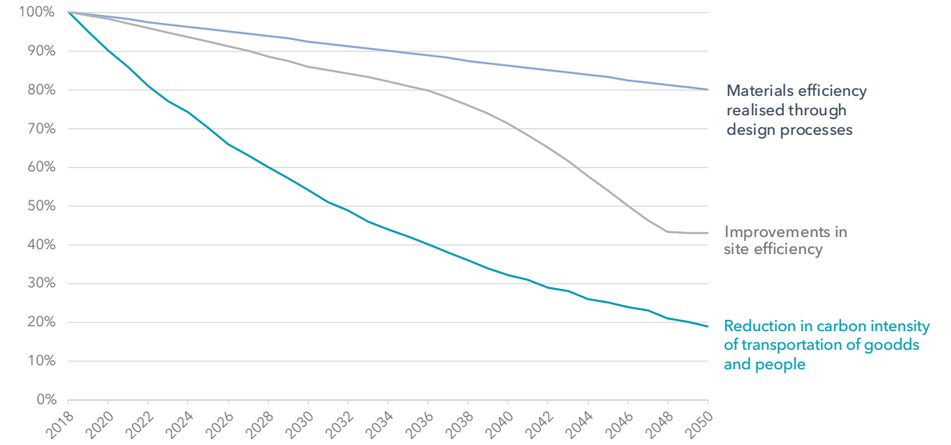


Figure 14: Carbon intensity reduction projections per material category

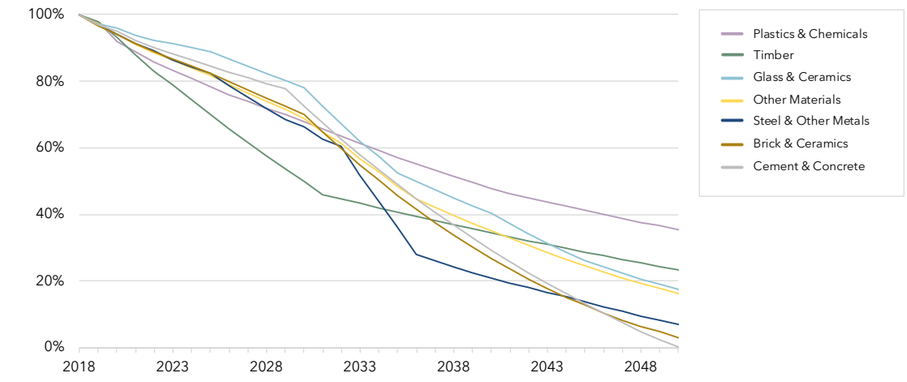
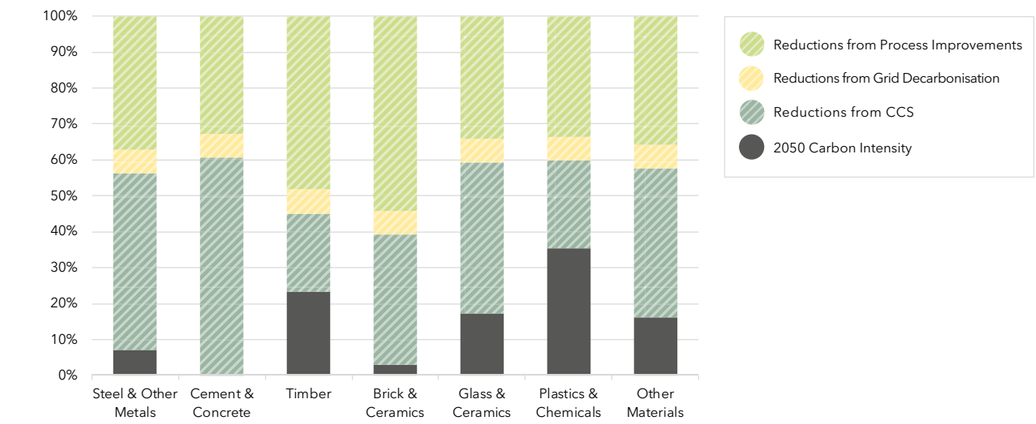


Figure 15: Carbon intensity reduction (2050) breakdown per material category



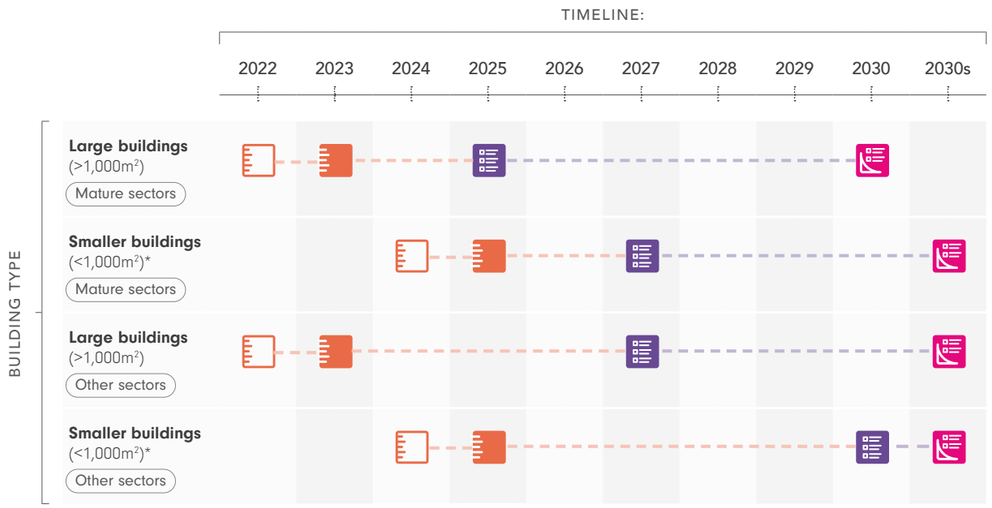
Policy Recommendations

Given the embodied carbon reductions required in the coming years, regulation of embodied carbon will need to be introduced to mandate consistent measurement before introducing emission limits.

Key Policy Recommendations for Government

Implement a regulatory policy framework for embodied carbon in new buildings, with clear signposting of a phased pathway:

- **Mandatory measurement and reporting** of Whole Life Carbon by **2023** for large buildings (>1,000m²) and residential developments (≥10 dwellings).
- **Minimum standards** (limits) for Upfront Embodied Carbon by **2025** for large buildings (>1,000m²) in more mature sectors (i.e., those with sufficient asset level benchmark data), with associated **fiscal incentives and penalties.**
- **Minimum standards** (limits) for Upfront Embodied Carbon by 2027 in all sectors.
- Final phase to introduce minimum standards for all size buildings (with a suitable minimum threshold) in all sectors by **2030**.



Reading this timeline

Mandatory measurement & disclosure of upfront embodied carbon introduced into Building Regulations at the earliest opportunity

Mandatory measurement and disclosure of upfront embodied carbon comes into force

* With suitable minimum size threshold. Area thresholds and sector maturity criteria to be refined.

Progressive tightening of standards for upfront embodied carbon in line with carbon budget trajectories

Minimum standards (limits), fiscal incentives, and penalties for upfront embodied carbon

Regulation must be supported with suitable data management and collection systems, as well as tools and incentives for industry to reduce embodied carbon. Building on progress already made within industry, the government will need to provide adequate support to areas such as embodied carbon data management, Environmental Product Declarations (EPDs), and circularity. Supporting policy recommendations include:

DATA MANAGEMENT

- Develop a freely available national embodied carbon assessment tool.
- Utilise existing industry resources to establish a national asset and product embodied carbon database, such as the Built Environment Carbon Database (www.becd.co.uk).
- Recognise and support the development of existing embodied carbon standards and benchmarks.
- Publish embodied carbon benchmarks (using industry standard methodology & carbon factors) and voluntary best practice standards by 2023.
- Support the industry in developing competency standards and QA processes for the assessment of embodied carbon.

EPDS

- Support the industry to develop EPDs (to EN15804 & 3rd party verified) at the scale and quality required.
- Incentivise and eventually require manufacturers to declare the impacts of their products.
- Provide financial support to SMEs for EPD development.

CIRCULAR ECONOMY

- Remove VAT on refurbishment works (i.e., 0% VAT) which retain building structural frame and achieve energy performance targets (to incentivise re-use over demolition) - while proportionally increasing the VAT on new builds to make this change fiscally neutral
- Establish a nationwide second-hand materials database, building on city-level networks.
- Update National Planning Policy Frameworks to require evaluation of embodied carbon impacts of new build before permitting demolition.

LOCAL PLANNING REQUIREMENTS

- Enable local planning authorities to set more ambitious limits on upfront carbon for new development than those introduced via Building Regulations.

Key Policy Recommendations for Local Authorities

Local authorities can encourage embodied carbon reductions on projects by introducing planning policy requirements focussed on whole life carbon and upfront embodied carbon, re-use and circularity.

The UKGBC New Homes Playbook recommends the following key policies:

- Require all developments to demonstrate design stage actions taken to reduce embodied carbon and maximise opportunities for reuse through the provision of a Circular Economy Statement.
- For application sites with existing buildings, use the Circular Economy statement review, and the determination process to critically appraise the need for demolition, and seek the reuse of foundations / superstructure.
- Require that major developments calculate whole lifecycle carbon emissions (A-C) and upfront embodied carbon (A1-A5) through a nationally recognised Whole Lifecycle Carbon Assessment methodology and demonstrate actions taken to reduce lifecycle carbon emissions.
- Monitor any performance change via updated final As-Designed and As-Built embodied carbon assessments via the discharge of conditions.

Industry Action

The reduction of embodied carbon must be prioritised with the same strategic importance as the reduction of operational carbon emissions.

PROJECT TARGETS

- **Investors** and **lenders** should set embodied carbon targets within project funding criteria.
- **Developers** should include targets for embodied carbon and material re-use alongside operational energy intensity targets in project briefs. Whole Life Carbon should be established as a first order consideration within initial site development appraisals. This will usually result in the prioritisation of refurbishment and/or extension, as opposed to demolition and new build.
- **Architects** and **Engineers** should advocate for embodied carbon targets on projects and embed embodied carbon and design efficiency targets within their own organisational KPIs. Net Zero design options should be undertaken at every stage and presented to the client, even if not explicitly asked for. The ability of design teams to quickly and clearly present the embodied carbon impact of design options during feasibility and concept design stages will be critical.
- **Contractors** will need to work with their supply chains and **Material Manufacturers** to set carbon intensity reduction targets, require mandatory disclosure of supply chain data, and track and reduce construction site emissions. Carbon should be evaluated alongside cost in all value engineering exercises.
- All **Material Manufacturers** should develop embodied carbon reduction plans for their products and operations, focusing on reducing materials, energy usage, manufacturing waste, packaging, and transport needs.

DATA MANAGEMENT

- Further work is required to improve the availability and transparency of embodied carbon data across the industry. There is currently a wide variation in data quality across different supply chains. Robust data tracking and reporting will help expand datasets and enable further refinement of targets.
- **Professional Institutions** have a key role in maintaining and championing standards, guidance, and central databases for carbon information, such as the Built Environment Carbon Database (BECD). Centralised and well-populated databases showing both asset and product level data will be a critical part of enabling the mainstreaming of embodied carbon assessment on all projects.
- **Developers, Architects, Engineers, Contractors,** and **Product Manufacturers** all have a role to play in increasing data transparency via central databases. Data ownership will vary across each stakeholder, requiring a comprehensive effort across the value chain.
- **Occupiers** and **Facility Managers** are key to generating and improving datasets relating to embodied carbon from the use stages of buildings. While a significant share of embodied carbon relates to construction stages, it also occurs during refurbishment, repair and maintenance, and the data for this is less prevalent. As with domestic retrofit, non-domestic refurbishment approaches to improving energy performance should be assessed through a whole life carbon lens.

EPDS

- Improving EPD availability (EPD A-D to EN15804 & externally verified) across all supply chains is a priority action.
- **Developers** and **Contractors** will need to work with their supply chains and **Material Manufacturers**, to stimulate EPD demand by requiring that increasing percentages of products and materials used in new projects have EPDs (EPD A-D to EN15804 & externally verified).
- **Occupiers** and **Owners** can also require mandatory disclosure of supply chain EPDs on maintenance and repair works, or when undergoing refurbishments or major renovation works.
- All **Material Manufacturers** should begin developing EPDs (A-D to EN15804 and externally verified) for product portfolios, working towards 40% of their standard product portfolio (in terms of embodied carbon impact) by 2025, with minimum thresholds and support and subsidies for SMEs. By 2030, all **Material Manufacturers** should have declared their entire standard product portfolios via EPDs. i.e. 100% EPD by 2030 (with suitable groupings and minimum thresholds).
- Particular focus is required to overcome the challenges in those supply chains where embodied carbon data is limited, for example, mechanical and electrical services.

SKILLS AND TRAINING

- Mainstreaming low-embodied carbon design and delivery will require upskilling across various disciplines. The industry must begin systematically improving carbon literacy and competency across all levels and disciplines.
- **All Stakeholders** should implement Net Zero Carbon (NZC) skills and training plans supported by **Professional Institutions**, with reference to the Climate Framework, to establish carbon literacy across all students and staff.
- Carbon literacy requirements may vary depending on role and responsibility, from needing baseline carbon knowledge to developing abilities to assess and evaluate embodied carbon across complex projects. The **Professional Institutions** will play a critical role in defining what competency levels look like per discipline and role, and embedding this into membership criteria and CPD, through the deliverables of the CIC Climate Action Plan.
- It will be critical that all **Architects** and **Engineers** maintain a common understanding of standards and guidance, so that **Developers** are presented with consistent data on which to make decisions. Embodied carbon assessment should be embedded within internal design protocols and quality procedures and checkpoints. **Cost Consultants**, **Quantity Surveyors** and **Project Managers** will need to ensure that carbon is evaluated alongside cost in all value engineering and optioneering exercises.

CIRCULAR ECONOMY

- The circular economy will play an important role in reducing the total life cycle impact of built environment projects. All the themes discussed in the previous sections will help create momentum towards circularity by emphasising the importance of a whole life carbon approach at each project stage. Attitudes across the industry must shift towards prioritising re-use of assets and materials, especially within urban development.
- **Developers** should prioritise the re-use and retention of existing building structures within urban development sites wherever possible. They can also engage with local authorities and supply chains to support and drive city-level second-hand material markets to accelerate circularity and material re-use.
- **Architects** and **Engineers** should similarly prioritise reuse, demonstrating to clients how existing structure or sub-structure can be retained whilst still achieving site development potential. **Structural Engineers** should proactively identify opportunities to utilise re-used structural elements and design for disassembly, and advocate for maximum re-use of existing building structure / substructure (and if structures must be demolished, advocate for controlled deconstruction over demolition to maximise reuse potential of structural components).
- Pre-demolition surveys are key to identifying re-use and retention opportunities. **Architects**, **Structural Engineers** and **Contractors** all have roles throughout the stages of increasing project detail (initial high-level site appraisals through to detailed demolition planning).

Embodied & Operational Carbon: Infrastructure

Operational and embodied emissions from infrastructure make up 6% of UK built environment emissions. Whilst this proportion appears modest, infrastructure is linked to broader emission impacts through the use of infrastructure assets, i.e., transport emissions.

Infrastructure investment can enable net reductions in emissions, for example, investments to decarbonise the energy sector. Conversely, transport programmes which enable and induce increased vehicle usage can have a significant emission impact.

The decarbonisation of the infrastructure sector therefore requires a systems-thinking approach aligned with the national Net Zero target, balancing embodied carbon impacts of infrastructure investment with the full emission impacts in other sectors.

SYSTEMS THINKING

Infrastructure projects must be reviewed through a full carbon lens that encompasses the inter-relationship between embodied and operational carbon and emissions from the use of infrastructure, and be placed within the context of overarching carbon budgets.

Growth rates in all infrastructure categories are projected to increase within the trajectory, driving increases in embodied carbon. However, elements of this investment are linked to the wider transition to Net Zero in other key sectors, for example electricity, which in turn is driving decarbonisation in buildings. Infrastructure assets do not exist in isolation and will be critical in enabling deep decarbonisation of the UK system as a whole.

All sources of carbon therefore need to be at the forefront of infrastructure decision-making in the context of the overarching carbon budgets, and with an understanding of the inter-relationship between embodied, operational, and use emissions of different infrastructure assets.

CONSTRUCTION WASTE

The trajectory for infrastructure sets out anticipated changes in construction and demolition (C&D) waste volumes and destinations, linked to upstream material re-use drivers. Total C&D waste reduces by 5% by 2050, with modest reductions in the carbon intensity of waste processing.

Re-use rates of C&D waste increases by 100% by 2050, linked to increased circularity and re-use of high value materials within the built environment. Recycling rates increase by 6% and make up 80% of all waste by 2050. As a result of these improvements, landfill rates reduce by 14% by 2050.

SUPPORTING INDUSTRIAL DECARBONISATION

Strategic infrastructure investments are required in the industrial sector to enable the decarbonisation of construction material supply chains, as set out in the previous section. Decarbonisation will be reliant on both hydrogen and CCS due to hard-to-abate process emissions, including at dispersed sites outside of industrial clusters (solutions to which are currently unresolved).

These measures should be viewed as national infrastructure networks rather than localised abatement measures, with suitable conditions for investment created via certainty on the long-term policy framework. This will need to include a long-term strategy on carbon pricing and anti-carbon leakage measures to enable UK industry to maintain competitiveness.

If supply chain decarbonisation investments are not planned for and delivered as projected, then other areas of the built environment will be required to deliver reductions to keep total emissions within budget.

EMBODIED & OPERATIONAL CARBON: INFRASTRUCTURE

Other categories have been greyed out

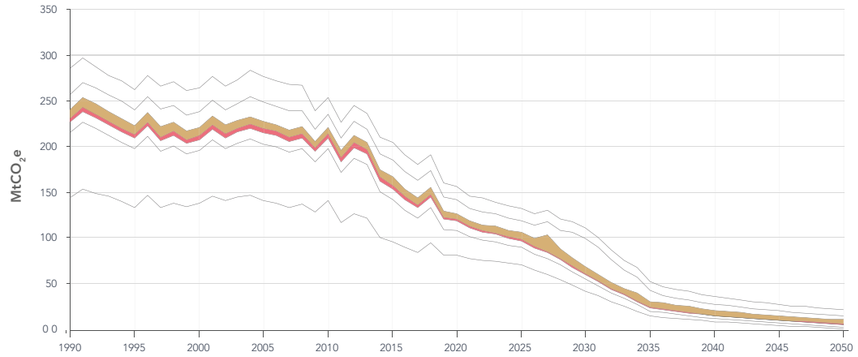
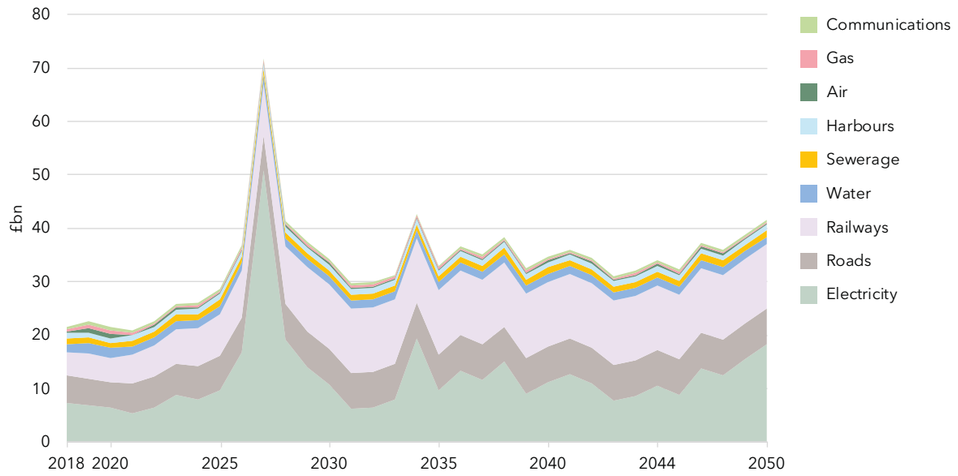


Figure 16: Infrastructure investment projections



INFRASTRUCTURE: PATHWAY

GROWTH

- 100% increase anticipated in total infrastructure investment 2018 – 2050, driven by increased investment in electricity and rail sectors.

CONSTRUCTION AND DEMOLITION (C&D) WASTE

- 5% reduction in total C&D waste by 2050.
- 2% reduction in waste processing emissions intensity by 2050.

STREET LIGHTING

- 68% reduction in external lighting emissions via LED street-lighting and central controls.

WASTE DESTINATIONS

- 100% increase in re-use rates of C&D waste by 2050.
- 6% increase in C&D waste recycling rates by 2050.
- Landfill rates decreases from 25% in 2020 to 14% by 2050.

Policy Recommendations

The decarbonisation of the infrastructure sector requires a systems-thinking approach.

Key Recommendations to Central Government

INTEGRATED DECARBONISATION OF INFRASTRUCTURE SYSTEMS

- Introduce the role of a National Infrastructure Integrator to enable holistic decision-making across UK infrastructure investment with full visibility of all carbon impacts.
- Demonstrate leadership within public procurement via Infrastructure and Projects Authority (IPA) commitment to the CSIC Carbon Reduction Code (which includes integrating carbon reduction targets and reporting commitments explicitly in all procurement documents from 2021).
- Set a requirement for all regulators to develop an explicit first-order objective to support the transition to net zero by 2050.
- Mandate for PAS 2080 (or equivalent standard) to be fully implemented across all Infrastructure projects by 2025.

INDUSTRIAL DECARBONISATION

- Drive and support 'low regrets' energy efficiency and fuel switching measures within industry to enable the decarbonisation of construction supply chains.
- Support the development of Carbon Capture and Storage (CCS) for use in industry, to deal with hard-to-abate emissions for which there are no alternative mitigation options, e.g. process emissions from cement production. Deliver on plans for initial CCS deployment in two industrial clusters by 2025 with two more by 2030.

Work with concrete and cement sector to identify feasible options for CCS deployment and transportation in dispersed sites.

Support the deployment of hydrogen within industry to aid decarbonisation (i.e. for high temperature processes) and adopt a transparent and robust science-based approach to the options available for hydrogen production.

CARBON PRICING

Ensure carbon pricing policies such as the UK ETS continue to drive deep industrial decarbonisation whilst maintaining competitiveness and minimising carbon leakage.

Considerations must include increased carbon prices, links with the EU ETS, the phase-out future of free allowances, and an equitable supply adjustment mechanism which keeps pace with the EU Carbon Border Adjustment Mechanism (CBAM) and, once tested, may enable the phase-out of free allowances.

Set the UK Emissions Trading Scheme (UK ETS) cap based on the pathway to the UK Net Zero target and consider expanding the scheme to include increased coverage of materials and sectors.

NATIONAL PLANNING POLICY FRAMEWORK

Incorporate carbon accounting into the National Planning Policy Framework (NPPF) to ensure net-zero is consistently included in all areas of planning policy.

Key Recommendations for Local Authorities

Local authorities must also consider infrastructure projects systematically. Project carbon can be reduced by updating planning policies to prioritise whole life carbon.

Many of these policies are captured in previous sections as they will also be applicable to building projects. However, local authorities have significant influence on larger regeneration projects with associated infrastructure needs.

Local Authorities can help decarbonise infrastructure by:

- Introducing planning policy to ensure WLC impacts of infrastructure projects are quantified at planning stage.
- Updating financial appraisal systems to include WLC and climate impacts for assessing infrastructure projects.
- Local Plans and Transport Plans to introduce policies to support walking, cycling and public transport.

Industry Action

Industry stakeholders have a key role to play in ensuring strategic carbon reduction decisions and actions are implemented across the infrastructure landscape.

CARBON TARGETS & REPORTING

- **Infrastructure Clients** and **Owners** must include carbon reduction targets and reporting commitments explicitly in all procurement documents, as a deliverable of the design and procurement process, using PAS 2080 (or equivalent standard) as the reference standard.
- Carbon baselines should be established for all projects by adopting PAS 2080 and targets set for carbon reduction against these, driving innovation.
- **Infrastructure Clients** should assess the total emissions impact of new infrastructure projects and retrofits before undertaking projects and review resultant emissions within the context of sector carbon budgets.
- **Infrastructure Clients** and **Owners** can utilise performance / outcome-based specifications and commercial arrangements with their supply chains, where possible, ensuring outputs are not constrained to current thinking but encourage low carbon innovations.

DATA SHARING

- The Net Zero Infrastructure Industry Coalition has identified that limited embodied carbon data is hampering project life cycle comparisons and accurate benchmarking.
- It is critical that carbon targets and carbon measurement are mainstreamed consistently across all infrastructure projects, with commitments to using an agreed industry-wide set of carbon emission factors for construction products and buildings materials.
- Carbon reduction data should be shared openly via an industry-wide central embodied carbon database (i.e., BECD) for the purposes of benchmarking and performance improvement, with commitments to sharing own best practice across the supply chain / sectors and learning from and adopting others best practice where possible.

OPERATIONAL CARBON

- **Owners** of existing assets should develop strategies on how to best reduce operational carbon, recognising that in many cases (e.g., roads) it is the users of those assets who produce the most emissions.
- Operational investment plans must align with the national net zero obligation, including retrofitting decarbonisation to existing asset operations and their use.
- **Infrastructure Owners** should also develop net zero strategies for asset system maintenance, refurbishment, and low-cost upgrades (i.e., not major projects), including identifying big-ticket actions for targeting reductions.

SKILLS AND TRAINING

- All Stakeholders should implement Net Zero Carbon (NZC) skills and training plans supported by Professional Institutions, to establish carbon literacy across all students and staff.
- Infrastructure Designers should proactively recommend and adopt carbon measurement and carbon reduction methodologies in all projects for both design and construction, regardless of whether clients are requesting them.

Conclusions

The built environment is directly responsible for 25% of UK emissions. The urgency to act on climate changes has never been greater, and the built environment sector has a moral and legal responsibility to address the climate emergency and accelerate sector decarbonisation.

The Roadmap has identified five key priorities which government and industry need to support and implement across the sector in order to deliver Net Zero for the built environment:

1. **Nation-wide retrofitting of existing homes.**

   To transform UK housing so it is efficient, warm, and cheaper to heat, whilst phasing out fossil fuel heating.

   There should be a national home retrofit programme, which builds on existing relevant work in local authorities. This program must prioritise building fabric upgrades that reduce heating demand and enable the potential for widespread and effective deployment of domestic heat-pumps. The programme will also bring health and wider societal benefits, help eradicate fuel poverty, and create 500,000 green jobs directly supporting the national levelling up agenda.

2. **Energy performance disclosure for non-domestic buildings.**

   To ensure that real-world performance of assets is visible to the market, and can influence asset valuation, market transactions, and management.

   The currently proposed introduction of a performance-based rating system for large office buildings represents a critical opportunity to demonstrate the benefits of mandatory energy performance disclosure, followed by a phased rollout to other non-domestic sectors. Mandatory energy disclosure will stimulate markets to achieve significant energy efficiency improvements.

3. **Adoption of a design for performance approach.**

   To shift away from the theoretical "notional building" approach and to focus on how energy intensive buildings will be in practice, alongside other key net zero enablers such as peak demand limits.

   Approximately 20% of buildings that will exist in 2050 are yet to be built. Integrating Net Zero performance standards into building fabric from the outset is far more cost-effective than future retrofitting ahead of 2050, less than halfway through the average building's lifespan, and minimises the risk of future occupant disruption, cost and embodied carbon emissions.

   There should be rapid reform in how energy performance of buildings is evaluated within Building Regulations. Shifting from the notional building comparisons to in-use energy performance metrics (Energy Usage Intensity - EUI, i.e., kWh/m^2/year),will drive industry towards an outcomes-led "design-for-performance" approach that forms a golden thread throughout the design, construction, handover, and management of buildings.

4. **Whole life carbon measurements and agreed limits.**

   To start with mandatory measurement, followed by the phased introduction of embodied carbon limits for new buildings to reduce demand, alongside changes to planning and VAT to incentivise the re-use of existing buildings.

   Embodied carbon emissions make up approximately 50% of building lifecycle emissions, yet are currently unregulated, and measurement and mitigation within design and construction is entirely voluntary.

   Solving the issue is both a demand and supply issue, requiring more efficient design and optimised material choices from buildings designers, in tandem with supply chain decarbonisation via industrial strategies and carbon pricing policies. Development of the UK building stock requires a focus on "retrofit first", driving the circular economy, developing second-hand materials markets, and increasing re-use.

5. **National infrastructure investment based on the net emissions impact.**

   To consider all forms of carbon, alongside a policy framework and investment to drive industrial decarbonisation of key construction supply chains.

   The infrastructure sector influences emissions from the transport (vehicle usage), and energy (supply) sectors, and decarbonising these sectors is also necessary for the UK's Net Zero 2050 commitment. The decarbonisation of the infrastructure sector therefore requires a systems-thinking approach, balancing embodied carbon impacts of infrastructure investment with emission reductions delivered in other sectors such as transport, through the use of those infrastructure assets.

   Infrastructure projects must be reviewed through a full carbon lens that encompasses the inter-relationship between embodied, operational and user carbon and be placed within the context of overarching carbon budgets.

Future of the Roadmap

Updates and Ownership

The intention of this project is to create and share a resource to industry of lasting value and impact. The carbon trajectory data published in this report is available online for download and review by stakeholders across the industry.

Tracking sector progress against the trajectory will be crucial, and UKGBC is committed to refreshing the datasets on an annual or biennial basis to provide progress updates to the sector.

Progress updates will enable the industry to track carbon reduction progress and identify sub-sectors which are not moving fast enough.

There is also potential to undertake periodic updates and recasting of the trajectory to reflect updates in national policy or strategy within the built environment and identify the impact on the carbon trajectory.

Ongoing Roadmap Development

Sub-Sector Roadmaps

The carbon trajectory provides an overarching carbon budget which will inform sub-sectors emission reduction plans and identification of interim targets. The roadmap trajectory forms a consistent umbrella dataset, complimenting detailed pathways for sub-sectors or industry stakeholder groups, ensuring a consistent sector approach while accounting for unique challenges and opportunities at a more granular level.

Asset Level Targets

The Roadmap carbon budget and sub-sector trajectories provide an invaluable resource to inform the development of standards and targets at asset level, ensuring that targets are consistent with the sectoral Net Zero pathway.

The Roadmap datasets should inform the following workstreams:

- Identifying EUI target pathways to 2050 within the Government's Performance-Based Policy Framework for non-domestic buildings.
- New Building EUI targets (industry targets and future regulatory standards).
- Developing science-based pathways for asset level embodied carbon targets (industry targets in support of future regulatory limits).
- Domestic retrofit stock modelling of different house architypes to identify cost-optimal levels of fabric upgrades.
- Asset level Net Zero Carbon standards and any verification scheme requirements.

Links with Other Industry Programs

ConstructZero

Construct Zero is an action plan for the construction industry and includes a performance framework highlighting and measuring industry progress towards carbon reduction outcomes on a quarterly basis.

By taking action against Construct Zero, the construction industry should be reducing its carbon footprints, with overall sector progress validated via regular updates of the Roadmap as the overall sector's carbon footprint reduces over time.

Carbon Zero: Professional Institutions' Climate Action Plan

The CIC Climate Action Plan coordinates the efforts of the professional institutes in the built environments in meeting the Net Zero. The Roadmap Stakeholder Action Plans compliment and are coordinated with the Action Plan.

Stakeholder Engagement

Stakeholders can use the Roadmap and Stakeholder Action Plans to understand the key actions, policies and milestones that need to be undertaken to deliver a net zero built environment, and how different interventions interact on the decarbonisation pathway.

The Stakeholder Action Plans provide a resource to industry bodies, trade associations, and professional institutions, with the intention that these are developed, refined and embedded within industry activity.

Future Research

The following areas have been identified through the process as benefitting from further research and analysis:

- Embodied carbon of retrofit (i.e., embodied carbon impacts of the domestic retrofit programme and mitigation opportunities)
- Material design efficiencies per building sector and design package
- Decarbonisation plans for key construction supply chains

Call to Action

The Roadmap is a resource for the sector that establishes urgent priorities and actions for decarbonisation. Achieving the net zero 2050 target is feasible, but will require a transformative shift in industry practices, as well as Government policy and investment into key delivery programmes and technologies.

A new context for addressing the climate emergency has emerged that is moving radically faster than previous years, with drivers towards net zero increasingly being put into place by Government, industry, financiers, occupiers, and the wider community.

Extensive collaboration and efforts will be required to deliver the net zero scenario, but the science is clear on the dangers of failing to act. Everyone must play their part and while the work is only beginning, the path forward is clearer than ever before

Acknowledgements

Project Team

UKGBC Project Team & Technical Partners

- **Alex Green** – Stakeholder Engagement Lead, UKGBC (seconded from BPF)
- **Alexandra Jonca** – Project Officer, UKGBC
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With special thanks to the Chairs for helping lead the Task Groups.

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- **Property Market Analysis LLP**
- **UK Warehouse Association**
- **Structural Timber Association**
- **Timber Trade Federation**
- **Climate Change Committee**

The organisations listed above within Steering Group and Task Groups provided pro-bono support to the project through donation of time. This acknowledgement does not imply endorsement of all aspects of this report, which have been arrived at through a collaborative process. The proposals put forward in this report may not reflect the views of all participants.

Endnotes

1 BEIS Energy and Emissions Projections: (https://www.gov.uk/government/collections/energy-and-emissions-projections)

2 BRE Trust (2020). The Housing Stock of The United Kingdom. Available at: https://files.bregroup.com/bretrust/The-Housing-Stock-of-the-United-Kingdom_Report_BRE-Trust.pdf

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QUESTIONS AND FEEDBACK

We welcome input from any interested stakeholders from across the building value chain on the content of this guidance and any future revisions.

If you have any questions on this guidance, or would like to provide feedback, please email ANZ@ukgbc.org.

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