The Institution of Engineering and Technology

Decarbonising the Built Environment

Guide for decision makers

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Contents

Decarbonising the Built Environment **is published by the Institution of Engineering and Technology (IET)**. Written with the participation of Dr. Richard Miller, in collaboration with the Built Environment and Energy Panels of the IET.

Please note that the views expressed in this publication are not necessarily those of the IET. The guide only intends to identify the relevant issues and to inform a public policy debate around the topic, rather than to provide a definitive solution.

The IET's Built Environment, Design and Manufacturing, and Digital panels would welcome any comments you may have on the contents of this guide and your ideas for future publications. Please get in touch by emailing **policy@theiet.org**.

The Institution of Engineering and Technology

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1. About this report

This document gives an overview of the key points involved in developing strategies for decarbonising buildings and identifies opportunities for the engineering profession to develop solutions. This report is for decision-makers and others who need an overview of the issues.

The growing issue of climate change is developing greater resonance in the public imagination. Consequently, governments are developing plans to cut the carbon emissions that drive climate change and adapt to inevitable warming.

The built environment causes some **40% of the UK's carbon emissions** and **28% of global emissions**. There is no path to the 2050 net zero targets without tackling buildings.

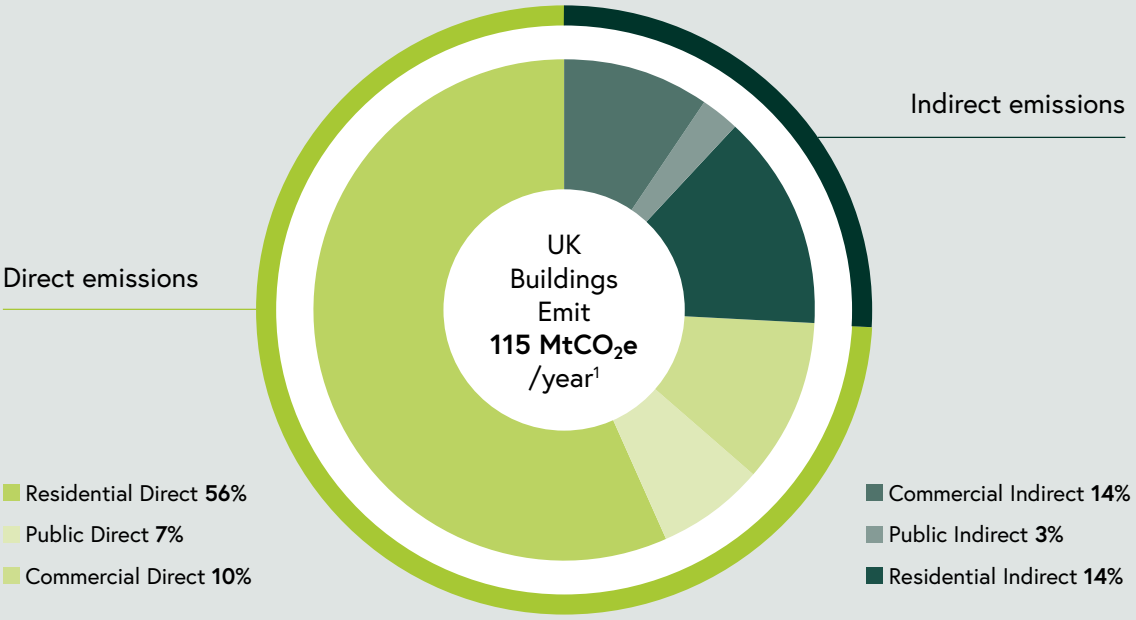
2. Embodied and operational carbon

Buildings contribute carbon emissions throughout their life-cycle, from construction and use to demolition and disposal. Carbon emissions come in two forms:

- Carbon embodied in the materials used in the building and the energy used in construction, renovation and demolition.
- Carbon from energy used in the day-to-day operations of the building.

Embodied carbon in buildings represents about **17% of UK emissions** and **11% of global emissions**. Operational carbon emissions from day-to-day activities are approximately 23% of UK emissions and 17% of global emissions. Embodied carbon will become a larger part of the problem as we decarbonise energy and heat supplies. Currently, **73% of operational emissions are direct**, using gas and other fossil fuels for heating and hot water, and **27% are indirect emissions** from electricity use.

To achieve net-zero, we must eliminate or offset both embodied and operational carbon for buildings. For existing buildings, the embodied carbon is a sunk cost. Therefore, we must reduce operational emissions to zero and ensure that any upgrades and retrofits target zero embodied carbon. For new builds, the goal must be net-zero for both embodied and operational carbon.



[1] The Climate Change Committee, The Sixth Carbon Budget: Methodology Report (2020), Ch.3 - Buildings, pp 86 - 89.

3. Approaches to eliminating embodied and operational carbon emissions

To achieve a net-zero built environment, we must tackle both embodied and operational carbon emissions.

Eliminating embodied carbon

The earlier you examine embodied carbon, the greater the amount you can save.

There is a simple hierarchy of options, starting with the most significant savings:

- Build nothing – challenging the need for new construction.
- Build less – repurposing and refurbishing existing buildings.
- Build clever – reduce the amount of material used, switch to low-carbon materials, and minimise emissions from site operations.
- Build efficiently – embrace new construction techniques to minimise waste energy use.

The first two approaches affect planning and design. Digital twins, Building Information Modelling (BIM) and other modelling tools are making it easier to consider and plan for alternatives to new construction.

Building cleverly and efficiently requires more engineering innovation.

Eliminating operational carbon

To tackle operational carbon, we must eliminate both direct and indirect emissions. A key challenge for the UK is that energy needed for heating peaks in the winter, at six times the electricity demand of the summer.

Electrification of heat is one approach. The carbon intensity of the UK grid should reach net-zero by the mid-2030s. However, the higher winter heat demand means we cannot easily electrify everything. Instead, we must reduce the energy demand of buildings.

To reduce operational carbon emissions, we can:

- Reduce building demand:
  - Cut consumption – through behavioural changes and more efficient use of energy.
  - Improve the efficiency of the building envelope – reducing losses and improving ventilation control.
- Decarbonise the energy supply to buildings:
  - Use net-zero electricity – more renewables, better storage and local power-sharing.
  - Use net-zero heat – electrification, heat networks and blue and green hydrogen.

There have been successful demonstrations of operational carbon reduction strategies:

- Combinations of price signals and smart building technologies reduce consumption.
- The design principles for highly efficient building envelopes are well understood and used in new build and retrofits.
- The carbon intensity of electricity grids is dropping quickly, with renewables being the lowest-cost solution for new capacity worldwide.
- Heat pumps are slowly increasing their market share. Together with district heat networks, these are the main solutions for the UK.

4. Scaling up - market barriers and trends

It is technically possible to deliver zero-carbon buildings today. However, it is not happening at the speed and scale required. There are barriers to wider deployment of zero-carbon building solutions, but also positive trends that are shifting the market.

The key reported barriers are:

- Lack of customer demand – without regulatory mandates, net-zero is a 'nice to have' option. Not helped by the perception that the cost accrues to the individual, but the benefits to society.
- Lack of strong government policy – they accept the need for net-zero, but are reluctant to mandate the changes.
- Perceived or actual cost – costs, particularly capital costs, are a significant barrier.
- Perceived or actual risk – as with any innovative construction methods and technologies, customers, suppliers and sources of finance are reluctant to take on that risk.
- A lack of trusted evidence and information – with few reliable sources of information, suppliers and customers lean on traditional approaches.
- Lack of supply chain capacity and skills – zero-carbon buildings require new skills which are in short supply.
- Inadequate technical solutions –available technical solutions fall short in performance or economic viability.
- Lack of financing – it is difficult to raise funding for net-zero buildings.

There are also positive market trends:

- Driven by Environmental, Social and Governance (ESG) policies, tenants and users of non-domestic properties demand low-carbon and net-zero buildings.
- There is increasing pressure on UK domestic rentals, both private and social, to cut carbon emissions.
- In the UK, the public's awareness of climate change is rising. Around 80% of the population is concerned about climate change and supports a net-zero transition.
- The economic potential of reducing building emissions has become a hot topic. The EU estimates a net-zero buildings strategy will increase GDP by 1% and create 1.2 million new jobs.

5. Engineering opportunities

The engineering professions can be at the heart of clearing the logjam and smoothing the path to net-zero.

Their influence will be strongest when new design and technology come together to reduce the barriers and support positive market trends. There are two potential areas of engineering opportunity:

- **Technological innovation**, improving individual components and subsystems.
- **Systems approaches** providing integrated solutions.

Technological Innovation

We do not need radical technological innovation. We have the technologies required to decarbonise the built environment, but there is substantial room for incremental improvement. Engineers can take existing technologies and:

- Reduce cost
- Improve performance
- Improve manufacturability and reliability
- Tackle ease of installation, use and maintenance
- Design for remanufacture and recycling

Areas for innovation include:

- Energy-efficient building envelopes
- Improved heating systems
- Net-zero energy systems
- Digital everything.
- Reducing embodied carbon

Systems approaches

A constant theme in this study is that decarbonising the built environment is not mainly a technology problem, but a systems problem. We have the core technologies required for full decarbonisation. We can make those technologies more efficient and reliable, with lower upfront and operational costs. But that is not the main barrier to wider deployment. Our core problem is creating integrated systems that improve efficiency and reduce carbon emissions. So we should encourage and support greater levels of systems thinking in construction, from individual buildings to neighbourhoods and cities.

Systems thinking is better established in other industries; for example, energy, automobiles and some aspects of transport. We need a transfer of knowledge into the construction sector, adapting it to the specific needs.

We need a new breed of designers, engineers and installers who understand the latest technologies and how they go together. This means upgrading skills in the sector and a more multidisciplinary approach.

The existing business models within the sector are a barrier to a holistic approach, with fragmentation a constant problem. The way procurement methods, contracting and subcontracting practices, and how responsibility & liability are managed throughout a project, all make a systems approach difficult. The Better Building Partnership[2] has drawn attention to the problem of 'design for compliance' instead of 'design for performance'. Coupled with the tendency of individual specialisations to carry out value engineering that compromises the design intention, the ambitions of clients and users are not met in practice.

[2] https://www.betterbuildingspartnership.co.uk

6. Recommendations

A single player cannot deliver decarbonisation of the built environment. Progress relies on breaking down the walls between existing silos and reconfiguring relationships across specialist sectors. Decarbonisation creates new connections between subsystems. Building fabric, ventilation, energy use and user habits interact in new ways in a low-carbon building. The traditional breakdown of tasks and responsibilities is no longer viable.

Therefore, an overarching recommendation is to:

Develop new relationships and understanding between the built environment groups involved in creating, using, and disposing of buildings. If they were to improve their leadership role, trade and professional organisations could play a key part in fostering a fresh decarbonisation approach to structures. Government, innovation funders and the education base should support them.

Specific recommendations

Policy

The Government should set a clear policy for the transition of the built environment to net-zero by 2050. The policy should be:

- Consistent and long-term – it should not undergo constant change.
- Outcome oriented – the policy should describe the desired outcome and how it should be measured. It should not specify the solutions to allow space for unexpected innovation.

The Government needs help to develop the policy from trade and professional associations and the research base.

Technological innovation

Decarbonising the built environment requires innovation. We understand the technical solutions but need innovation to render those solutions practical and cost-effective. Areas ripe for innovation include:

- Packages of technologies that work together effectively – guaranteed 'kits of parts'.
- Improvement of existing technologies to deliver:
  - Easier installation.
  - Simpler operation and maintenance.
  - Lower cost.
  - Reduced hassle for buyers and users.
- Fully exploiting the digital revolution – from initial design through construction to operation, digital technologies can improve carbon efficiency.
- Scaling down powerful solutions – we have technological solutions for large projects. These provide lower costs, faster delivery and improved performance. We must make Building Information Modelling (BIM), Building Management Systems (BMS), building modelling and smart systems viable for every project, from a domestic retrofit to a new office block.

Innovation can be supported by:

- Government – providing development funding and ensuring policies and rules do not hinder innovation.
- Innovation funding agencies – supporting both early stage R&D and commercialisation.
- The research base actively looking for commercial solutions.
- Intermediate agencies – acting as facilitators to novel approaches.
- Professional and trade associations – promoting the opportunities, providing appropriate CPD and linking users, innovators and funding sources.
- Innovators and entrepreneurs – responding to the opportunities with practical solutions.

New business models

Existing construction business models promote silos making them barriers to information flow and collaboration. We need to rethink this.

There are several opportunities:

- The emergence of new types of integrators:
  - People who pull together packages of technologies that work together to deliver net-zero in a single building.
  - People who understand how to link groups of buildings together to take advantage of their resource generation capabilities and needs, and extending that into neighbourhoods, cities and nations.
- Learning more effectively from other industries. Work on Modern Methods of Construction has begun the industrialisation of the construction sector, but take-up is slow. Current business models are a barrier.
- Designing new ways of paying for the benefits of the built environment. The idea of heat or comfort as a service has been explored in the Energiesprong[3] approach and in the Smart Systems and Heat[3] demonstrator programme. Changing how we pay for the services of the built environment unlocks low-carbon opportunities.

[3] https://energiesprong.org
[4] https://es.catapult.org.uk/case-study/smart-systems-and-heat

The development of new business models should be:

- Encouraged and supported by government policy – the role of the regulators is vital.
- Encouraged and supported by the professional and trade organisations – alerting innovators to the opportunities.
- Explored by the research base.
- Supported by pump-priming funding from government and innovation agencies.

Marketing and information

With changes to design, materials and components, everyone involved must understand how they work. Designers, installers and customers must know that a heat pump is not a gas boiler. It behaves differently and is installed and operated differently. Buildings cannot deliver their promises if we don't communicate the differences effectively.

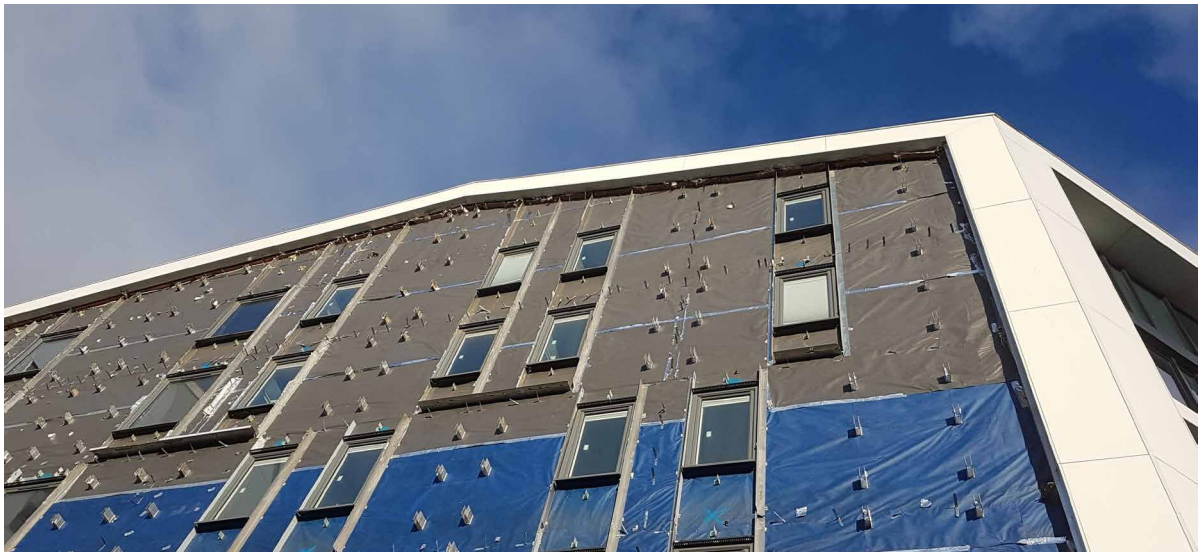
There is also a need for trusted information on how different solutions perform and how to integrate them. The relevant professional and trade associations should collaborate to collate and spread this information. The Construction Leadership Council[5] could act as the focal point. This is not only a technical task, but a marketing task to reach all interested parties.

Skills and education

The transition to net-zero touches every aspect of the built environment. The current system allows specialist teams to operate independently, not understanding their part in the whole.

The education system and the professional and trade associations should work together to encourage systems thinking at every level. Suppliers and installers need to understand how their components and subsystems fit into efficient operation of the building. Building designers and planners must understand how the building will integrate into local and national infrastructure.

We must develop a workforce which lifts its eyes to broader horizons.



[5] https://www.constructionleadershipcouncil.co.uk

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We are the IET – a charitable engineering institution with over **158,000 members** in **150 countries** – working to engineer a better world.

Our mission is to inspire, inform and influence the global engineering community to advance technology and innovation for the benefit of society.

As a diverse home across engineering and technology, we share knowledge that helps make better sense of the world to solve the challenges that matter. It is why we are uniquely placed to champion engineering.

We bring together engineers, technicians and practitioners from industry and business, from academia and research, and from government and the third sector. We are member-led, independent and impartial.

We cover engineering across industry from design and production, digital and energy to healthcare, transport and the built environment. We bring together expert practitioners from the built environment industry, academia and third sector.

We champion engineers and technicians working in the sector by offering networking, volunteering and thought leadership opportunities. Together, we campaign on issues of the day and provide policy input to government.

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