Circular construction

What impact can circularity have on decarbonising the built environment?

April 2024

Contents

The challenge facing the construction sector is how to build more and emit less. Construction must continue despite its considerable environmental impact. Material manufacturing is a heavy emitter and recycling doesn't drive improvements compared to other waste streams. Reusing materials could significantly support net zero goals, but it is costly and there are other commercial obstacles. Whilst we foresee these challenges easing, stakeholders should take action and prepare for change immediately.

To overcome these challenges, businesses in the construction sector should take action and embed circular approaches to deliver on their net zero ambitions.

"Circular approaches can be applied to any sector, but deploying circular approaches in the built environment is particularly important because of the lifespan of building stock and the significant contribution of the extraction and processing of materials used in the sector to global emissions. By implementing circularity there is a unique opportunity to lock up emissions for the long term and respond to social needs for quality affordable housing at the same time.

The sector as a whole has been slower to implement circularity compared to other product categories due to a number of regulatory and commercial barriers. However, we are already seeing new technologies and evolving business models provide an opportunity to find where economic and environmental value converge."

Melissa MacEwen
Circular Economy Lead Asia Pacific, PwC

Executive summary

The built environment, inclusive of the products and services involved in the construction and operation of buildings, contributes roughly one third of UK and global emissions. Approximately three-quarters of these emissions are 'operational' (primarily driven by heat and electricity usage in buildings) with the remainder driven by emissions 'embodied' in the materials, equipment and services generated in the construction phase. Actual jobsite emissions are typically less than 1%.

37% reduction in built environment emissions between 1990 and 2018

The UK has made progress in reducing built environment emissions, generating a 37% reduction from 1990 to 2018.[1] The majority of this progress has been achieved through reducing operational emissions via improvements in heating efficiency and insulation, supported by decarbonisation of the energy supply. Short to medium term investment in decarbonisation will continue in these areas (e.g. retrofitting heat pumps).

Despite these improvements, achieving net zero requires the sector to confront embodied emissions (of which c.60% are produced in the extraction and manufacturing of materials such as steel and cement).[2]

60% of embodied emissions in the construction sector are produced in the extraction and manufacturing of materials

Increasing recycling is one way to tackle embodied carbon, but it has relatively low levels of impact; it is already common in these processes, and the intensity of the underlying steel and cement production process is not reduced by recycled content to the same extent as consumer packaging (e.g. PET bottles). Emissions reductions in these processes will require significant investment in carbon capture and a transition to alternative production methods (such as electric arc furnaces), alongside the widespread adoption of green energy sources.

Circularity through reuse is another way to tackle embodied carbon. Examples include the retrofit of existing structures, or the reuse of steel beams, floor tiles and paving blocks from demolished buildings.[3] However, the return on investment for this approach often does not stack up, especially when considering the reuse of whole building materials.

The key barrier is a lack of commercial incentive, primarily due to uncertainty in carbon pricing, and clarity on who should pay. Historically, landfill tax increases were a success in providing certainty on the quantum and timing of price increases.

Whilst the 'winning' solution was unknown, it created an inflexion point in the market at which point diverting waste from landfill became more viable. In turn, investors, financiers and firms began to invest in alternative waste paths. Reducing embodied emissions in the built environment relies on this commercial clarity, particularly for landlords and other investors.

Alongside commercial considerations, there are also barriers associated with regulation (an ever-increasing complex set of regulations, a lack of certification of reused materials, a lack of requirement to report). Our latest CEO survey indicated that UK Industrial Manufacturing and Automotive CEOs believe decarbonisation is held back by a lack of demand from external stakeholders and a shortage of climate-friendly technologies.

Finally, materials reuse is inherently complex and requires a system wide solution across the value chain, from 'designing for deconstruction' to the integration of a waste management value chain. This shift will have to be enabled by the development of digital tools such as material passports, to build confidence in second-hand materials.

To enable decarbonisation in the built environment, circularity through reuse must be prioritised. But this is only going to be possible if government and other regulatory agencies establish a set of commercial incentives that will create a framework for investment. Sector players must prepare for this situation as, without this, the UK's ambition of reaching net zero will not be achieved.

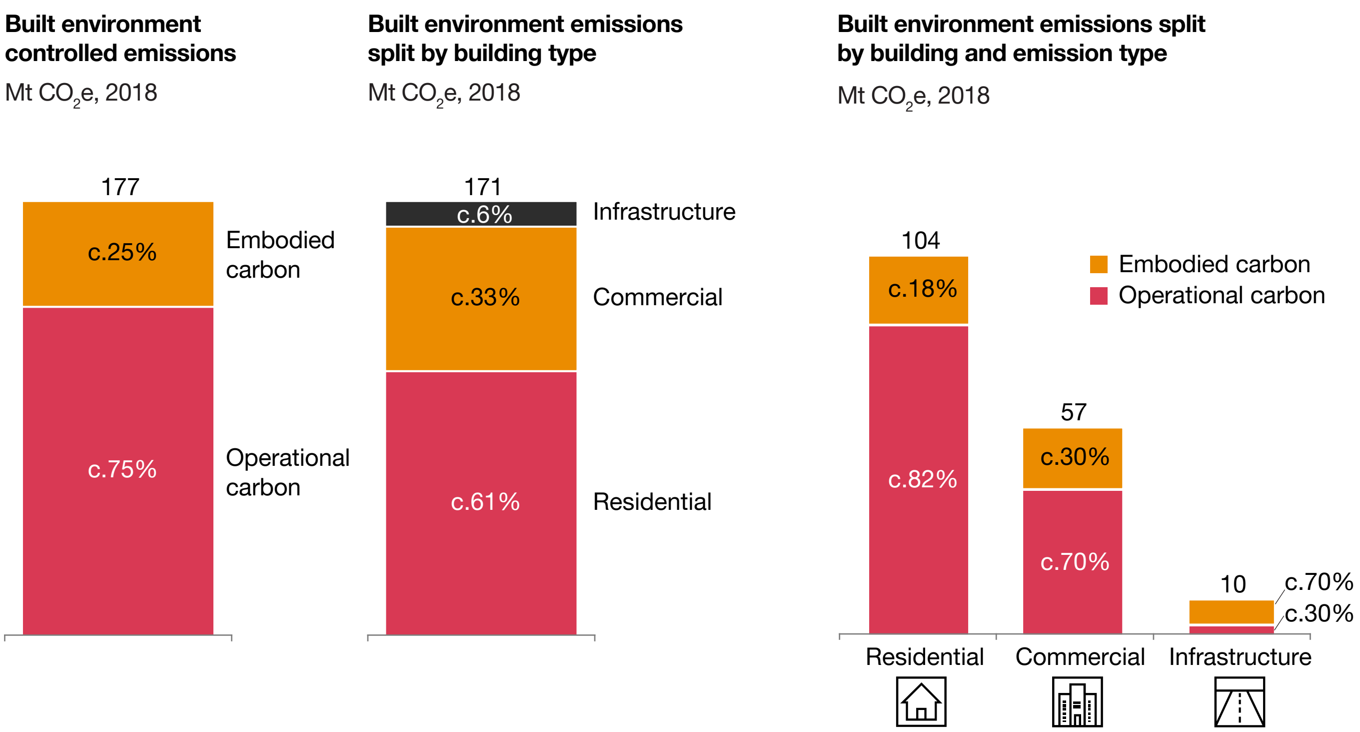
Carbon in the built environment: build more, emit less

Globally, the built environment (encompassing the construction and the wider operation of buildings and infrastructure) contributed c.39% to total global emissions in 2019, and roughly one third in the UK.[4] Residential and commercial buildings make up 61% and 33% of this respectively with the remaining 6% being in infrastructure.

Three quarters of all emissions from the built environment are driven by the 'operational' life of the building. This includes heating and electricity demand which is driven by the efficiency of a building to generate and retain heat (through insulation and double glazing), the efficiency and usage of appliances and lighting, and the emissions produced by the underlying energy source (renewables or fossil fuels).

The remainder of emissions are referred to as 'embodied' and are driven by the materials, equipment and services that are used and generated in the construction phase of a building. The majority of this (c.60%) is driven by materials such as steel and cement, followed by usage of the construction plant and machinery (c.30%). We provide more detail on the source of these emissions in the next chapter of our article.

Figure 1: UK greenhouse gas emissions by sector and in the built environment



Notes: Analysis does not include operational F-gases
Source: UK Green Building Council (UKGBC)

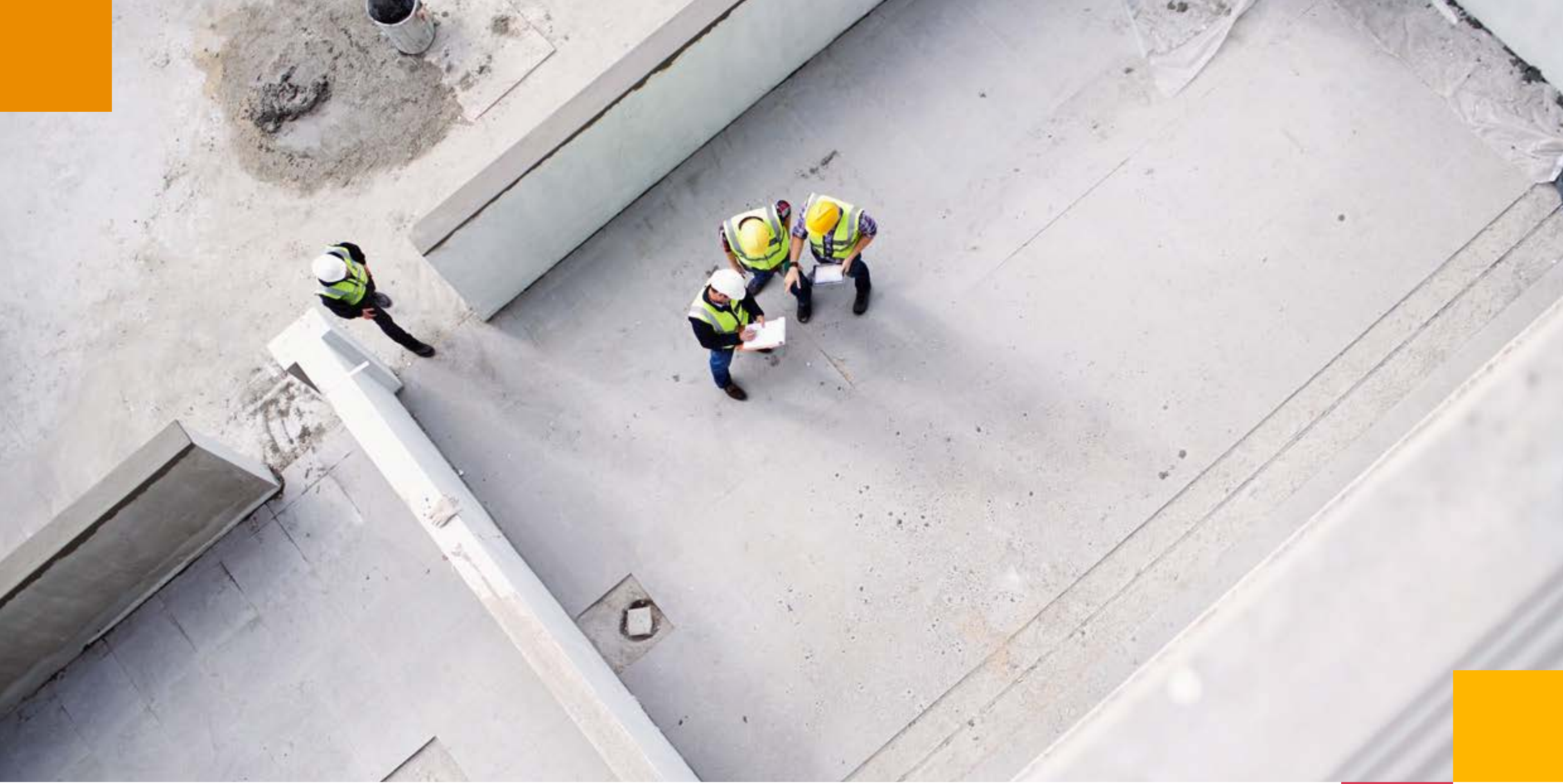
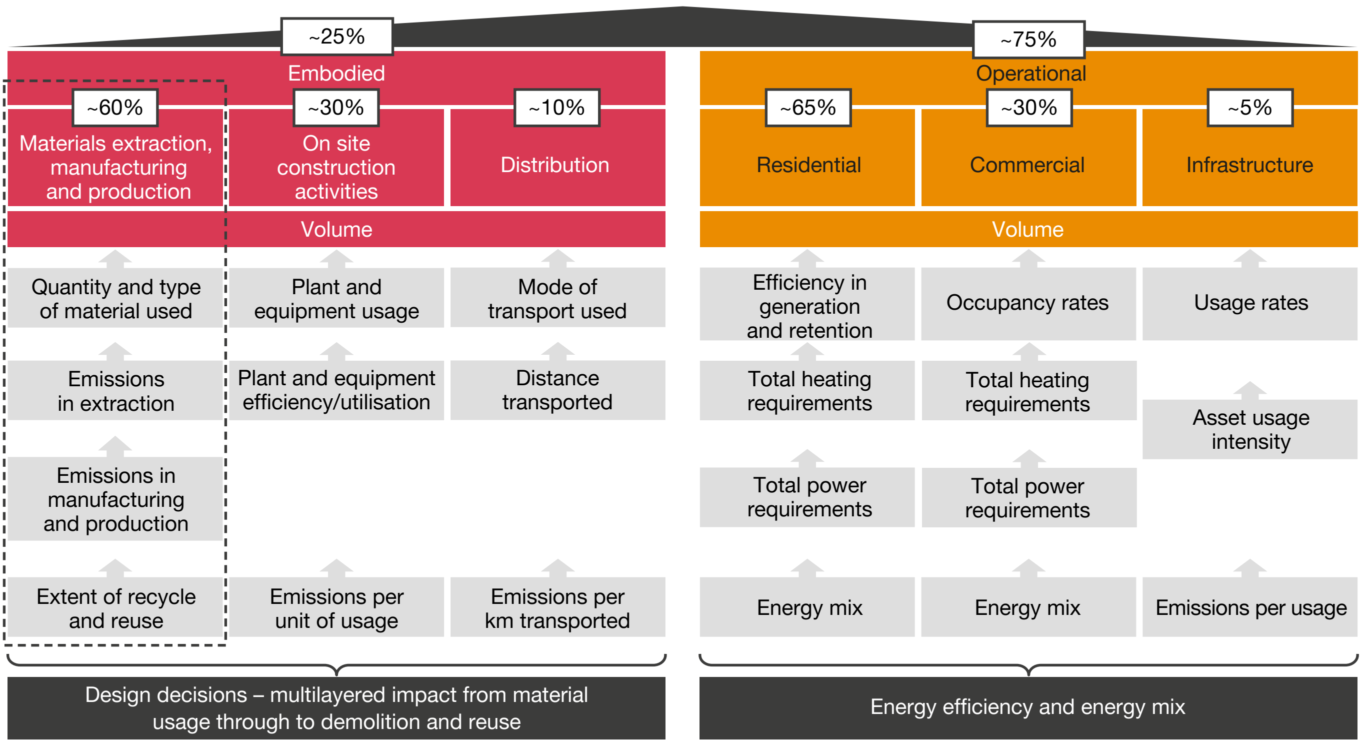


Figure 2: Drivers of CO_2e in the built environment

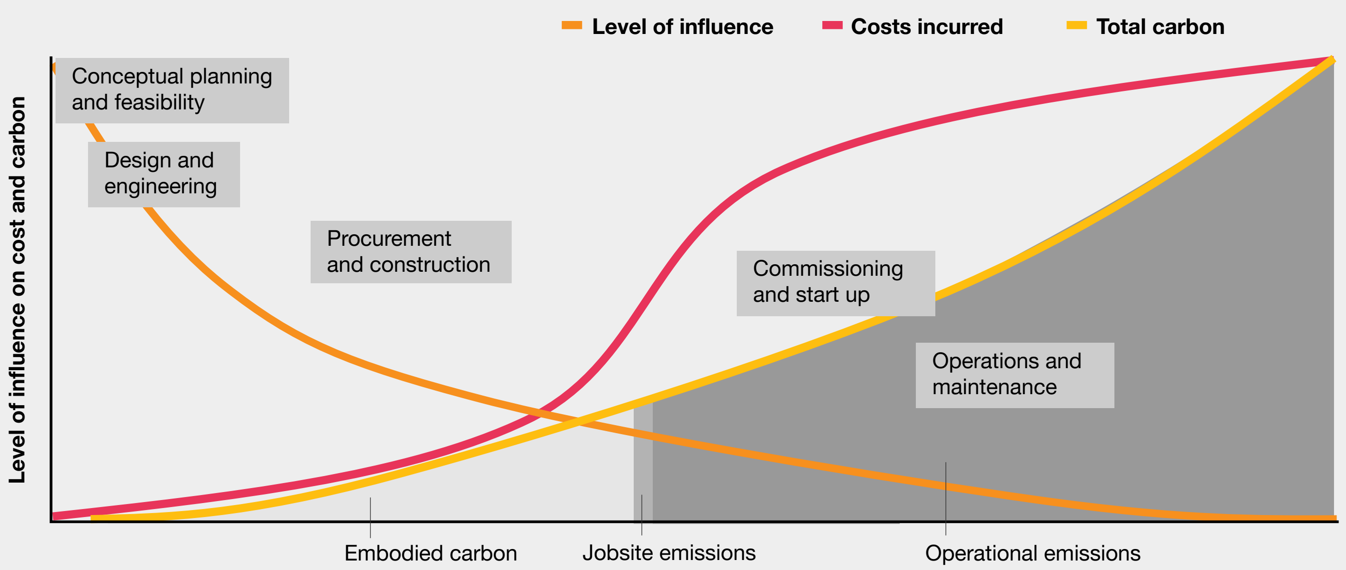


Source: UKGBC, Strategy& Analysis

The chart below shows the stages of the building lifecycle and the point at which the different emissions are realised. The ability for businesses in the construction sector to influence the carbon emissions of a given building decreases over time.

The most critical decisions are taken in the planning and design phases of the lifecycle.

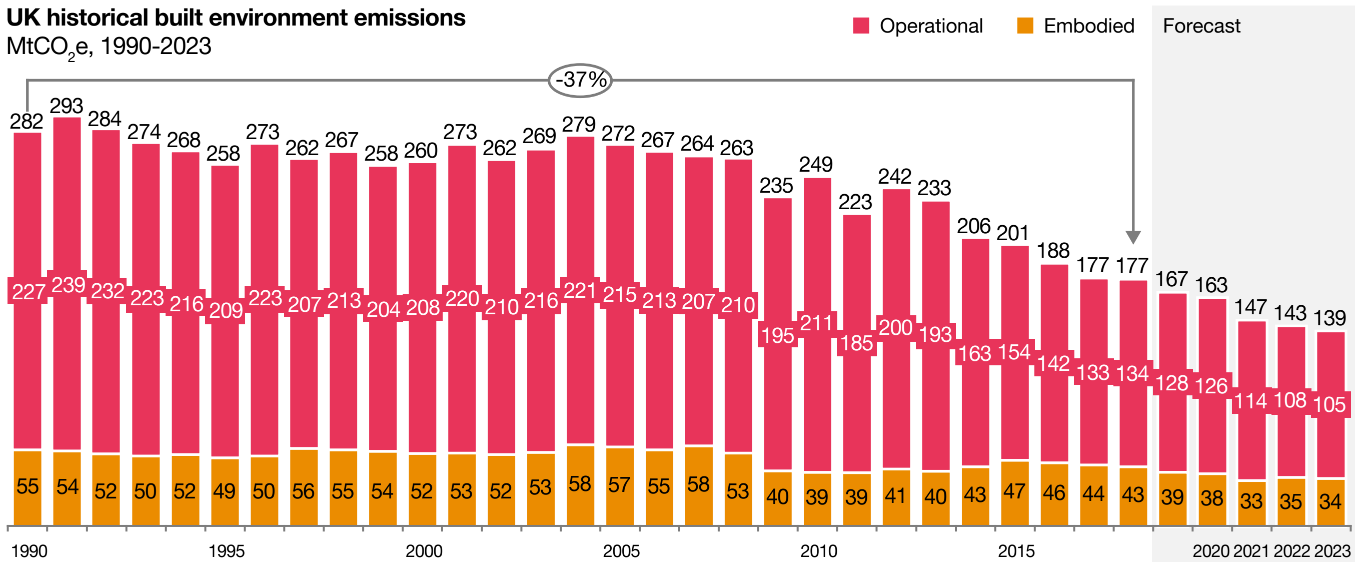
Figure 3: Ability to influence costs and carbon over the building lifecycle



Built environment emissions in the UK have fallen by 37% from 1990 to 2018.[5] Progress has been driven by a 41% reduction in operational emissions, and a 22% reduction in embodied emissions.

This has been driven by advancements in the UK energy grid (and a transition away from coal power), the extensive retrofit of insulation, double glazing and heat pumps, more energy efficiency lighting technology, and the installation of photovoltaic capacity.[6]

Figure 4: Historical built environment emissions, 1990 – 2023



Source: UK Green Building Council

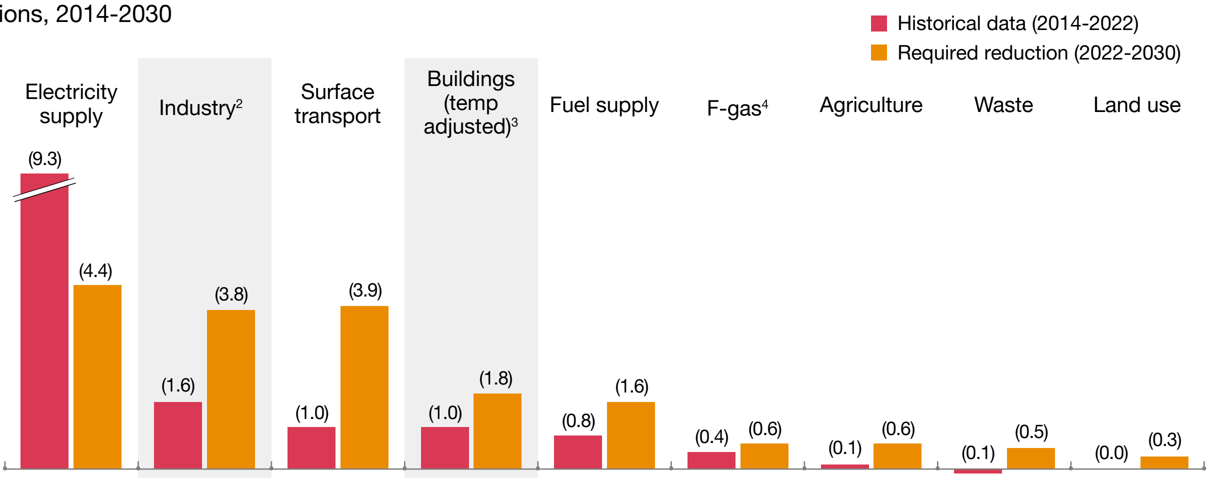
Despite this progress, reaching net zero is still an ongoing challenge for the UK built environment.

Illustratively, UKGBC data suggests that the UK built environment emitted c.1,000 tonnes of CO_2 equivalent emissions for every £1m of new construction output in 2021.

If the built environment was to reduce emissions in line with the overall UK government 2035 target of 78% (vs. 2019), and assuming that construction output grows at 1.5% per year to 2035 (historical rate of growth 2002 – 2021), emissions per £1m of output would need to reduce by more than three times to c.350 tonnes[7] (this estimate is lower than that of UKGBC and is likely to exclude emissions embodied in material).

Figure 5: UK historical emissions reduction by sector compared to reduction required to hit 2030 targets

Change in emissions per year to meet UK 2030 targets[1]
$MtCO_2$ Emissions, 2014-2030



	Electricity supply	Industry	Surface transport	Buildings (temp adjusted)	Fuel supply	F-gas	Agriculture	Waste	Land use
Total emissions ($MtCO_2$, 2019)	52	105	115	89	39	17	52	31	10
Annual % decrease needed to hit 2030 targets	13%	8%	4%	2%	5%	4%	1%	2%	3%

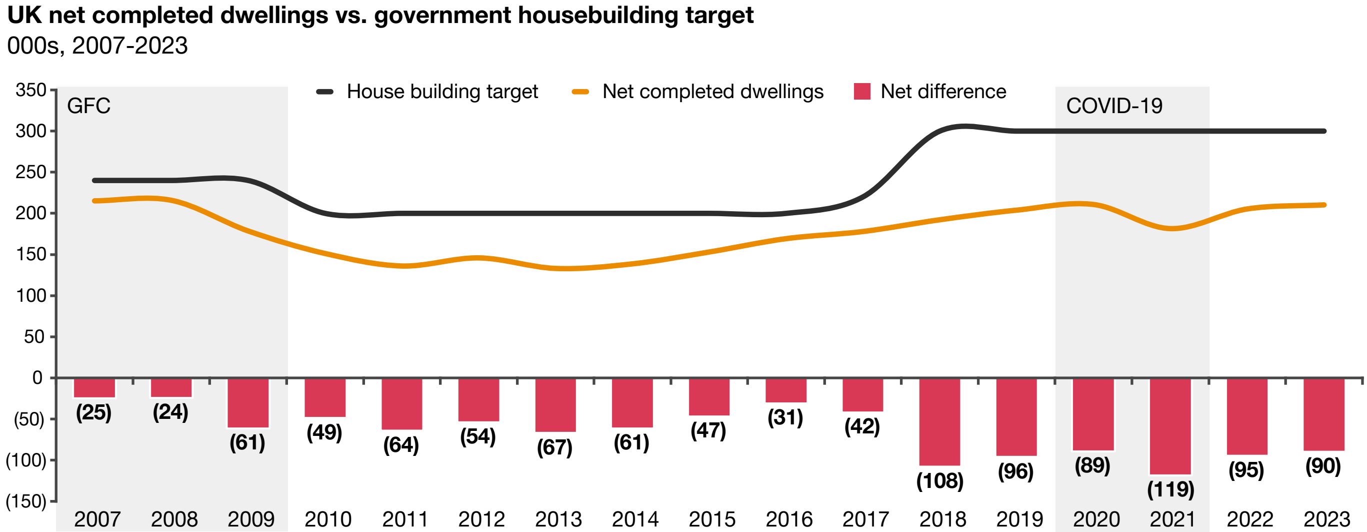
Notes: 1) Excludes emissions from aviation and shipping due to the impact of COVID; 2) Industry includes manufacturing and construction; 3) Buildings includes heating and domestic energy use; 4) F-gases are fluorinated gases

Source: UK Climate Change Committee

This challenge is likely to become more difficult as new construction output stabilises and grows in the coming years as indicated by our recent report on 'Construction and Housebuilding Outlook'[8] that forecasts growth from 2025 stimulated primarily by housing stock.

One particularly acute tension is in housebuilding, where the UK faces a chronic shortage of housing, and in particular affordable housing.

Figure 6: UK net completed dwellings from 2007-2023 and UK government housebuilding targets



Source: UK Government, ONS, Strategy& Analysis

Housebuilding has declined in the UK since the 1970s. The number of completed dwellings has decreased by c.44% from 1970-2023 and net completed dwellings has not met UK government housebuilding targets since before the Global Financial Crisis. This is especially dramatic within the affordable home segment.

Recent analysis in the wake of COVID-19 has suggested converting unused commercial space into residential space to help to alleviate the situation. However, whilst office vacancy rates have climbed from 5% to nearly 10%, retrofitting this space alone will be insufficient.

Assuming that 100% of vacant office space was converted to residential, it would only generate c.6% of the UK government's target for the year of 300,000 dwellings (based on an average size of 650 sqft per dwelling).

To meet these targets, increased construction is essential. But, with an uptick in new dwellings, the associated emissions resulting from construction will also increase.

The Science Based Targets Initiative's (SBTi) own estimate suggests that total floor area is set to grow approximately 75% over 2020-2050, driving a potential dramatic increase CO_2 emissions if no material decarbonisation efforts are made in the sector.

Therefore, participants in the built environment face opposing pressures: to keep pace with underlying demand for construction, whilst also revolutionising traditional business models to decarbonise.
This requires careful thought and considerable levels of investment.

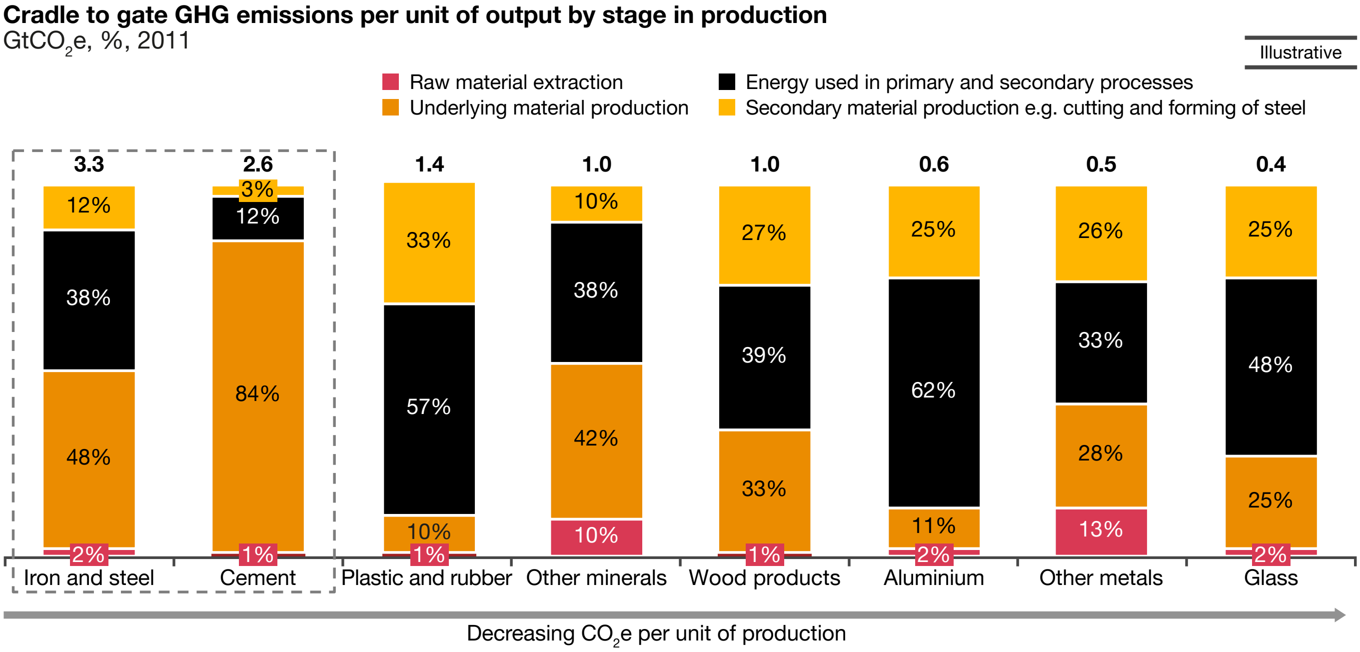
Embodied emissions: the next challenge

Considerable progress has been made in operational emissions to date, and this remains a critical carbon reduction lever going forward. According to UKGBC analysis, to reach net zero by 2050 the UK needs to end sales of fossil boilers by 2030, decrease average dwelling energy intensity by 60% by 2040, install 23m heat pumps by 2040 (covering 80% of all UK homes), and install standard capacity (4kW) domestic photovoltaic capacity in one in four houses[9].

We expect significant investment to be focused in this area with respect to existing buildings. However, to achieve net zero in the built environment, the sector must reduce the embodied emissions that are contained in new buildings, and the focus will be on materials.

> “
> The construction sector must find a way to both deliver the buildings our economy and society needs, and achieve its net zero ambitions. Taking a circular approach to tackling embodied emissions will be crucial.”
>
> **Chris Temple**
> Net Zero Transformation Leader, PwC UK

Figure 7: Embodied emissions by material and cradle to gate emissions of building materials

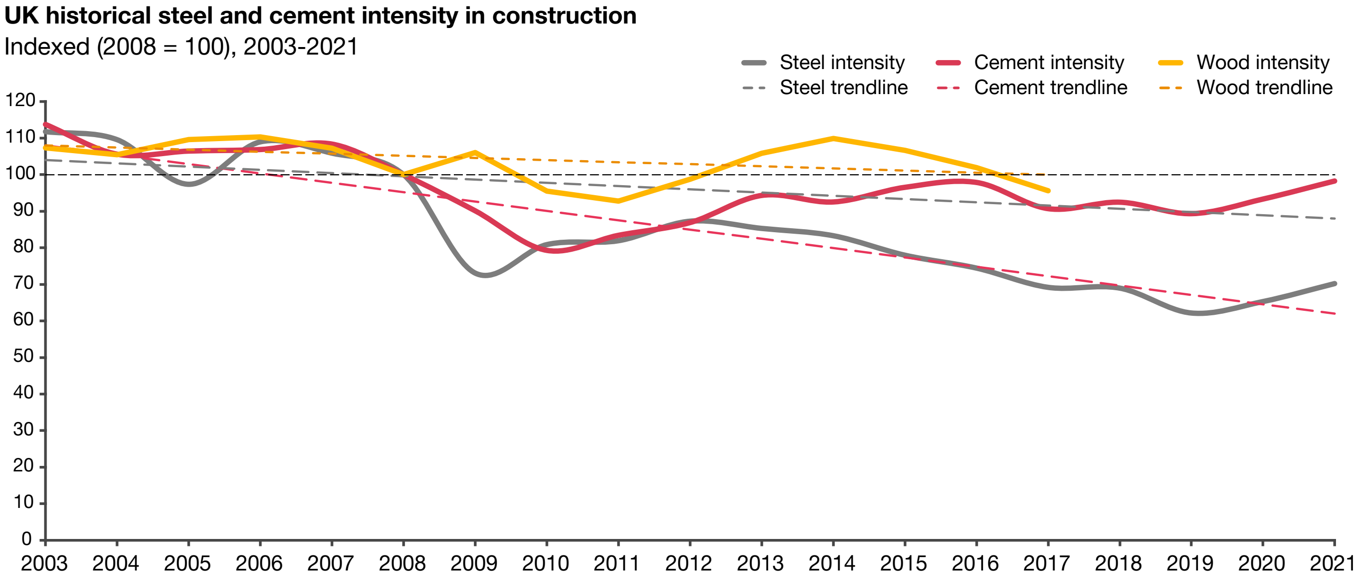


Source: UKGBC, Nature Geoscience: Increased carbon footprint of materials production driven by rise in investments

Cementitious products along with steel are the two biggest contributors to overall emissions in the UK and are included within embodied emissions. Steel is responsible for 2.4%[10] of total UK greenhouse gas emissions, whilst concrete and cement are responsible for 1.5%[11].

To date, realistic replacements for these two materials have not found. Therefore, to reduce these emissions, the sector can either use less of these materials per unit of output, or reduce the underlying CO_2e per unit.

Figure 8: Steel, cement, and wood intensity in UK construction[1]



Notes: 1) Methodology for UK wood apparent consumption changes in 2018
Source: Euroconstruct, Department for Business & Trade, World Steel Association, Forest Research UK

The usage of steel and cement has been in gradual decline over the last two decades, largely due to increased efficiency in using the materials and a gradual shift to material that has a higher strength-to-weight ratio. We have estimated that steel usage per unit of construction output has decreased 30% since 2008. This significantly improves efficiency, reducing emissions while still increasing construction output.

However, achieving net zero in steel and cement will rely on more than efficiency improvements, which are likely to only offset growth in production in a best-case scenario. Cement and steel production are highly carbon intensive processes, and opportunities for decarbonisation are primarily focused on carbon capture technologies and alternative production methods.

Cement production generates approximately five times the CO_2e of steel on a per unit of output basis. Approximately, 85% of emissions from cement are generated during its production, largely from chemical reactions involved in the calcination (in the manufacture of clinker), which directly emit CO_2e.[12]

In many consumer-facing markets, such as packaging, increasing the recycled content of a container is the primary lever for decarbonising. This is driven by the fact that the emissions generated from the chemical process involved in producing recycled input material (through grinding, washing and often pelletising waste) is lower than that of a virgin material (which generally involves a chemical reaction – e.g. for plastics, fractional distillation of crude oil and cracking of hydrocarbons).

However, recovering cement and using it in the primary production process of calcination is not possible. Aggregates recovered from building sites are already used in high quantities in secondary processes, such as the manufacture of cement. But the emissions in this part of the process are much lower.

Therefore, the fact that c.90% of hard construction and demolition waste is being recycled into aggregates has relatively little impact on carbon emissions in the cement production process itself, despite it reducing the waste added to landfill.[13] The most important lever for decarbonisation in cement production is investment in carbon capture and storage technology.

Steel is a slightly different story, but with a similar scale of challenge. Steel is primarily manufactured using two different technologies – blast oxygen furnaces and electric arc furnaces. In 2021 82% of UK steel was made using blast oxygen furnaces, with the remaining 18% using electric arc furnaces.[14] The proportion made from electric arc furnaces will increase as new investments are made at sites across the UK.

Electric arc furnace technology has enabled steel to be highly circular and reduce its carbon footprint relative to blast oxygen furnace steel. The main input material is scrap steel, which is then melted at high temperatures to be re-cast into steel. This is primarily used in long-steel production, most applicable to construction.

In the EU 90% of end-of-life stainless steel is collected and recycled into new products, including as feedstock for electric arc furnace production.[15] Circularity through recycling has therefore largely been achieved in steel production and, in a similar way to cement, decarbonisation is reliant on investments in the industrial heating processes, and on the investment in green power required to maximise electric arc furnace impact.

Installing electric arc furnace capacity saves 1.65 tonnes of CO_2e per tonne of steel produced, versus blast oxygen furnace technology.[16] However, converting to electric arc furnaces requires sizeable investment, with Tata Steel's new electric arc furnace costing £750m, backed by a £500m government grant.[17] Given recent steel industry dynamics in the UK (e.g. site closures at British Steel), investment of this scale is likely to be challenging at this stage.

A specific challenge that the UK faces in reducing these production emissions, is that the UK has relatively low levels of control over its steel and cement supplies. This reflects a wider issue of UK being a large net-importer of CO_2e emissions.

Given its lower levels of industrial capacity today, the UK imports approximately 45% of its emissions making it one of the largest emissions importers in the world today.[18]

Historically, 90% of cement has been produced domestically, however this has decreased since 2006 with 22% of cement now imported.

The share of UK steel demand met through imports was 54% in 2021, with upwards of 60% common pre-pandemic.[19] Consequently, the UK has far less control over the production processes and therefore emissions produced.

To see how the upfront procurement of green building materials will need to evolve please refer to the PwC report, Sustainable by design: a blueprint for sourcing green building materials.

Overcoming blockers to change in the built environment

Industrial Manufacturing and Automotive CEOs interviewed in PwC's recent CEO survey recognise the need to decarbonise. But, they are facing a number of blockers inhibiting decarbonisation; a lack of demand from external stakeholders, regulatory complexity, a lack of climate-friendly technologies and lower returns for climate-friendly investments.

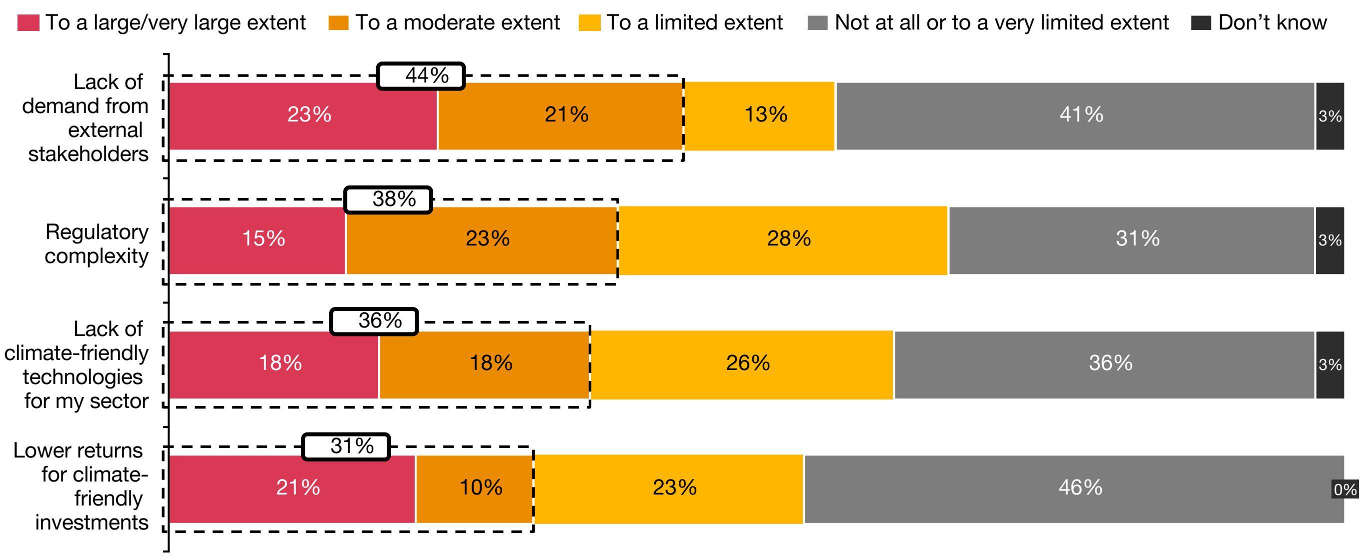
A lack of demand from those commissioning buildings for green products in construction, is broadly driven by the lack of incentive (or dis-incentive) that landlords (and other investors) currently face with regard to reducing emissions.

This is due to a mismatch in investment cost and payback. Building more energy efficient and environmentally friendly buildings does not necessarily result in higher sales or rental returns for landlords.

Despite it potentially leading to operating cost savings for the tenants (e.g. on lower maintenance or utility bills), these are not currently priced in, discouraging investment.

The price differential for an environmentally friendly building is referred to as the 'green premium'. Studies of a green premium in sales values vary drastically from 5% to 30%,[20] whilst others dispute the existence altogether, particularly for domestic rental properties.[21] This incentives mismatch is further exasperated by tenants' separate CAPEX and OPEX budgets, holding back energy saving initiatives, even when they are economically viable on a long-term basis.

Figure 9: To what extent, if at all, are the following factors inhibiting your company's ability to decarbonise its business model?



Source: PwC 27th Annual CEO Survey

Secondly, regulatory complexity and a lack of accountability of emissions reporting is currently discouraging circularity and alternative building materials.

The Carbon Emissions (Buildings) Bill currently being read in the House of Commons would mandate the reporting of whole-life carbon emissions of buildings and set limits on the embodied carbon emissions in construction. Alongside this, building regulations and standards, such as RICS[22] and LETI[23], are beginning to require upfront carbon assessment for the whole lifecycle of the building. As these regulations and standards emerge and whole lifecycles are considered, the pressure to introduce circular practices will increase.

However, there is no current requirement for reporting of emissions, or increasing recycling or reuse of materials. The lack of certification for secondhand materials is a particular barrier for circularity through reuse, particularly those used in a structural capacity, such as steel. Without a clear framework to document and grade materials depending on the previous use and current condition, designers and contractors may be reluctant to reuse them.[24]

Policymakers are exploring options to increase circularity through both standards and legislation as decarbonisation becomes more urgent. Policy suggestions range from fiscal incentives such as reducing the VAT on refurbishments to supporting standardisation and documentation of materials through material passports.[25]

Finally, a lack of climate friendly technologies and lower returns is further limiting investment into the sector.

As discussed above, the scale of investment required to enable decarbonisation of embodied emissions is significant, given the complexity and scale of technological advancement that is required. Investors and firms do not currently have the certainty in the future path to commit to these investments.

This is primarily driven by carbon pricing and at what point new low-carbon production methods will out-compete traditional high-carbon methods. Establishing an effective carbon price is the way to drive this behaviour and create a premium for high-carbon methods of production.

Example 1: Landfill tax

Introduced in 1996, landfill tax was designed to divert waste away from landfill towards more environmentally friendly options. From 2000 to 2021, local authority waste sent to landfill in England fell by 90%, making the tax widely considered a success.[26] A key feature of this success was the introduction of a duty escalator.[27] Introduced in 1999, the tax was increased to £10 per tonne and commitments were put in place to increase the tax every year by £1 per tonne for at least the next five years. These pre-planned increases have continued onwards.

The elements of the landfill tax that made it successful were a known price today and, crucially, commitment to a staircase going forward. This enabled investors to measure payback and the inflexion point for landfill vs. other waste destinations, and subsequently plan investment.

It is important to remember that a number of new technologies (e.g. Electric Vehicles, Wind Power, Incineration and Solar Panels or Photovoltaics) relied to some extent on subsidies or taxes to support initial adoption. Some evidence of these mechanisms are in place for construction materials.

Example 2: CBAM

The UK government has already announced that a UK Carbon Border Adjustment Mechanism (CBAM) will be implemented in 2027, mirroring the EU's transitional current scheme. This is a mechanism that protects local, lower-carbon goods, from international higher-carbon competition. However, it doesn't yet provide certainty over the future carbon price that the sector needs to stimulate the large-scale investments required.

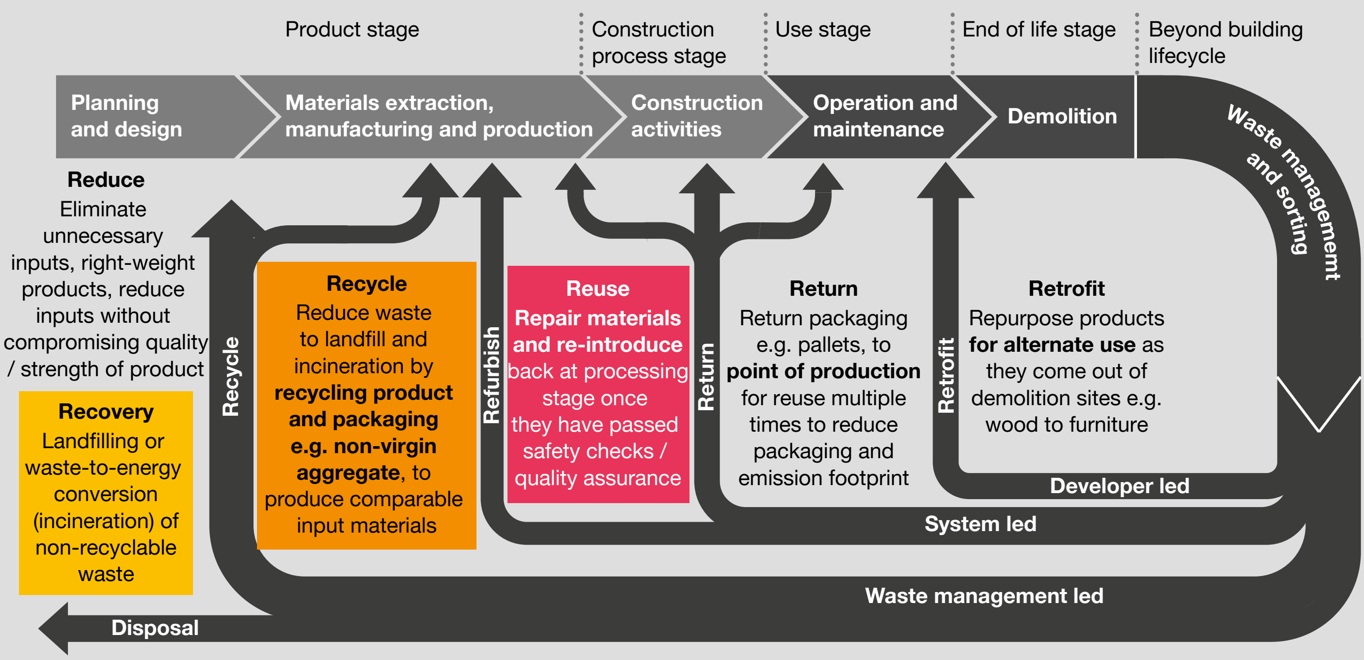
Circularity today: commercial opportunities

Despite the difficulties and limitations, research suggests that buildings and construction sector offers the greatest potential savings in material usage and greenhouse gas emission from circular strategies. With estimates suggesting a potential 57% reduction in materials usage and a 50% reduction in greenhouse gas emissions respectively (although more must be done if the built environment is going to reach a 78% reduction as mentioned earlier).[28]

The UKGBC has stated that 'the implementation of circular design principles is an essential part of the solution for a net zero carbon future'[29] and we believe a whole-value chain approach is required for this to be achievable.

There exist three primary levers – increasing the direct reuse of materials, collecting and recycling more construction waste, and designing for more efficient resource use.

Figure 10: A circular value chain in the built environment



Source: Strategy& Analysis

As a consequence of the high emissions from production and manufacturing, the built environment will need to lengthen the useful life of materials and buildings. One way of achieving this is through direct reuse opposed to recycling which often requires the materials to be broken down into those of lower value or fed back into the high emissions production processes. Reusing typically requires less reprocessing or reworking.

There are opportunities to create circular solutions in the built environment today. During the construction of the London Olympic Stadium, 2,500 tonnes of repurposed steel tubing was used, reducing the carbon footprint and lowering the cost. This was possible due to the close relationships between suppliers and designers, allowing for low carbon materials to be integrated at the design stage, matching the supply of repurposed materials with construction demand.

However, to ensure decarbonisation and circularity are achieved in an economically viable and efficient way, the construction sector will need to create a more effective circular ecosystem which includes the efficient collection, sorting, and reusing of materials. This will involve the entire value chain, including intermediaries such as material suppliers adapting their business models towards reuse.

Example 3: Cleveland Steel

Part of Cleveland Steel specialises in buying scrap steel from demolition projects, offcuts, and cancelled projects, and re-working them for reuse. The steel can then be used on projects such as the construction of a warehouses for the National Tube Stockholders, a company in the same group. The reuse of steel from a nearby cancelled construction project saved £650,000 in construction costs and eliminated 51,000 miles of HGV transport.

Other parts of the required ecosystem are also emerging. Demolition and waste firms will be key to the recovery and redistributing of reusable materials.

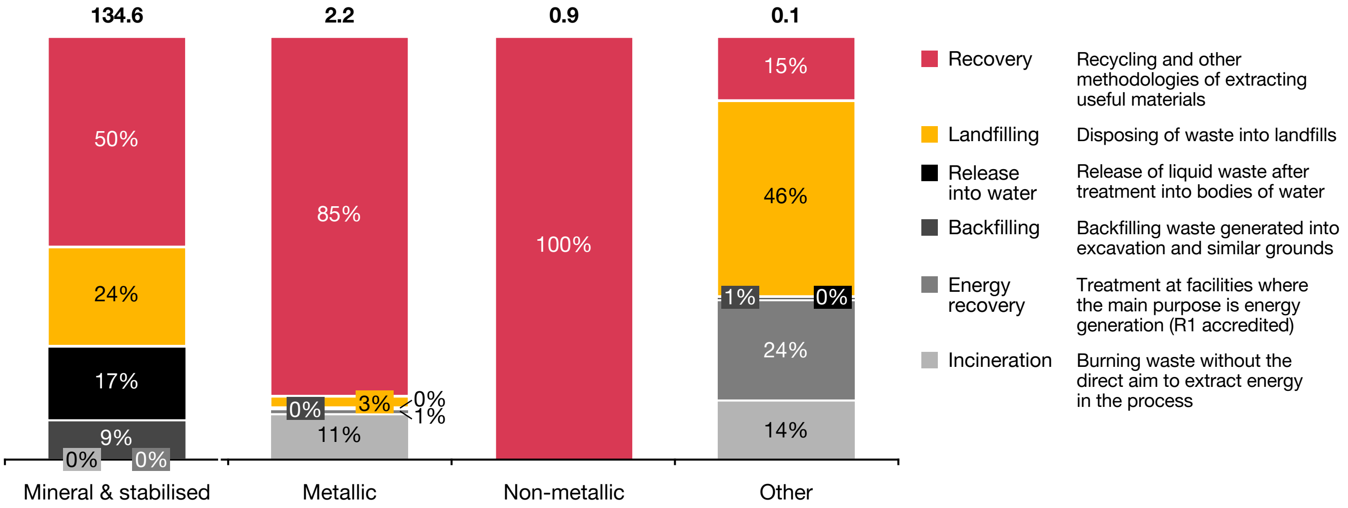
Example 4: Keltbray

In October 2023, Keltbray were contracted to prepare the former IBM building for follow on works through deconstruction and partial demolition. As part of the works, Keltbray reinstalled 40 tonnes of dismantled steel from another Keltbray demolition for the new structure, reducing the embodied carbon from 577kg to 47kg per tonne. Furthermore, through pre-demolition audits, used to identify materials for reuse, they have ensured resources such as floor tiles, paving blocks, and bricks have been salvaged for reuse.

Aside from reusing materials such as steel, the reuse of buildings through refurbishment is an alternative way to reduce emissions and extend the useful life of the built environment. In some densely populated cities such as London, there has been an increase in the reuse of existing structures due to limitations on planning permission for new buildings.

Figure 11: UK construction waste destination by waste type

Construction share of waste treatment volumes by type of waste and final destinations
% (totals in M tonnes), 2018



Source: DEFRA, Strategy& Analysis

There remains significant value leakage in the construction and demolition value chain. According to DEFRA, only 50% of construction waste is recovered and recycled, with c.25% ending up in landfill.[30] The true extent of recycling and recovery that takes place is not clear.

In large scale projects there are often obligations for the developer to dispose of the waste suitably. The challenge with building a substantial waste material flow for construction is the long tail of local demolition companies given many smaller scale projects. Only in larger scale demolition projects e.g. power plants, are the margins high enough to encourage a more strategic approach to the recovery of waste materials.

However, there is hope for these waste flow supply chains to be more developed given there has been a run of vertical integration activity between developers and waste management firms. The more of the waste management value chain developers can control, the greater the opportunity to reduce value leakage by recovering more materials from demolition sites and reintegrate them into their operations.

Circular construction is dependent on changing the principles of design to encourage and simplify the reuse and recycling of materials both now and in the future. Design is crucial through its multi-layered impact across all parts of the value chain, from material choice and quantity, operational efficiency, and ease of deconstruction and material reuse. As technology, commercial incentives, and regulation develop, design best practices will change to encourage and enable circularity in the built environment.

Emerging regulations and standards are likely to require upfront carbon lifecycle/whole of life assessments. This will bring circular thinking forward to the design stage, encouraging the consideration of sustainable materials, including the availability of recycled or reused materials. Alongside choice of materials, the design stage impacts the construction processes used. By switching to new processes such as modular buildings, time, money, and materials can be saved by constructing off-site.

Designers will also need to adapt to the increase in building lifecycles through retrofitting. Buildings may have a variety of future users, switching from office space to commerce to residential interchangeably. Ensuring buildings can be adapted for these variety of uses will reduce the need for demolition and new construction.

Perhaps most importantly for circularity, is designing for the deconstruction and reuse of buildings. This will partly be driven by developments in technology. Digital twins are advanced models of buildings which are often developed alongside the original design. By mapping out the materials used, digital twins can not only optimise the quantity of materials used, but also help pre-demolition audits to locate and assess the suitability of materials for recovery and reuse.

Alongside this, digital twins can store and calculate a material's future strength and corrosion levels. This is crucial for providing confidence to developers who are hesitant about depending on pre-used steel, glass, or concrete.[31]

This can further be aided by the adoption of material passports which contain key information on materials and components.

Example 5: Material passports

In the development of London's 8,600m^2 Edenica office development, the structural engineering consultancy firm, Waterman Group in collaboration with Circuland, are developing a framework and platform for producing material passports. One of the aims of the project is to compile a database of the materials used to provide transparency for future recycling and reuse. Additionally, developers hope to create a marketplace to connect supply and demand of reusable materials. As these initiatives increase in prevalence, it will make sourcing reusable materials far easier and more convenient for new construction projects.

Conclusion

Progress in reducing emissions in the built environment through the reduction of operational emissions has been made. And it is vital that the investments in efficiency, heat retention, and the broader decarbonisation of the UK grid continue. This is largely because the payback period for these investments was clear.

However, as the UK looks to reduce embodied emission and achieve net zero, tools and techniques must change to ensure decarbonisation continues without conflicting with other macroeconomic goals, such as housebuilding and infrastructure improvement.

Reducing embodied emissions will be far more difficult to achieve, requiring sizeable CAPEX investment to decarbonise production processes of underlying materials used, particularly cement and steel.

Given the scale and complexity of investment required, combined with mixed commercial incentives, it is vital that government regulation provides certainty over future taxes, levies, subsidies, and environmental requirements. This clarity will allow financiers and manufacturers to plan investments today, ready for the future.

Reuse is a key lever in achieving circularity. This will extend the lifetime of existing materials and structures. Digital product passports and other design innovations will provide the confidence required for the sector to make this transition.

Enacting circularity is possible today but will require collaboration across the value chain, from demolition and recovery. Navigating this ecosystem is complex, but those that move first and establish lasting partnerships are most likely to 'win' in a circular economy.

Appendix

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Figures

Figure 1: UK Green Building Council, Net Zero Whole Life Carbon Roadmap (2021), Strategy& Analysis

Figure 2: UK Green Building Council, Net Zero Whole Life Carbon Roadmap (2021), Strategy& Analysis

Figure 3: Ability to influence costs and carbon over the building lifecycle

Figure 4: UK Green Building Council, Net Zero Whole Life Carbon Roadmap (2021), Strategy& Analysis

Figure 5: Climate Change Committee, Progress towards reaching Net Zero in the UK (2023)

Figure 6: UK Government, ONS, Strategy& Analysis

Figure 7: Nature Geoscience: Increased carbon footprint of materials production driven by rise in investments

Figure 8: Euroconstruct, Department for Business & Trade, World Steel Association, Forest Research UK

Figure 9: PwC 27th Annual Global CEO Survey

Figure 10: Strategy& Analysis

Figure 11: DEFRA, Strategy& Analysis

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Key contacts

Chris Temple
Net Zero Transformation Leader, PwC UK

+44 7715 704870
christopher.temple@pwc.com

Paul Sloman
Engineering and Construction Sector Leader, PwC UK

+44 7725 633353
paul.sloman@pwc.com

Toby Smith
Senior Manager, Strategy&, PwC UK

+44 7718 978270
tobias.smith@pwc.com

William Brown
Senior Manager, Strategy& PwC UK

+44 7925 268292
william.brown@pwc.com

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