green alliance...

Circular construction

Building for a greener UK economy

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The analysis and recommendations presented here are solely those of Green Alliance and do not necessarily reflect the views of the Circular Economy Task Force members or the organisations we spoke to as part of our research.

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Experts and organisations consulted

We set out to understand the extent to which the construction industry could reduce its material use based on existing techniques and technologies. Our study is based on a comprehensive baseline of material use in the UK construction industry by the UK FIRES academic consortium, to which we applied the reductions in material requirements for future buildings and infrastructure that have been deemed feasible in academic literature.

Two workshops were held to test our findings with industry representatives and academics, and we also spoke to individual companies and trade associations. The views expressed in this report are entirely those of Green Alliance and those named below do not necessarily endorse our views or conclusions.

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Summary

> “A circular construction industry would help to provide the housing and infrastructure the country needs.”

The construction sector uses more raw material than any other in the UK, produces the most waste and is responsible for a quarter of the country’s carbon emissions. It is due an overhaul.

In addition to its environmental impact, it faces challenges ranging from housing shortages and the affordability crisis to supply chain risks and the need to ensure buildings and infrastructure are fit for a net zero carbon future.

Change in some areas is coming, with energy efficiency requirements meaning that, from 2025, new buildings need to generate 75 to 80 per cent less carbon after they are built. But this will not address all the environmental impacts the sector is responsible for and it will not help with all the other problems the industry faces.

One obvious answer, as many are beginning to realise, is a more circular economy. What this means for construction is reducing raw material use through changes to design and a focus on preserving materials and entire buildings at their highest value for as long as possible. It means regenerating, reusing and recycling building materials already in use, at the end of their first life.

A circular construction industry would help to provide the housing and infrastructure the country needs, without the current negative impacts. Many circular measures also offer opportunities to drive

down housing costs, increase productivity, relieve supply chain pressures, and improve businesses' profitability. Previous research has shown circular construction business models can increase profitability, improving financial returns by as much as 26 per cent.

> "Techniques and technologies already available could reduce the use of materials by over a third."

New analysis we conducted for this report shows that, by 2035, techniques and technologies already available could reduce the use of raw materials by over a third. This could also reduce the sector's carbon footprint by 39 per cent in addition to relieving pressures on land use, biodiversity, water and waste.

To set this change in motion, we recommend the government follows the example of the Netherlands and introduces a bold, sector specific resource reduction target for construction. It should then help the industry achieve it by prioritising three areas for urgent action:

Financial incentives and support

As a matter of priority, the government should redress the imbalance between new build, currently zero-rated for VAT, and retrofitting, which is charged VAT at 20 per cent. The VAT holiday for energy saving products, like insulation and heat pumps, should be made permanent and extended to other retrofitting activities that preserve or improve the environmental performance of a building. A funding package should help small, innovative companies to bring new solutions to market, to improve the reuse of construction materials and build secondary supply chains.

More circular design and retrofitting

Central government should follow London's example and require all developments over a certain size to submit a circularity statement. This should be

extended as circular design becomes the norm. Pre-demolition assessments should be conducted before planning consent is granted to replace existing buildings, to make a clear case for demolition in relation to carbon emissions and material use.

“Progress will be limited until there are agreed and commonly used metrics for circularity.”

Better data

Progress will be limited until there are agreed and commonly used metrics for circularity. The government should support and co-ordinate efforts by the UK Green Building Council, the Institute for Structural Engineers and others to identify the right metrics and then mandate their use. It should also support and co-ordinate efforts to develop ‘material passports’ for buildings to track crucial information about the materials, components and products used in them.

Construction is one sector where there is still plenty of low hanging fruitin the improvement of resource use and climate impact, with huge untapped potential to improve its performance. The government should trigger action now to ensure the industry is fit for the future.

Building for a sustainable economy

> “Devolved administrations are already ahead.”

A new approach to resource use, and a target to reduce it, are needed to create a green economy in the UK. This will not only cut climate impacts, but also help to reduce and reverse degradation of the natural environment.

The UN estimates the extraction and processing of resources, food and fuel is the source of half of global carbon emissions and 90 per cent of biodiversity loss and water stress.[1] We have shown previously that the UK government should be aiming for an absolute reduction in resource use.[2] The devolved administrations are already ahead, with targets to bring it in line with planetary boundaries.[3]

Given the UK consumes almost 15 tonnes of non-renewable resources per person a year, against the UN’s stated sustainable level of between six and eight tonnes, we recommend that England’s target, like Northern Ireland’s, should be to halve raw material use by 2050.[4,5] Meeting this target should be driven through measures for specific sectors and materials, and by setting binding interim targets, based on agreed metrics.

Nowhere is this more important than the construction sector, which uses the most materials in the UK, is the biggest producer of waste and generates a quarter of the country’s consumption emissions.[6] It should be a priority for the government to set clear, long term targets for change.

The 2021 Environment Act gives the government the power to set such targets in England. Unfortunately, initial plans for a target to increase economy wide resource efficiency were dropped in December 2022 and the government chose instead to set only a legally binding target for waste minimisation.[7] This excludes the major mineral wastes

from construction that make up the majority of the UK's waste stream.

We have identified how, largely through available technologies and best practice, the most resource intensive industry in the UK has huge scope to reduce its use of materials.

> "The most resource intensive industry in the UK has huge scope to reduce its use of materials."

Our study is based on a soon to be published analysis by researchers at the UK FIRES academic consortium, which has provided a comprehensive baseline of material use in the UK construction industry. We analysed the potential impact of quantifiable resource efficiency and demand reduction measures to understand how they would affect the material requirements for future buildings and infrastructure.

Two workshops were held to test our findings with industry representatives and academics, and we spoke to 16 individual companies and trade associations (see page one). This has enabled us to identify the barriers to a more resource efficient construction industry and the immediate action needed to overcome them.

While the findings and recommendations here are ours, the feedback we had from the industry is clear: with the right metrics, incentives and policies, significant material savings in the UK's building industry are possible.

The construction sector and the environment

> “The industry is responsible for ensuring that existing and new buildings and infrastructure are fit for a net zero future.”

The construction sector is one of the biggest and most important in the UK. It shapes the lives of every citizen, through the houses we live in, the buildings where we learn, work or shop, and the infrastructure that determines how we travel.

But the sector needs to change. It has problems with productivity, supply chain risks, the housing and affordability crises and the need to skill up its ageing workforce. And the industry is responsible for ensuring that existing and new buildings and infrastructure are fit for a net zero future.

Change in some areas is coming, with new energy efficiency requirements in the Future Homes and Buildings Standard. From 2025, new buildings will need to generate 75 to 80 per cent less carbon after they are built, which commentators have suggested will require “fundamentally changing the way that we design and build homes in the UK”.[8]

But the focus on energy efficiency will not address all the sector’s environmental impacts. A significant proportion of the emissions associated with construction come from its use of materials.

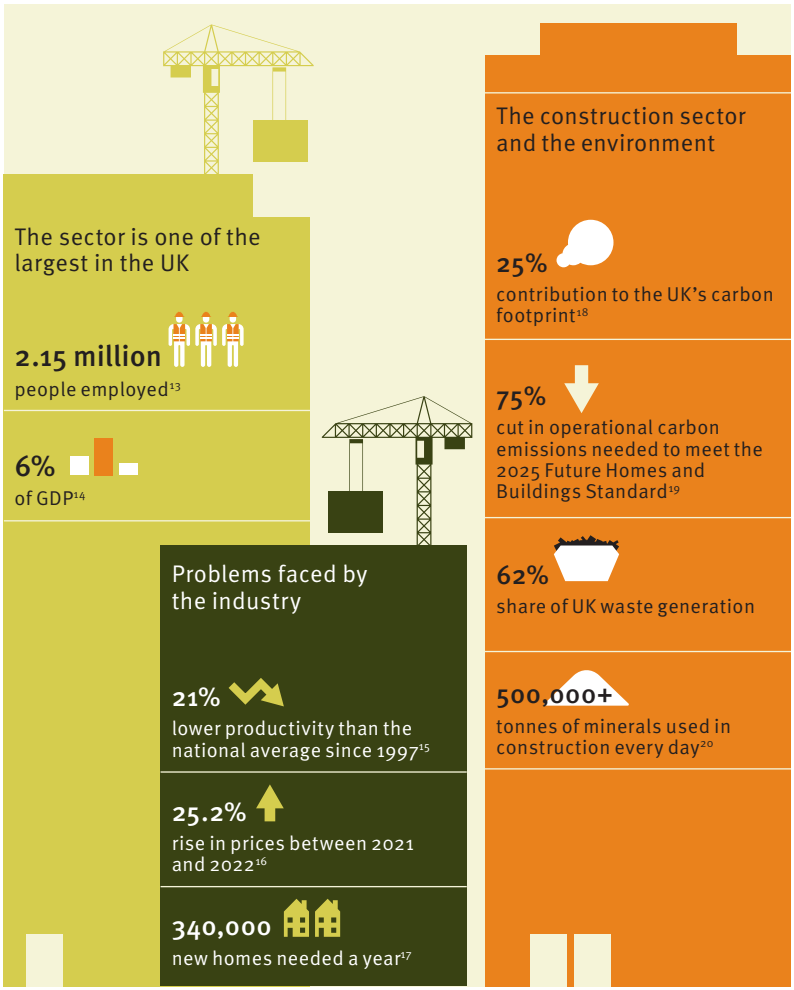
Embodied carbon is expected to account for half of the built environment’s emissions by 2035.[9] In 2018, this was around 43MtCO_2e on a consumption basis, which includes emissions that occur in supply chains overseas. Sixty per cent of these were derived from the extraction, manufacturing and production of materials.[10] Through the Part Z initiative, supported by over 150 building industry organisations, the sector is campaigning for future building standards to go further and account for whole life carbon emissions.

> **“Construction, demolition and excavation generated 62 per cent of UK waste in 2018.”**

Our research indicates that building standards should go even further and address material use in its own right. The industry uses vast amounts of resources, from home and abroad, including over half a million tonnes of minerals every day.[11] It is also responsible for the majority of waste produced: construction, demolition and excavation generated 62 per cent of UK waste in 2018.[12]

The problem with focusing only on operational carbon and waste is that it ignores the need to tackle the fundamental issue of the industry’s overconsumption of resources. Raw material extraction is driving serious environmental impacts, including damage to ecosystems.

The UK construction sector at a glance



Carbon in construction

Embodied carbon

This describes greenhouse gases resulting from extracting and processing materials and making them into products and buildings, as well as the emissions associated with transport and work on a construction site. After a building is finished, further embodied emissions are associated with materials, parts and products involved in maintenance over its lifetime.

Upfront carbon

These emissions are a subset of embodied carbon and are what is released before construction is completed. Upfront carbon excludes the embodied emissions from maintenance and repairs and, for most buildings, is a larger share than maintenance or operational emissions.[21] Upfront carbon accounts for over half of a domestic building's total emissions.[22]

Operational carbon

These are emissions from the day to day energy consumption of a building. They are the only emissions targeted by government regulations, like Part L of the Building Regulations and the forthcoming Future Homes and Buildings Standard. It is worth noting that only the energy consumption related to fixed building assets, like space heating, cooling, ventilation, water and lighting, are regulated. Operational emissions from IT equipment, cooking and refrigeration systems, and external lighting are unregulated.

Whole life carbon

This is the total building related emissions that occur over a built asset's entire life, including upfront embodied carbon and additional embodied emissions from maintenance, as well as operational carbon from day to day energy use (both regulated and unregulated). The accuracy of a whole life carbon assessment depends on knowing how long a building will last, which can be hard to assess.

Circular construction is the answer

> “London has taken the lead on pushing change throughout building supply chains.”

The solution to many of the environmental and other problems facing the construction sector, as many now realise, is a more circular economy. That means reducing raw material use through changes to design and a focus on preserving materials and entire buildings at their highest value for as long as possible. It means regenerating, reusing and recycling the materials used at the end of their first life.

This approach would help to provide the housing and infrastructure the country needs while minimising environmental impacts and, in some instances, it can lead to more affordable housing and higher productivity (see page 19).

It is also financially beneficial for companies: research by Arup and the Ellen MacArthur Foundation into five circular construction business models found they all offered increased profitability, with one improving financial returns by as much as 26 per cent.[23] Retrofitting can offer cost savings over demolition and new build. For example, the 1 Triton Square retrofit for British Land’s headquarters in London, carried out by Arup, took 30 per cent less time than new build at 15 to 18.5 per cent lower cost.[24,25]

Innovation in more circular construction is in its early days. In the UK, London has taken the lead on pushing change throughout building supply chains, requiring circular economy statements and whole life carbon assessments for the largest developments referred to the mayor’s office. This has led to suppliers of new circular products struggling to meet demand. Many see this as an important development which, if widely and wholeheartedly adopted alongside other regulatory drivers and financial incentives, could drive action and a different mindset across the industry.

> “By 2050, the Netherlands aims to have a fully circular construction sector.”

Circular economy ambition in the Netherlands

As in the UK, the Dutch construction industry is the largest producer of waste and one of the highest emitters of carbon in the country.[26,27] Faced with this, the Netherlands is decisively aiming for a circular construction industry, as part of its wider aim to achieve a national circular economy.

Cross economy targets have been set for the industry to be completely circular by 2050 and for raw material consumption, excluding renewable resources like timber, to be reduced by 50 per cent by 2030.[28] The Dutch government has divided the ambition into three stages and likened the target to climbing to the summit of a mountain. By 2023, it seeks to establish a ‘base camp’, meaning it will have identified the metrics, policies, legislation and market conditions to achieve the goals; by 2030, it hopes to have progressed to halving its raw material use; and by 2050, the Netherlands aims to have a fully circular construction sector.[29]

This plan has three pillars: first, the optimal use of materials for all phases in the construction cycle; second, to use as many ‘infinite’ materials as possible, with more and higher grade reuse; and, third, to make use of finite sources as efficiently as possible.[30] Priorities supporting these aims include developing uniform measurement of circularity, for which PBL (the Netherlands’ environment assessment agency) has been establishing the baseline for metrics and monitoring.[31,32]

The Dutch government has explicitly recognised its powers to drive change through regulation and financial incentives, as well as to create demand for more circularity as the construction industry’s primary client.[33] When it comes to infrastructure in particular, this is also the case in the UK.[34]

A senior minister championed this approach, which has been vital to progress. Stientje van Veldhoven was the cabinet member responsible for the environment at the time the commitments were adopted. Now vice president of the World Resources Institute, she has promoted circularity in international forums, including pushing for worldwide adoption of the EU’s Green Deal commitments on reuse and organising a 2021 World Circular Economy Forum on the links between climate change and the circular economy.[35,36] Her enthusiasm was central to achieving cross departmental buy in, and the latest Dutch coalition agreement contains at least 11 references to the circular economy, including explicitly linking it to climate policy.[37]

What the experts told us

> **“Excess material use is rife, and unnecessary demolition and material intensive new build are the norm.”**

We consulted widely with experts in industry, trade associations and academia (see page one). They highlighted to us that, at present, there are few incentives to adopt circular practices in UK construction.

Progress is held back by design and demolition practices, disjointed supply chains and low material prices, particularly for cement and concrete. These factors mean excess material use is rife, and unnecessary demolition and material intensive new build are the norm as they are perversely more economically viable than renovation.

It need not be this way. The experts we spoke to largely agreed that the technologies to improve material use, and therefore the environmental performance of the construction industry, already exist. Many suggested the best way to ensure they are deployed is through regulation. One industry representative suggested policy is the “most potent” way of driving change in the sector, while another industry insider said regulation has historically been one of the “principle drivers of innovation”.

The main messages from our consultation

	Barriers to circularity	Opportunities for action
Design phase	The circular economy is difficult to measure. Better and more consistent metrics are needed. Data quality is poor on material impacts and material flows, including after demolition. Design practice, particularly in infrastructure, is "gruesomely wasteful", encouraged by cheap material availability (particularly concrete) as well as risk aversion and habitual practices. It is difficult to scale up innovation, including for modern methods of construction (see page 19), which require consistent business orders to justify setting up factory sites.	Whole life carbon reporting, while important, can be misleading if a building does not last as long as predicted. It should, therefore, be introduced alongside material intensity reporting and other circularity metrics, to deal with upfront and operational carbon. Planning policy could include incentives for circular design, as is happening in London, and the longer use of buildings, as in France, where unnecessary demolition is discouraged. The government could limit overspecification, particularly in infrastructure where it is the major client and responsible for more than half of all investment in recent years.[38]
Construction phase	Supply chains for reused materials and products lack co-ordination and it is difficult to guarantee the availability of reused material when needed. Wider use of timber is held back by concerns around fire safety, although other countries have managed these risks. There are problems with fraud and mislabelling around timber sustainability certification, and there are questions around whether these standards are stringent enough.	Material passports could be an enabler of reuse, so long as data is easily accessible and useable. Regulations, for example targets around modular construction or low carbon cement, could allow existing technology to scale up and have a much greater impact.
End of life	VAT on retrofit, unlike new build, discourages circular practices, as do other perverse financial incentives.	Separating reuse and recycling reporting would stimulate innovation. This is especially significant for high impact materials, like steel and concrete, which could be reused in much greater quantities. Further categories within recycling reporting would encourage a shift away from low value downcycling.

The route to a circular industry

> **“The amount of raw material needed for building can be reduced by moving swiftly to a circular construction sector.”**

The amount of raw material needed for building housing, offices, shops, schools and infrastructure can be reduced by moving swiftly, as the Netherlands is doing, to a circular construction sector.

This should have two main features: first, it should reduce the amount of raw material needed per building ie the virgin resources that have to be newly extracted or manufactured; and second, it should ensure materials remain in use at their highest value for as long as possible, by prioritising renovation over new build.

The first of these can be addressed by better design, reusing components and materials, and increasing recycled content. The second can be dealt with by extending the lifetimes of existing buildings and their components and materials. This should prioritise adaptation for new uses, for example when office blocks are retrofitted into flats, helping to increase the density of housing in urban centres which supports people to live lower carbon lifestyles.

Material use in construction

Today’s construction sector uses nearly 100Mt of materials in new buildings and infrastructure projects each year.[39] This does not include all the materials used for internal fittings, such as bathrooms, kitchens, lighting and furniture, which are often replaced repeatedly throughout a building’s lifetime.

Nearly two thirds of the materials used in construction (61 per cent) are used in buildings, including houses, flats, offices and public buildings. The remaining 39 per cent are used in infrastructure and other construction, such as for transport, power, communications, water and waste.

Reuse and recycling of steel, glass, aluminium, timber and the aggregate in concrete meets 18Mt of the demand from the sector. Concrete dominates the primary raw materials used, at 79 per cent of all new material, and an even higher proportion in infrastructure.[40]

How construction could change by 2035

> “Concrete dominates the primary raw materials used.”

Material use in construction is huge, and dominated by concrete, but this could change. Circular practices could reduce material use and its associated environmental impacts. To illustrate their potential impact, we compared a business as usual scenario, where construction practices continue as they are and material use remains similar to today, with a scenario for 2035 where a more circular industry prioritises resource efficiency and reduces demand for new buildings and infrastructure.[41]

For the 2035 circular scenario, we modelled interventions that lead to clear materials reduction, according to academic research, to show their potential cumulative impact.[42] As we focused on available technologies and best practice, it is likely we have underestimated their long term potential, and that other measures and changes will be possible in future. More support for innovation is also likely to lead to further resource savings.

Circular measures modelled

Design	Optimising the design of buildings using digital tools, to minimise the need for concrete and steel Reducing the overspecification of materials in infrastructure Flexible formwork technology to create more complex concrete structures that minimise waste Optimising the reinforcement of concrete Optimising the use of structural steel Post-tensioning concrete floor slabs, to reinforce them while requiring less material Increasing the use of precast concrete elements
Demand reduction	Tripling the number of flats created through retrofitting commercial buildings Reducing projected spending on roads to cover only maintenance
Reuse	Reusing structural and sheet steel, structural timber and bricks Repurposing entire foundations in a small number of cases Increasing the reuse of stone, glass, aluminium and plastic by five per cent
Modern methods of construction (MMC) and material substitution	Increasing the use of timber in structural elements of low and mid-rise buildings to reduce demand for steel, cement and bricks Increasing the use of modern methods of construction to 30 per cent in both housing and commercial buildings to reduce material waste
Recycling	Increasing the recycled content of steel, aluminium, glass and plastic to 95 per cent

See our full methodology at: green-alliance.org.uk/publication/circular-construction

> “Pre-manufacturing can reduce embodied carbon by 45 per cent.”

Modern methods of construction

Modern methods of construction (MMC) include onsite technologies and the offsite manufacturing of building components in a factory, as alternatives to traditional ‘bricks and mortar’ construction. They can range from using drones on construction sites, to making a building’s components, such as staircases, floors or wall panels in a factory. Entire housing modules can be made remotely and transported to site.[43]

Offsite manufacturing has the potential to improve resource efficiency, as less product is wasted. Up to 90 per cent less waste has been reported in some cases.[44] Pre-manufacturing can reduce embodied carbon by 45 per cent as well as enabling high quality insulation to be added to floor and wall panels during factory construction, to create energy efficient buildings.[45] It can also vastly improve productivity. Some case studies suggest it can increase the quality of buildings with 70 per cent less onsite labour and projects delivered 20-60 per cent faster.[46] There is an expectation that costs could fall significantly if these methods are successfully scaled up, costing 20-40 per cent less than a traditional building.[47]

For these reasons, MMC should be part of the solution to housing shortages and the crisis of affordability, and it can help the industry improve its productivity and environmental impacts.

The government has set up a taskforce to speed up MMC, and its Affordable Homes Programme requires 25 per cent of new housing to be delivered this way.[48,49] However, barriers include financing, where lenders find the upfront investment too risky; planning, where uncertainty and long application times prevent factories scaling up production; and public procurement, where the environmental benefits of MMC are not fully accounted for.

Some experts we spoke to were concerned that some pre-manufactured, modular homes can be difficult to recycle once finished with, as components can use large amounts of glue and other sealants to prevent damage during transit, which makes it difficult to separate materials. Design considerations, like ease of disassembly and reuse, will be important as MMC becomes more common.

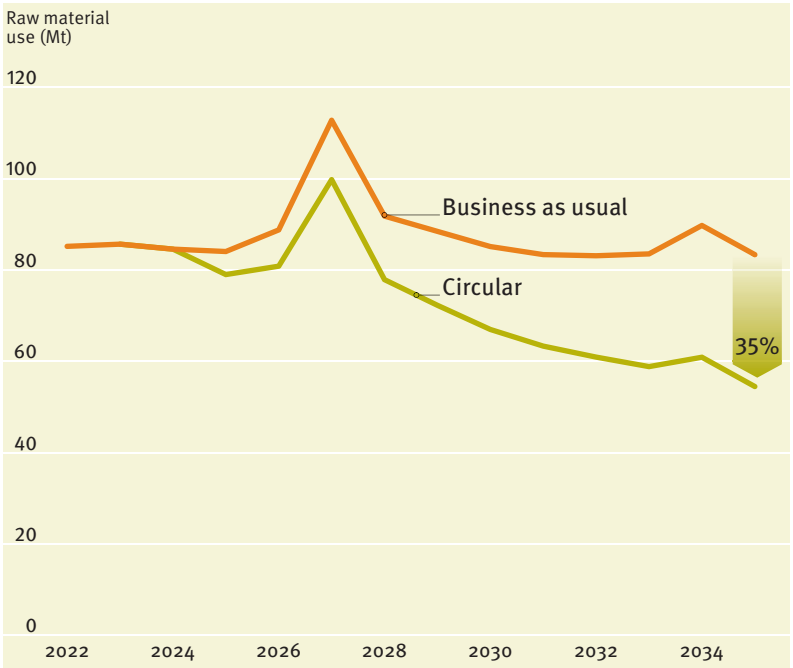
Others were concerned that the need for less labour on site could detrimentally impact those who rely on the industry for employment. Impacts on jobs and communities will have to be factored into planning for a just transition.

Circular measures could cut raw material use by over a third by 2035

Our circular scenario reduces raw material used in construction by 35 per cent by 2035, compared to business as usual. Between now and 2035, circular measures could prevent 418Mt of raw material being extracted, equivalent to the total needed to build 1.7 million detached houses.

> “Interventions optimising material use at the design stage have the most impact.”

Raw material use in construction could be cut by a third by 2035



Improving design has the biggest impact

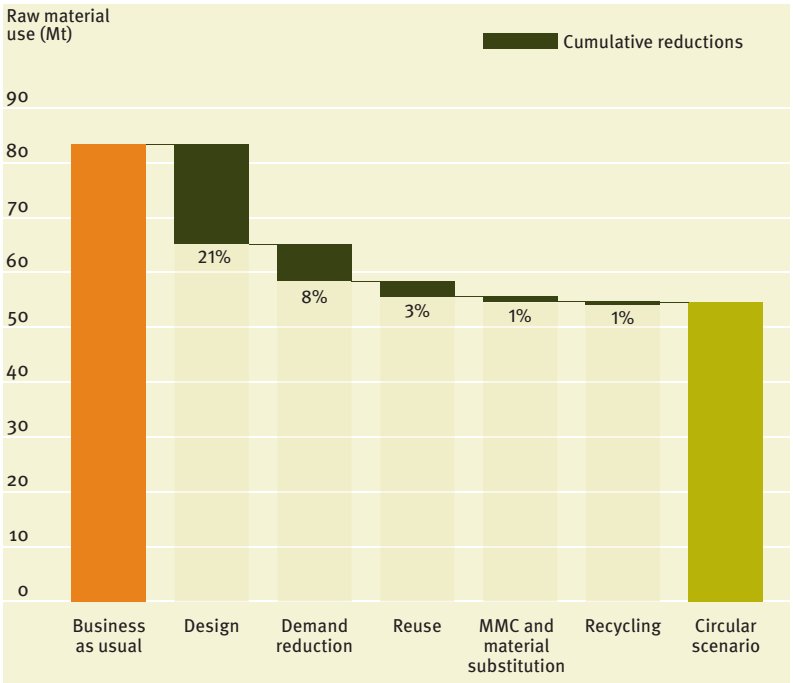
A circular construction sector incorporates interventions at all lifecycle stages to improve and reduce resource use. Our circular scenario groups these interventions into design, demand reduction, reuse, modern methods of construction and material substitution, and recycling (see our methodology at green-alliance.org.uk/publication/circular-construction for full details).

We found that interventions optimising material use at the design stage have the most impact, for example reducing the overspecification of structural steel and concrete. This is particularly so in the case of concrete, which made up

over three quarters of the raw material used in construction in 2018. Similarly, other cement based products, like mortar and plaster, stone and clay products, like bricks and tiles, are often difficult to remove from a building for reuse. So initial design decisions that reduce demand for them in the first place will have a big impact.

> **“For some materials, measures such as reuse and recycling will be more important.”**

Design changes are the best way to reduce raw material use



Changes to design need to be paired with other approaches to optimise material use. For some materials, measures such as reuse and recycling will be more important.

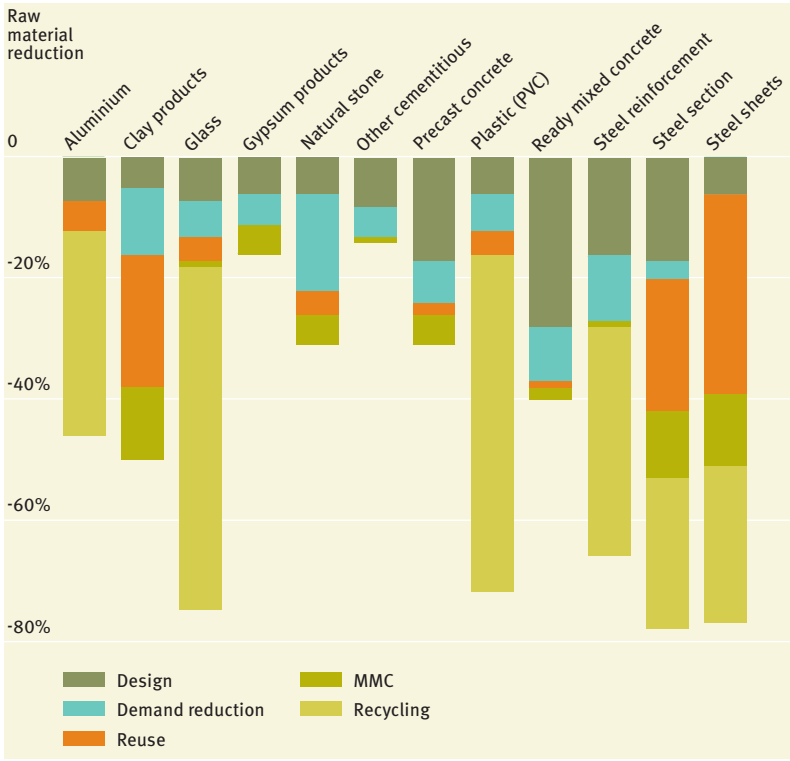
Reuse generally has more impact than recycling, and this is particularly true for clay based products, like bricks, as well as for steel sections and sheets, and timber.

Recycling is significant for aluminium, plastic and glass, as well as steel, where it can result in major reductions in demand for virgin material. After design improvements and reuse, aluminium, glass, plastic and steel recycling can be increased to 95 per cent. However, as these are used in smaller volumes, the overall impact on total material use across the sector is relatively low.

> “If timber is sourced sustainably, it is a better choice than concrete, steel or bricks.”

Material substitution could result in a slight rise (one per cent) in overall material use if timber is used instead of concrete, steel and bricks. But, if the timber is sourced sustainably, it is a better choice, as wood is renewable and acts as a long term carbon store (see page 28). In fact, countries that want to increase timber in construction, such as the Netherlands, exclude it and other bio-based materials from their raw material use calculations on the grounds that, unlike finite mineral and metal resources, it is renewable.[50]

The best circular measures vary for different materials



As this graph shows, the best circular measures vary for different materials. Recycling is important for plastics, glass and aluminium, reuse can play a significant role for steel and clay products (bricks) and design changes are the predominant way to reduce the amount of all types of concrete used.

Carbon saving potential

Reducing the raw materials needed for construction leads to significant carbon savings. The 35 per cent raw material reduction in our circular scenario would cut the annual upfront carbon emissions from construction by 10MtCO_2e.

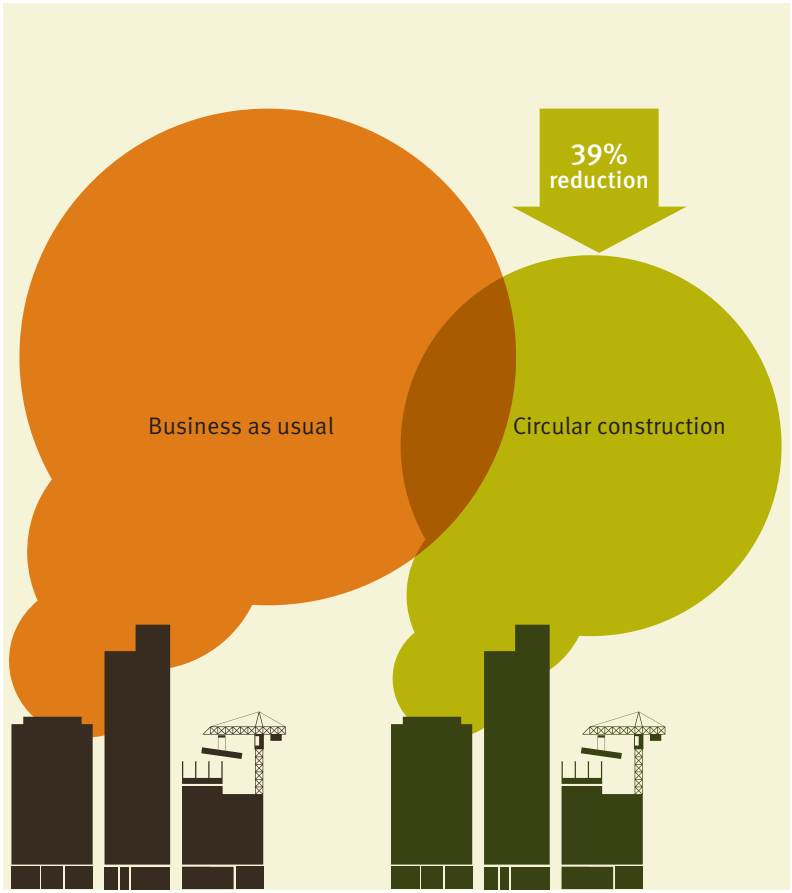
> “Material reduction through circular measures can help to meet net zero targets faster.”

This carbon saving is calculated before reductions from lower carbon production methods and the wider shift to low carbon transport and energy systems are considered. Foundation industries, ie those that create the core materials for construction, like cement, metals, glass and ceramics, are challenging sectors to transition and may still emit some carbon into the 2040s.

For example, over 60 per cent of upfront carbon emissions from construction in 2018 were caused by concrete and other cementitious materials.[51] The sector plans to rely on carbon capture and storage (CCS) to meet net zero carbon targets in these areas.[52] This process is costly and requires additional energy input. Material reduction through circular measures can help to meet net zero targets faster, at lower cost and with less environmental impact.

But it is not all about concrete. Although production and processing of metals such as steel and aluminium make up just three per cent of material use by weight, they are responsible for 26 per cent of the construction industry’s upfront carbon emissions. Therefore, reducing the amount of new metal needed through better design and higher levels of reuse would have a big impact on reducing total carbon emissions.

Nearly 40 per cent of upfront carbon emissions from construction can be cut through resource efficiency



Other environmental benefits of lower material use

Beyond reducing climate impacts, resource efficiency addresses the wider environmental impacts of construction too, including pressures on land use, biodiversity, water and waste.

Global biodiversity
Extracting metals in vulnerable, protected ecosystems is increasing. In 2019, 75 per cent of global iron ore extraction, used to manufacture steel, occurred in three species rich, critical biomes.[53]

Local ecosystems
A quarter of the aggregates extracted in the UK are derived from marine dredging, which seriously harms sea floor ecosystems and accelerates coastal erosion.[54]

Pollution
In 2020, aggregate mining in the UK produced 18,000 tonnes of particulate matter, which was 2,000 tonnes higher than passenger cars for the same year.[55]

Water
Creating a tonne of flat glass is water intensive, mainly because of the Solvay process used to produce soda ash. This requires nearly three litres of water for every kilogram of glass produced.[56]

Waste
Waste is produced at every stage of a material's lifecycle not only at end of life. Every tonne of steel produced requires 2.4 tonnes of iron ore, coal and limestone.[57] While much of this is potentially used as inputs to other industrial processes, some of it is hazardous. Extracting iron ore leads to more toxic waste than any other metal, apart from copper.[58]

Material impacts

Lack of data makes it challenging to quantify the impacts of reducing raw material use, beyond carbon savings. It also depends on the processes used and the location of extraction. The effect on water resources of a mine in a desert, for instance, will be very different to that of a mine in a rainforest. Likewise, biodiversity impacts, and the potential for nature restoration, will vary between agricultural land and biodiverse, complex environments like peat bogs or tropical forest.

> “A priority for government action should be to ensure better understanding of material impacts.”

Our assessment of commonly used UK construction materials shows, as far as is possible, the severity of current impacts and the potential to improve their performance. We used comparable metrics, where they exist, from independent sources for locations that supply the UK. As this was not always possible, we also based our judgements on data from trade associations, global averages and metrics that are not directly comparable.

The grey areas of the best practice potential table opposite reveal where it has been impossible for us to make any assessment based on available information. A priority for government action should be to close these information gaps and ensure better understanding of material impacts across the board.

Data available clearly demonstrates that no material can be called ‘green’ on all counts, even when best practice is followed. And, even with timber, which has the potential to perform best, there are questions around the ability to scale up production, not captured in the chart (see page 28). This highlights the importance of not only sourcing and processing materials carefully, but also the need to reduce their overall use.

For more details on our assessment, see our methodology at: green-alliance.org.uk/publication/circular-construction

Our assessments

Impacts of typical material use in construction

	Concrete	Steel	Timber	Brick	Glass
Carbon					
Production waste					
Biodiversity and land impact					
Water					
Pollution					
End of life					

Best practice potential

	Concrete	Steel	Timber	Brick	Glass
Carbon					
Production waste					
Biodiversity and land impact					
Water					
Pollution					
End of life					

> “Forestry has adverse environmental impacts if trees are not planted, managed or harvested appropriately.”

Is timber the answer?

Wood is often lauded as a sustainable construction material but its use still needs to be carefully considered. Its environmental benefit can be great, as it stores carbon throughout its lifecycle, and the Climate Change Committee has suggested its use for construction is currently – and is likely to remain – the most sustainable use of limited biomass resources.[59]

Substituting concrete for a cross-laminated timber frame in building design, for instance, reduces embodied emissions by 60 per cent, and simultaneously increases carbon storage potential by 400 per cent.[60] Timber is also a renewable resource, unlike other structural construction materials.[61]

However, forestry has adverse environmental impacts if trees are not planted, managed or harvested appropriately. Only eight per cent of forests worldwide are certified as sustainably managed and, of these, over 90 per cent are in Europe and North America.[62] Products such as plywood are primarily imported from China and Brazil, and just 42 per cent of the UK’s primary and secondary tropical timber imports are independently certified by the Programme for the Endorsement of Forest Certification (PEFC) and the Forest Stewardship Council (FSC).[63,64] Some experts suggest fraud and mislabelling are commonplace in the ‘sustainable timber’ industry and that standards are not high enough in any case.

The UK uses less timber in construction than many of its EU neighbours, and sources most from well managed forests in the EU. It is likely to continue to do so, even if timber use rises in UK construction in the near term.

Debates around the supply of sustainable timber are ongoing. Some suggest that a mass global expansion for building is possible, while one study has countered that global demand for it as a building material, from 2020 to 2050, will exceed what can be sustainably supplied by existing forests by approximately 3,900Mt.[65]

The impact of expanding production will vary based on location. With relatively low biodiversity to start with, Europe stands to gain from expansion, but regions such as Latin America would see a decline in biodiversity if more land was dedicated to forestry.[66]

Many of the industry and academic experts we spoke to said it was desirable to expand the use of timber carefully for particular uses, including for structural frames, as well as increasing the use of lower grade timber in engineered products.

> **“Our analysis shows it is possible to reduce raw material use by 35 per cent by 2035.”**

There is huge untapped potential to reduce the environmental impact of UK construction. The more efficient use of building materials can make businesses in this sector and the economy more resilient to supply chain pressures and case studies have shown that many of the circular economy practices we have described also save money.[67]

To realise these benefits and guide the construction sector to play a more active role in meeting the net zero carbon goal for the economy, the government should set a bold sector specific resource reduction target and outline how to achieve it.

Our analysis shows it is possible to reduce raw material use by 35 per cent by 2035, by using current technology and best practice. The government should use this as a minimum baseline to set a resource reduction target for construction. Once incentives exist to reuse and retrofit buildings and infrastructure and, in particular, to end the overspecification of materials, further improvements and technological progress will follow that can cut material use even further.

This was undoubtedly the case with the UK’s approach to driving greenhouse gas reduction in recent decades, through targets set by the 2008 Climate Change Act and the subsequent net zero carbon goal. Exact pathways to achieve these were not initially clear, but the process of target setting has led to a virtuous cycle of progress. New techniques and technologies have since been developed, making reaching the goals easier to envisage. Independent advice, via the Climate Change Committee, to support the government’s mission, including sector specific recommendations and five yearly carbon budgets, is an approach that could be replicated for reducing resource use.

The good news is that the many experts we spoke to in the construction sector said that no new technologies are

needed for the industry to start down this road. Instead, the focus needs to be on ensuring best practice is followed, as well as on adopting technological advances as soon they are available.

The industry experts we consulted repeatedly noted that government policy has a clear role in steering construction towards greater resource efficiency and reducing its harmful environmental impacts.

> “Government policy has a clear role in steering construction towards greater resource efficiency.”

Below, we set out three priority interventions, through which the government can help the industry meet an overarching ambitious reduction target. While not exhaustive, these would be a good start. They are achievable now and, considering how far behind construction is in the race to net zero and the outsized impact it has on material use, they should be acted on with urgency.

1. Financial incentives and support

Remove VAT on retrofit

New build is zero-rated for VAT while most renovation and repairs are levied at the full rate of 20 per cent. This encourages demolition over restoration. Energy saving products, such as insulation and heat pumps, were given a VAT holiday in the 2022 spring budget. This should be made permanent and expanded to other retrofitting activities that preserve or improve the environmental performance of a building, to encourage a ‘retrofit first’ approach. It has been estimated that even if the VAT on housing renovation and repair were to drop to five per cent in the UK, it would provide an economic stimulus of over £15 billion over five years and create nearly 100,000 extra jobs in construction and the wider economy.[68]

Target innovation

Experts we spoke to highlighted that, in a market dominated by large players, smaller companies often struggle to bring new solutions to market as they lack the funds to meet strenuous testing requirements and keep up with changing rules and regulations. Dedicated funding and greener public procurement processes would help circular economy innovators and enable solutions like modern methods of construction to expand.[69]

Funding does not have to come exclusively from government, as demonstrated by the success of the Innovation Energy Efficiency Accelerator scheme, administered by the Carbon Trust. This model could be replicated for the construction sector, whereby partnerships are created between developers of efficient technologies and companies willing to trial innovations on site.[70]

> “Passports for products and materials facilitate circularity.”

Reintroduce a National Industrial Symbiosis Programme

Between 2005 and 2013 over £27 million of public funding was invested into the National Industrial Symbiosis Programme (NISP) for England, to help redirect surplus resources between different industrial processes. The benefits of this included 10,000 new jobs, 42Mt of carbon reductions and savings of £1 billion.[71] Launching a successor programme to the NISP, focused on improving the reuse of construction materials, could help to build the necessary supply chains. This should aim to facilitate better dismantling, handling, testing, storage and reuse of secondary materials. Currently, these supply chains require greater effort to establish than the much more resource intensive and wasteful ‘just in time’ business models that dominate.

2. More circular design and retrofitting

Assess circularity at the start

As we have highlighted, decisions made at the design stage have the biggest impact on material use, so this should be a priority for action. Central government should follow London’s example and require all developments over a certain size to submit a circularity statement in addition to a carbon reduction plan. As circular design becomes embedded as a norm in the industry and supply chains develop, these requirements should be expanded to smaller developments.

In combination with this, design codes for infrastructure could be changed to limit material use. The experts we consulted suggested that, to avoid overspecification and over ordering in infrastructure projects, upper limits on material use should be included in design codes, in addition to the lower limits already specified to ensure infrastructure strength.[72]

> “New build is zero-rated for VAT while most renovation and repairs are levied at the full rate of 20 per cent.”

Require pre-demolition assessments

Before a building is demolished and planning consent is granted for a replacement, it should be necessary to make the case for demolition, in relation to carbon emissions and material use, and to assess the potential to reuse the foundations and superstructure.[73] This should include consideration of the potential advantages of demolition to increase housing density in urban areas as, in some circumstances, this could reduce carbon emissions by increasing the potential for walking and cycling, along with having other community benefits through denser settlement.

France has already gone further: prior to the demolition or major renovation of a building over 1,000 square metres, existing products, equipment, materials and waste are all assessed to identify opportunities for reuse.[74]

UK demolition policy is unfortunately moving in the opposite direction. The high profile public inquiry launched by Communities Secretary Michael Gove into Marks and Spencer’s plans to demolish and rebuild its flagship Oxford Street store is an outlier. Permitted development rights (PDR) have been extended so a proposal to demolish and rebuild vacant buildings no longer needs planning consent, if the building is replaced with residential property.[75]

Extended PDR that allows for the change of use of buildings formerly used for offices, agricultural, storage, light industrial and retail can also lead to poor quality residential conversions, compared to those approved through the planning system. A 2020 government review found offices converted to residential units are more likely to suffer from small, inadequately lit spaces and that light industrial facilities and storage units converted to housing had poor access to services.[76] PDRs should be reviewed to ensure suitable buildings, ideally in urban centres with transport links and local amenities, are identified and converted to a high standard.

3. Better data

Improve measurement

Metrics should be agreed as a priority and then used to set targets. As the UK Green Building Council (UKGBC) has noted, “measuring the impact created by the application of

circularity is infrequent, inconsistent, and difficult".[77] The UKGBC, the Low Energy Transformation Initiative (LETI, a network of over 1,000 built environment professionals), the Institute for Structural Engineers and others are working to identify metrics that could be prioritised to help drive much greater circularity in construction. There should be a suite of measurements, such as:

> "Dedicated funding and greener public procurement processes would help circular economy innovators."

- **Material intensity:** the total mass of material used per square metre of building.
- **Reused material content:** the proportion of structural materials used in a building that have undergone minimal reprocessing.
- **Recycled material content:** the proportion of material that has been reprocessed into the building structure; high and low quality recycling should be differentiated to encourage the use of materials at their highest possible value.
- **Reusable materials:** the products and components available for structural reuse in future, to encourage more careful disassembly.

The government should support and co-ordinate these efforts. Once the best metrics are identified, it should mandate their use by the construction industry. Reporting should be embedded over a few years before targets are set, based on the new comprehensive evidence base.

Introduce British material passports

Passports for products and materials facilitate circularity and will be particularly important for building structures that last decades or even centuries. They are not yet common, but can provide crucial information about what went into a building (materials, components and products) and, therefore, about how to maintain and extend resource use and ensure high value reuse. Priority information to include would be expected lifetimes, maintenance requirements and chemical properties. The government should build on the best practice guidance developed by the EU's Buildings as Materials Banks (BAMB) project and initiatives elsewhere, like the Netherlands.[78] To ensure the information gathered is used well, it should be stored centrally and be easily accessed by all those who need it.

Endnotes

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11 UK Research and Innovation (UKRI), 11 November 2020, 'Circular economy centres to drive UK to a sustainable future'

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15 Ibid. According to the 2019 construction sector deal, "Of the current UK construction workforce, 32 per cent are aged over 50, with a further 58 per cent aged between 25 and 49. Only 10 per cent are under 25. The sector faces the twin challenge of equipping workers with the skills needed to

adopt digital and manufacturing technologies effectively, while recruiting and retaining enough people with traditional skills to replace those leaving."

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