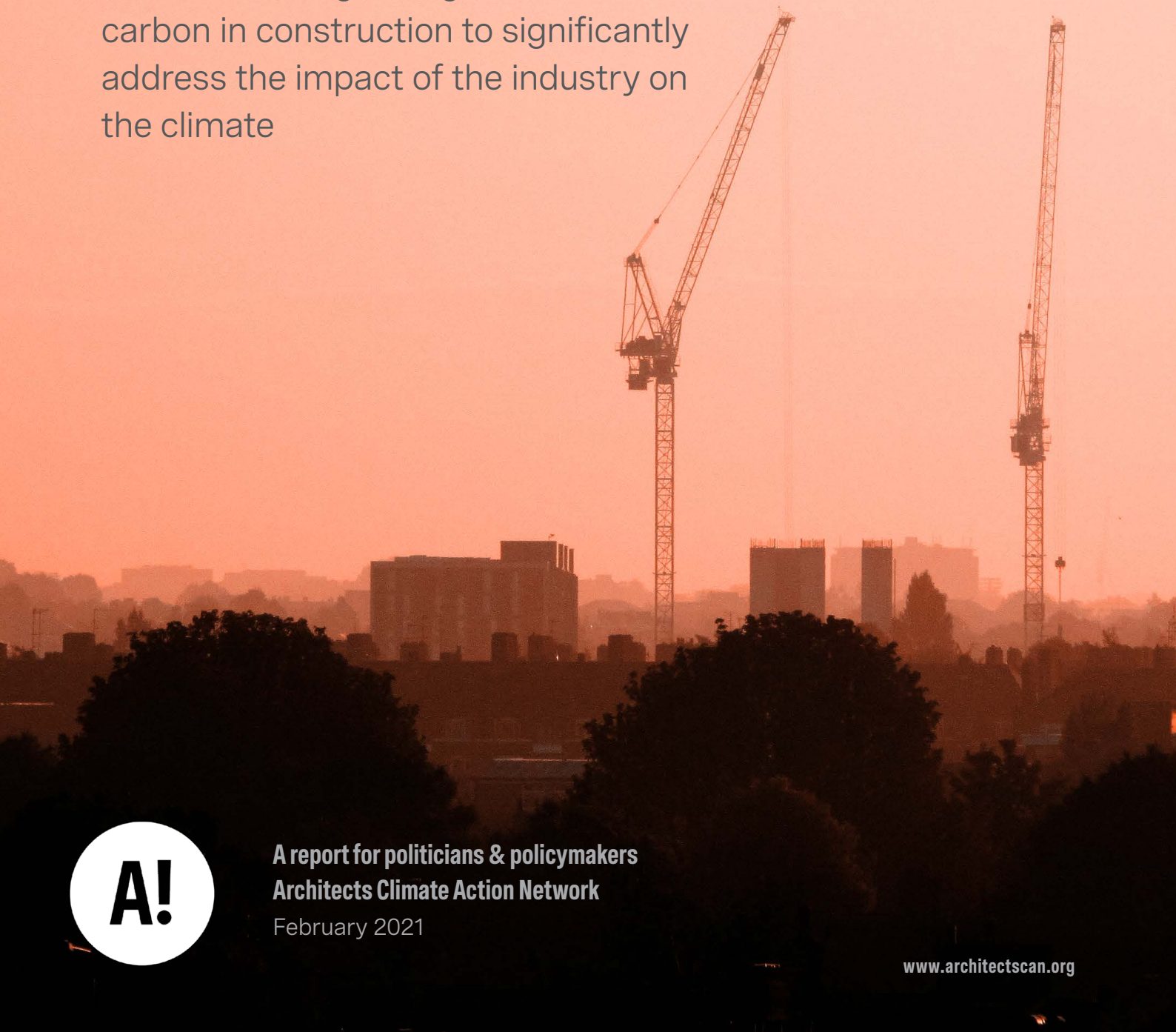
The Carbon Footprint of Construction

The case for regulating embodied carbon in construction to significantly address the impact of the industry on the climate



A report for politicians & policymakers

Architects Climate Action Network

February 2021

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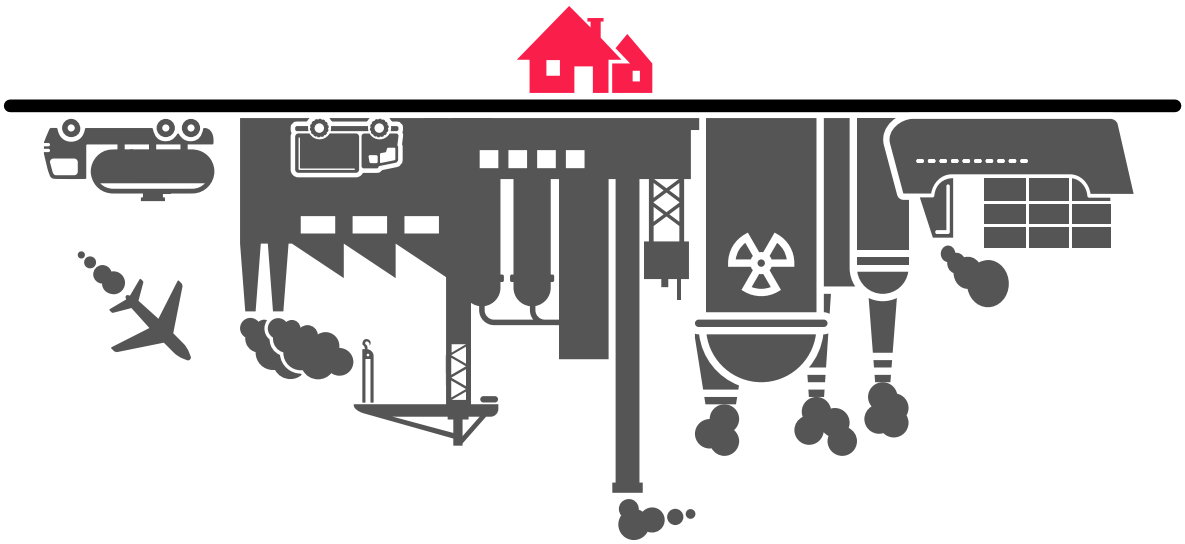

Architects Climate Action Network

Architects Climate Action Network **(ACAN)** is a voluntary network of individuals from within architecture and its related built environment professions taking critical action to transform our industry in the face of the climate and ecological crises.

Our Mission

ACAN exists to address the way our built environment is made, operated and renewed in response to the climate emergency. As a network of construction industry professionals, we channel personal energy, expertise and action towards a common goal; the systemic change of our profession and the construction industry as a whole. We see this as a matter of urgency. ACAN empowers individuals to pro-actively seek change and facilitates collective effort through a shared platform built on collaboration.

ACAN is driven by three aims: **Rapid decarbonisation** of the built environment, **Ecological regeneration** through the immediate adoption of regenerative & ecological principles, and **Cultural transformation** of the profession.

Our approach to this report

The authors met with representatives from other organisations and initiatives that are also currently engaged with efforts to further the industry's response to tackling embodied carbon and whole life carbon in construction. A detailed literature review was undertaken to capitalise on the wealth of research and investment that has been made to date. Interviews were held with industry experts, and campaign workshops were facilitated to capture a wide range of experiences and views. This report has undergone an industry consultation process to establish a platform of consensus.

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Revision A

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Endorsements

ASBP The Alliance for Sustainable Building Products

UNIVERSITY OF BATH

Confederation of Timber Industries

LETI

Timber Trade Federation
growing the use of wood

woodknowledge WALES

You've bought a new home, or moved into a brand new office. Before you've even stepped through the door, turned on the lights, switched on the heating or used hot water, that building may have caused more than half of the carbon emissions than it will over its lifetime.

These upfront carbon emissions are not regulated. Developers, architects, engineers, and contractors know how to lower these emissions, but don't have to by law.

Suppliers and manufacturers are not required to measure and declare the carbon emissions caused by building materials.

Since 2007 professionals have been advocating for embodied carbon generated by the construction industry to be regulated, to no avail. This report outlines how we, as an industry, are able and ready to measure, report and reduce embodied carbon emissions.

It also calls for policy makers to fill the huge legislative gap that currently exists by regulating these hidden emissions with no further delay.

Contents

Glossary of Terms

CCC - Committee on Climate Change
EPD - Environmental Product Declarations
GEA - Gross External Area
GHG - Greenhouse Gas
GWP - Global Warming Potential
LCA - Life Cycle Assessment
NIA - Net Internal Area
NZC - Net Zero Carbon
MHCLG - Ministry of Housing, Communities & Local Government
RICS - Royal Institution of Chartered Surveyors
WLCA - Whole Life-Cycle Carbon Assessment

Executive summary

49%

of UK total carbon emissions are attributed to buildings

50m

tonnes of CO_2e are released every year into the atmosphere from new buildings and infrastructure alone

In the context of the Climate Emergency, ACAN is calling for the urgent introduction of legislation to regulate embodied carbon emissions generated by construction activities in the UK.[1] These emissions amount to just under 50MtCO_2e per year[2] and as it is estimated that 49% of the UK total carbon emissions are attributed to buildings, their contribution to the global greenhouse effect is significant.[3]

Despite this, embodied carbon emissions are unregulated in the UK. Current policy and regulation focus solely on operational energy use as distinct from embodied carbon, and there are currently no national planning policy or building regulation requirements to assess, report or reduce embodied carbon emissions.

As described in this report, considerable work has been undertaken within the UK construction industry over the last 15 years in order to address the need for reduction in embodied carbon. This ranges from the creation of datasets to the adoption of standards for the measuring of embodied carbon.

Worldwide, a number of countries have stepped up to the Climate Emergency challenge. These countries are continually introducing new policies and regulations that reduce the embodied carbon emissions of buildings, and ensure that the construction industry is considered within a shift to a low carbon economy, in line with The Paris Agreement. A limited selection of these approaches are presented within this report, to demonstrate what can be achieved and to identify a national approach suitable for the UK.

In light of this information, ACAN believes that only new regulations covering embodied carbon emissions will enable the UK to meet its commitments under the Paris Agreement and reduce its emissions to true net-zero (which must include both operational and embodied carbon emissions) by 2050; now a legal obligation enshrined in the Climate Change Act 2008.

In this report ACAN asks for clear actions to be urgently adopted for the regulation and thus the dramatic reduction of embodied carbon emissions, with no further delay. These actions include:

The Building Regulations

- **Expanding The Building Regulations** to include requirements to assess, report and reduce embodied carbon, within a new part: **"Part Z: Embodied Carbon Emissions"**
- Compliance to be achieved through a **"Whole Life-Cycle Carbon Assessment"** following the British Standard BS EN 15978
- **Limits placed on embodied carbon emissions** set by building type
- **Regulation 7** to be revised to introduce carbon limits on specific materials

Planning Policy

- **Clauses to be introduced to the National Planning Policy Framework** with requirements for Whole Life-Cycle Carbon Assessments to be submitted at three stages for all new buildings; as part of pre-application enquiries, full planning submissions, and at practical completion
- As an immediate measure **New London Plan Policy SI2** to be adopted by local authorities around the UK

Whole Life-Cycle Carbon Datasets

- **Create a freely accessible UK Environmental Product Declaration (EPD) database**, or adopt an existing freely accessible database, to ensure consistent and reliable assessments
- **Require Environmental Product Declarations** to be submitted to the database from construction material suppliers above a certain size, with trade bodies assisting smaller organisations[4]
- **Establish a freely accessible database for anonymised Whole Life-Cycle Carbon Assessment data of new buildings**, to ensure lessons are widely learnt.

In parallel ACAN has set out a timeline that will enable the UK to meet its commitments to be Net Zero Carbon by 2050 and includes the following milestones:

2021

- Adopt the RICS "Whole Life Carbon Assessment for the Built Environment" professional statement[5] as the nationally agreed methodology for measuring embodied carbon emissions, as set out by BS EN 15978
- Regulation 7 to be revised
- New London Plan Policy SI2 to be adopted by local authorities around the UK

2022

All developments required to assess and report embodied carbon emissions

2025

Introduce strict limit values on embodied carbon emissions for all developments

2028

First reduction in limit values for all developments

2030 - 2040

Continually review and lower the embodied carbon limit values. By 2040 whole life-cycle carbon emissions for all new and refurbished buildings should achieve net-zero.[6]

ACAN believes that no building stone should be left unturned when it comes to the accountability of carbon emissions. Yet embodied carbon emissions will remain the unturned stones of the UK construction industry - with dramatic consequences for the lives of millions - as long as these proposed measures are not adopted.

As a voice amongst many in the construction industry, but also on behalf of ordinary citizens, we have no alternative but to demand immediate action from the UK Government.

Introduction

The Construction Industry and the Climate Emergency

The UK construction industry is increasingly aware of the impact of its activities on climate change and the environment. This impact - 50Mt carbon emissions equivalent (CO_2e)[7] released in the atmosphere per year[8]- amounts to nearly half of the UK total greenhouse gas emissions.[9] Yet currently embodied carbon emissions - those related to the extraction of materials and subsequent construction of a building or infrastructure - remain unregulated in the UK. As such, they continue to contribute to the hidden and unaccounted cost of our built environment on climate change, which has now reached a level of climate emergency.

2025

Limits on embodied carbon emissions to be introduced for all developments

For the last fifteen years various industry organisations have been working on developing datasets and methodologies to measure, record and benchmark these carbon emissions. Since 2005, data from hundreds of buildings has been collected whilst in more recent years more toolkits and guidance - many freely available - have been produced by construction professionals and leading institutions: The Royal Institute of British Architects (RIBA), Royal Institute of Chartered Surveyors (RICS), the Institute of Structural Engineers (IStructE), and the Chartered Institution of Building Services Engineers (CIBSE). Furthermore, a standardised calculation method for measuring embodied carbon already exists, as set out in British Standard EN 15978:2011 and which is widely adopted in the industry.

This industry-wide effort has culminated in 2019 in the creation of Architects Declare in the UK, a network of (now thousands) architectural practices committed to tackling the climate and biodiversity emergency. It was soon followed by Engineers Declare and Construction Declare, all committing to the global call for taking 'positive action in response to climate breakdown and biodiversity collapse'.[10] The UK's construction industry is thus clearly gearing up to tackle this issue and is ready for a legislative programme to be enacted as called for by the World Green Building Council.[11]

In parallel, in the UK alone, more than 300 District, County, Unitary and Metropolitan Councils have also declared a Climate Emergency, over 60% of which acknowledging that carbon neutrality needs to be achieved by 2030 if not before.[12]

With no further delays the construction industry needs support and legislation in place to rise to the challenges and address the climate emergency as declared by the UK Parliament on 1st May 2019 and laid out in clear scientific terms in a 2018 report from the **UN Intergovernmental Panel on Climate Change, 'Global Warming of 1.5°C'.**[13] In its 2020 Progress Report to Parliament, The Government's own advisory body on climate change, the CCC, recommended for this to be addressed by introducing a number of the measures that we call for in this report.[14] This recommendation builds upon earlier work by the CCC exploring a number of options for how embodied carbon could be tackled through the building standards framework.

This report, divided into **9 key sections**, aims to present a clear case for why a change is now urgent and what action is required by The Government.

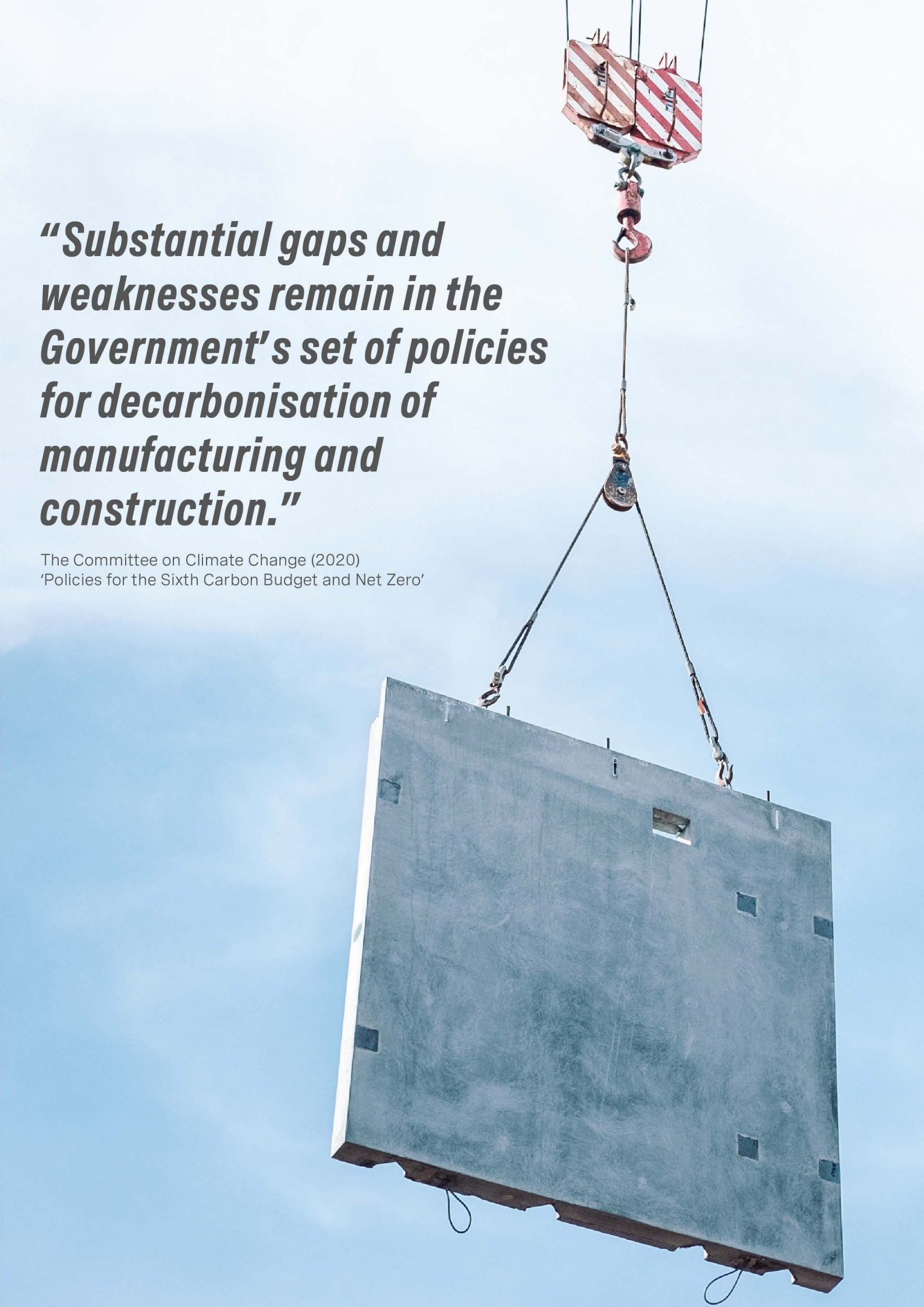
The **definition of embodied carbon** as it relates to the construction industry and the **impact of the industry-wide carbon emissions** are presented in the **first and second sections** of this briefing report, establishing the case for the urgent need to adopt regulations in the UK. This is followed by a **third section** on the **wider public benefits** such regulations would bring, from supporting the creation of thousands of 'green' jobs in the UK; turning a nascent circular economy into a thriving economic model, to the creation of healthy buildings and the acceleration of technological, and scientific R&D innovation of new materials.

The **fourth section** explains what measures can be adopted by construction professionals in order to achieve a significant **reduction in embodied carbon in the building sector**. It shows how any approach to reducing embodied carbon revolves around material use. The **fifth section** presents the options available for **regulating embodied carbon** with two broad approaches described: the whole building scale and the product/material scale.

In the **sixth section 'Our Proposal'** we identify 6 key routes policy makers can use at both local and national levels to introduce relevant policies. We contend that the most effective approach is the phased introduction of whole life-cycle carbon limits for new buildings. The **seventh section** details a selection of **'Supporting Policies'** that could be adopted as identified by the Carbon Neutral Cities Alliance from real-life global examples.[15] In an **eighth section**, the report presents a number of **'International Examples of Regulation'**, i.e. policy templates which we believe could be easily adapted to the UK context. The merits of these approaches are described.

In the **ninth and last section, 'Next Steps - Laying the Groundwork'**, we have set out a timeline that will enable the UK to meet its commitments to be Net Zero Carbon (NZC) by 2050 and includes key milestones from immediate action to a gradual implementation of measures that would allow the assessment and reporting of whole life carbon emissions, and result in the introduction of strict limit values for embodied carbon for all developments in 2025. We anticipate a period of 10 years or so during which life carbon caps would be further reviewed and reduced to eventually lead to all new and refurbished buildings achieving net-zero by 2040, ensuring further adaptation if necessary for the industry to be NZC by 2050.[16]

With COP26 fast approaching, there is an opportunity here for the UK to lead, by setting out a clear timeline for the introduction of regulatory requirements for new buildings to assess, report and reduce emissions over their entire lifespan, taking into account both embodied carbon emissions and operational energy use. The measures presented in this report would ensure the UK is fully able to commit to its climate change commitments, by tackling the hidden emissions behind our thriving construction industry.



"Substantial gaps and weaknesses remain in the Government's set of policies for decarbonisation of manufacturing and construction."

The Committee on Climate Change (2020)
'Policies for the Sixth Carbon Budget and Net Zero'

What is Embodied Carbon?

The term embodied carbon refers to all greenhouse gas (GHG) emissions associated with the extraction and manufacture of a product or delivery of a service. They differ from operational carbon emissions, which are associated with the energy used in heating, cooling, lighting, and powering a building or related equipment (e.g. lift). Embodied carbon emissions are measured in tonnes or kilogrammes of carbon dioxide (CO_2) equivalent (e) - as CO_2 is the most prevalent GHG in the atmosphere - and expressed in tCO_2e or $kgCO_2e$.

In buildings, embodied carbon includes emissions associated with the extraction and supply of raw material, their transportation to the manufacturing plant and their manufacturing and fabrication into building materials and products. Following this product stage, construction causes further emissions through the transport of these materials and assembly on site, and the construction and installation process on the project site itself. These are also known as 'capital', 'embedded' or 'upfront' carbon emissions. Lastly embodied carbon emissions are generated through repair, refurbishment, and maintenance throughout a building's lifespan, and finally the disposal of these materials and products or demolition at the end of a building's life.

Embodied carbon emissions are therefore additional to the emissions related to a building's in-use energy consumption. They represent a huge release of carbon into the atmosphere in a relatively short space of time before the building is occupied and the lights switched on, as a direct result of the building's creation. There are variations per building types but across all buildings large amounts of CO_2e are caused by building elements such as the structure or facade, the impact of which is led by the form and nature of the development.[17] The IPCC's report outlines the critical 10-year window that we as a planet have to change our GHG emissions trajectory, underlining the critical importance of regulating these upfront carbon emissions.

Figure 1 illustrates the typical breakdown of the GHG emissions associated with three building types, showing that the embodied carbon of a building can be up to 75% of its total emissions over a typical 60-year lifetime.

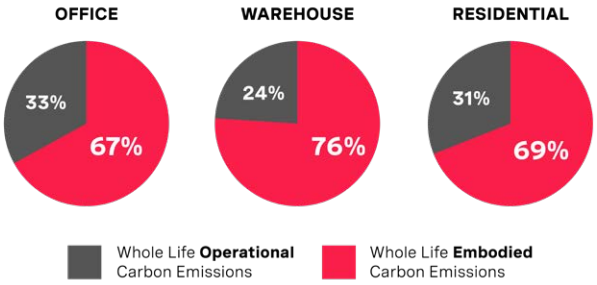


Figure 1: Embodied carbon emissions as a percentage of total building emissions - in pink. Source: Graphics based on data from Sturgis Carbon Profiling / RICS

75%

of a building total emissions from a typical 60-year lifetime can come from embodied carbon

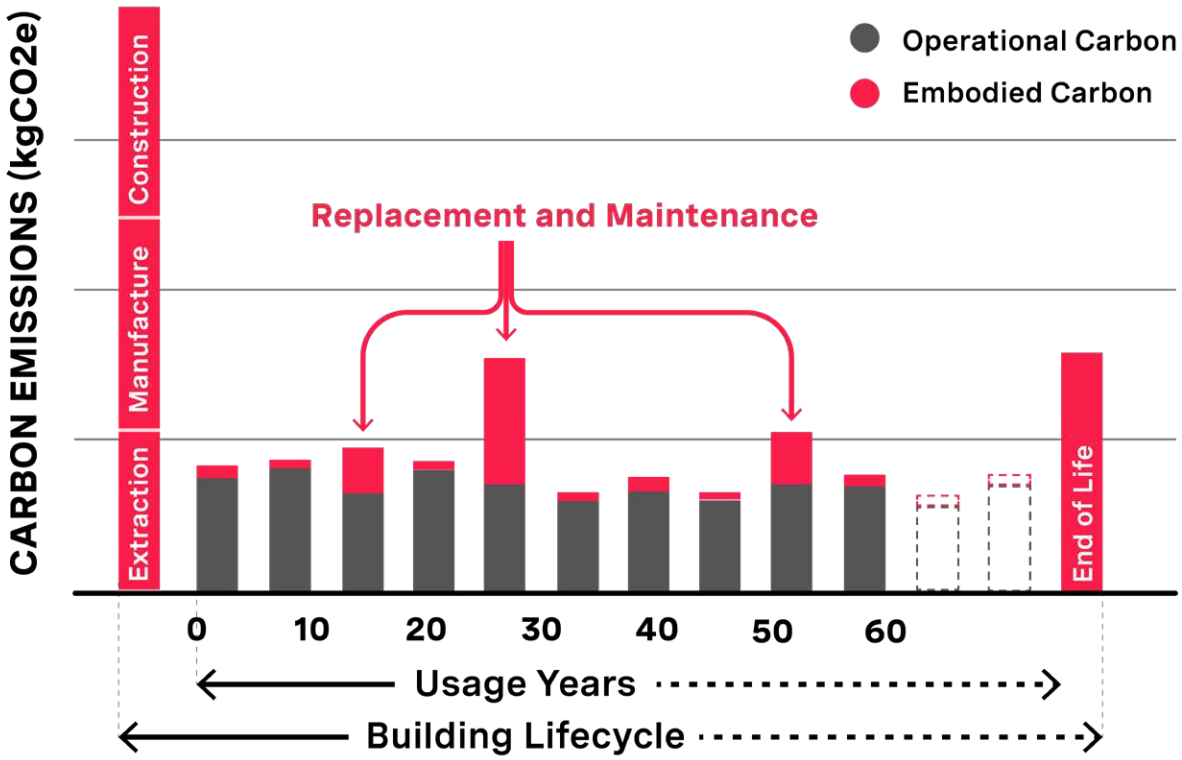


Figure 2: Indicative carbon emissions throughout the lifecycle of a building. Source: Graphic developed from work by LETI[18]

The graph in Figure 2 above illustrates how the total carbon emissions of a building are spread over a 60 year lifespan. The pink spike at the start of the graph represents the huge bulk of upfront carbon emissions. It also illustrates that embodied carbon is emitted throughout the entire life-cycle of a building. The embodied carbon and operational carbon related to energy use constitute together what the industry calls the Whole Life-Cycle Carbon Emissions of a building.

Currently, and despite their significance, embodied carbon emissions of buildings are unregulated in the UK and have been little discussed in public until recently. They constitute the hidden carbon footprint of buildings. Whilst operational energy use can be improved during the lifecycle of the building, the significant upfront embodied carbon emissions cannot, which is why regulating them is urgent. In most of the buildings we build between now and 2050, embodied carbon emissions will be more significant than those emissions released through energy use. This is a crucial point that the sector, including Local Authorities and Government, need to acknowledge when referring to Zero Carbon ambitions and targets. Failing to do so would be turning a blind eye to the majority of emissions.

In most of the buildings we build between now and 2050, embodied carbon emissions will be more significant than those emissions released through energy use.

Built environment professionals have been discussing the potential to regulate embodied carbon emissions since the 2007 Sullivan Report,[19] which recommended limiting the embodied energy of construction products, but noted that this was not possible at the time as such rules could contravene the now withdrawn EU Construction Products Directive. In 2014, the Embodied Carbon Industry Task Force, a group set up to ensure that embodied carbon would be considered in building design and to build a consensus on how it would be measured and reported, recommended that embodied carbon be included within the Zero Carbon Building regulations.[20] Unfortunately in 2015 The Government scrapped the plans for the Zero Carbon building regulations, and with it closed this route to embodied carbon legislation.

The Impact of Embodied Carbon Emissions

As a result of this regulatory blind spot, construction industry-wide embodied carbon emissions amount to a significant percentage of our annualised national GHG emissions for all industries. This has been estimated at around 10% of the UK's total emissions and does not account for carbon emissions related to imported products. This percentage will become significantly worse as the impact of other industries continues to decline at a faster rate.

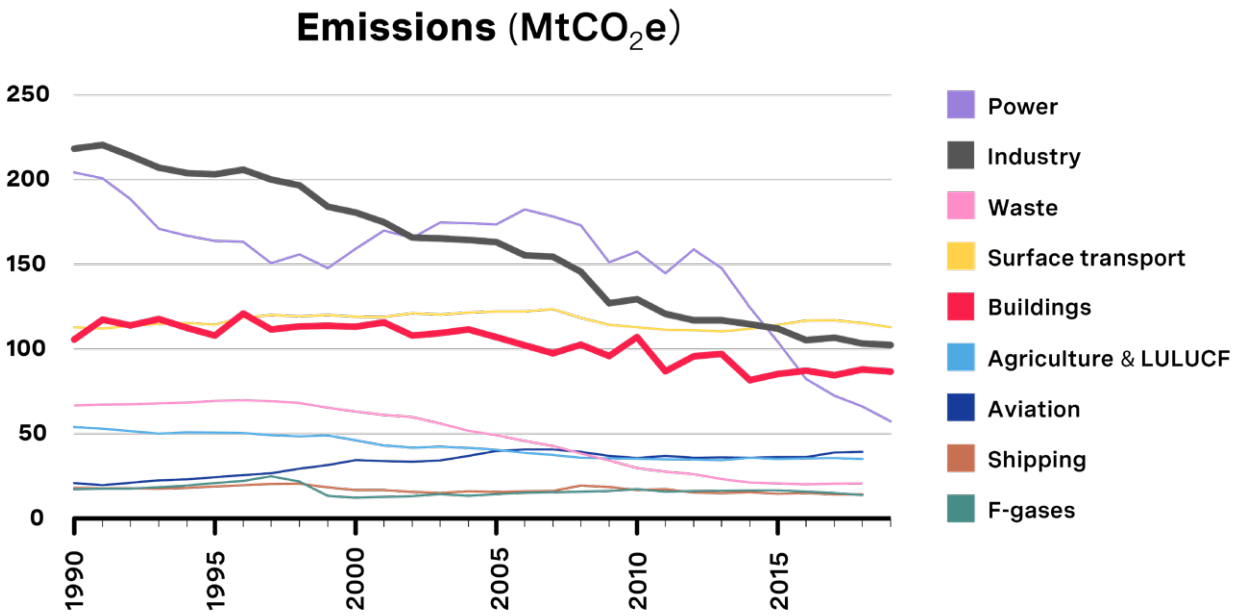


Figure 3: Buildings and Industry in the UK represent some of the highest emitting sectors and buildings have yet to have undergone significant reductions. Graphic based on work by the CCC [21]

In relation to buildings alone, it is estimated that just under 50 million tonnes of CO_2e are released in the atmosphere every year.[22] This represents the same CO_2e of 138,550 return flights from London to New York.[23] If that is not reduced dramatically in the next 15 years, the share of the construction industry carbon footprint will only increase with The Government's ambitious programme to build more housing in the UK along with the adequate infrastructure to support these developments.[24, 25]

50m

tonnes of CO_2e related to buildings is released into the atmosphere every year.

The same CO_2e as 138,550 return flights from London to New York

11%

of global greenhouse gas emissions caused by construction

The proportion of total emissions appears to be relatively consistent at international scale, with construction causing in excess of 11% of worldwide GHG emissions.[26] Domestically, Government commitments to constructing 300,000 new homes a year[27] and infrastructure projects like HS2 contribute significantly to this impact. Globally, urbanisation is forecast to expand at a rate equivalent to building a new Paris every week[28] and the World Green Building Council has pointed out that the embodied carbon emissions associated with this projected growth in building stock between now and 2050 threatens to "consume a large part of our remaining carbon budget".[29] That is, without urgent and coordinated action being taken at a government level.

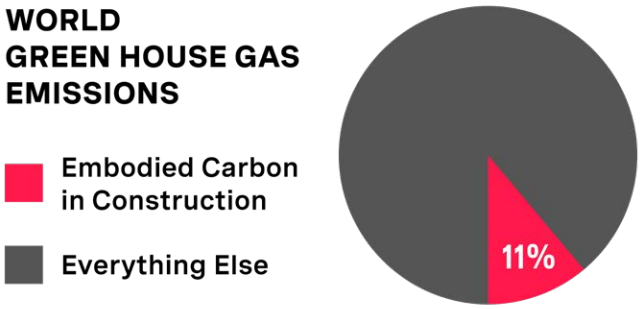


Figure 4: Worldwide carbon emissions.
Source: Graphic based on data from UKGBC/McAuley

Wider Public Benefits of Introducing Carbon Regulation

The introduction of a clear and ambitious regulatory timeline to tackle embodied carbon emissions will provide a number of clear benefits beyond the primary intention of reducing emissions:

- Support the creation of green jobs in the UK's sustainably managed timber and bio-based materials industry. This has been explored in a standalone report on the UK's bioeconomy by the CCC[30] and the Green Finance Institute[31] with further benefits to the UK's housing market highlighted by the All Party Parliamentary Group for the Timber Industries in 2019.[32]
- Deter the demolition of buildings by incentivising refurbishment, which is found to be more sustainable than demolition and redevelopment through an independent audit.
- Kickstart the nascent construction materials recycling industry. Analysis by WRAP has estimated that 500,000 jobs could be created in the UK through the transition to a more resource efficient circular economy.[33] This has the potential to embolden The Government's ten-point plan for a green industrial revolution that targets construction skills as a key transitional sector.[34]
- Incentivise the renewal of the British steel and concrete industries. As two of the UK's primary carbon intensive industries, regulation will provide market incentive for manufacturers to adapt to the UK's projected carbon budget timeline,[35] as designers seek out low carbon products.
- Provide businesses with the clear timeline they need to adapt to a net-zero carbon future. Clarity, communication, and investment will be needed to transition jobs in industries that require the greatest transformation - as called for by the internationally-recognised Just Transition framework.[36] For instance, 160,000 people are employed in the UK plastic industry.
- Stimulate the revival of British manufacturing as designers and contractors alike seek out locally made products[37] supporting up-skilling and growth in areas outside London and the South-East, including the Northern Powerhouse.
- Support the creation of healthier buildings by banning or limiting the use of certain materials with high toxicity - and conversely incentivise the use of bio-materials which have positive impacts, not only on CO_2e reduction but also well-being, productivity, and learning.[38]
- Drive scientific innovation in the development of new materials.

500,000

jobs could be created in the UK through the transition to a more resource efficient circular economy

“Reducing Carbon Reduces Cost.”

HM Treasury (2013)
‘Infrastructure Carbon Review’

Reducing Embodied Carbon in the Building Sector

There are two design approaches to the reduction of embodied carbon emissions from buildings: tackling carbon emissions in construction, repair and maintenance and further in time during demolition, disposal of waste, and re-use of material; and addressing the operational efficiency of a building to reduce use of mechanical and electrical (M&E) systems.

In terms of construction, the most impact is had by design decisions relating to the structure, facade and finishes. Design choices relating to the operational efficiency; the building envelope composition and the M&E systems in use, will also have a great impact on embodied carbon emitted.

In other words, any reduction of embodied carbon is dependant on material use, and the associated waste generated not only during construction but also beyond completion when maintenance and repair is required; when a building is being retrofitted or when it is earmarked for demolition. This is because the production of all building materials, components (incl. M&E equipment) and products generate carbon emissions, the level of which varies dramatically as extraction and manufacturing processes differ between them.

There are some very high embodied carbon materials that are used widely across the industry including but not limited to aluminium, steel, cement, and some plastic based materials. The properties of these materials - for example the versatility and durability of concrete or the efficiency of plastic insulations - warrant their use in some situations. In many other instances materials with a high carbon cost could be designed out, and this is critical if the UK is to reach its net zero carbon target by 2050.

Conversely, there are some materials that have very low or negative embodied carbon values at the point of use; bio-based materials such as softwood timber, plywood, cross laminated timber and plant fibre insulations. These remove carbon from the atmosphere as they grow and so could be used to 'lock' carbon into the building for the duration of its lifespan and beyond.

This is known within the industry as carbon sequestration and should be included within methodologies using Environmental Product Declaration data, such as PAS 2050.[39] The effectiveness of this strategy relies in part on the timeframe that 'biogenic' carbon remains within the building or component - and so is removed from the atmosphere for the coming crucial decades, whilst we transition fully in response to the twin emergencies of climate change and environmental degradation.

Another crucial aspect of the effectiveness of this strategy is the correct end-of-life processing of these materials. It is important for both material efficiency and GHG emissions that we maximise the recovery and re-use of wood. Encouragingly DEFRA's latest figures on UK waste calculates approximately 1% of wood waste going to landfill,[40] whilst more recent research suggests this has reduced to almost zero.[41]

Providing they are sustainably sourced, the overall balanced benefits associated with bio-based materials and their use in construction are many and well known, ranging from health and well-being to adequate resource management (as opposed to natural resource depletion) and ecological protection.

Low-carbon alternatives including the use of bio-based materials need not be costly. A recent study by UKGBC illustrates the cost of replacing traditional but carbon intensive materials with some low carbon alternatives to be only between 3.5%-5.3% higher in the case of an 18-storey residential building.[42]

The impacts of any material can be clearly and consistently communicated to the industry via Environmental Performance Declarations (EPDs).[43] These in effect are the equivalent to the nutritional labels on the food we purchase, informing the industry of the climate impacts a product or material has across a variety of metrics from global warming potential, to ozone depletion and toxic impacts amongst others. The production of EPDs requires capital investment from suppliers, but without the science-based messaging these provide, the industry would be hampered in its efforts to effectively and quantitatively design low-carbon solutions.

Databases exist that collate the ever-increasing global total of available EPDs across supply chains, such as EcoPlatform, and as of 2021, there are over 10,000 EPDs available[44] that comply with the relevant standard.[45] EPDs, however, are inextricably geographically-specific as they report on the impacts associated with transport and local grid carbon intensities. Crucially, in the UK there is no requirement for the supply chain to provide EPDs; this correlates with the UK's limited contribution to EPD databases and the associated challenges transferred to delivery teams.

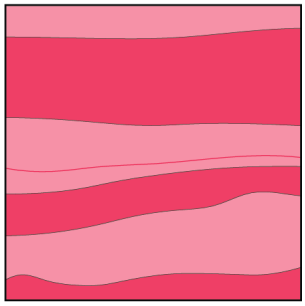
This inhibiting position can be reversed through proactive legislation. In 2014, Belgium decreed that any construction product that used environmental statements for its promotion must be accompanied by an EPD, registered within the federal database.[46] Beyond enabling an informed delivery-chain, it provides quantitative data to enable supply-side improvements and reductions in their emissions and consumer confidence against un-substantiated sustainability claims.

10,000

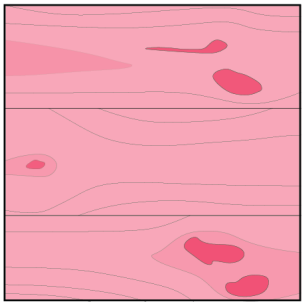
EPDs available that comply with the relevant standard

1%

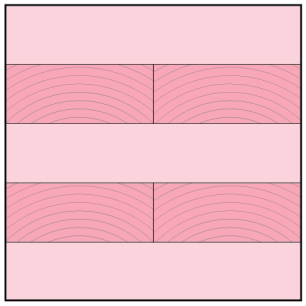
of wood waste currently going to landfill in the UK



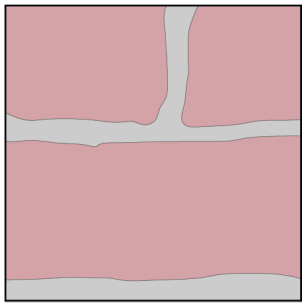
RAMMED EARTH
48 $kgCO_2e/m^3$
Ranges from 40 to 170 $kgCO_2e/m^3$



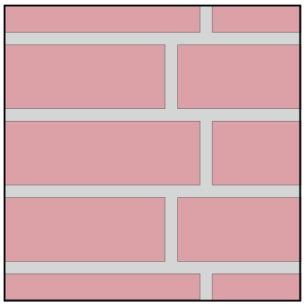
SOFTWOOD TIMBER
110 $kgCO_2e/m^3$
Ranges from 1 to 480 $kgCO_2e/m^3$



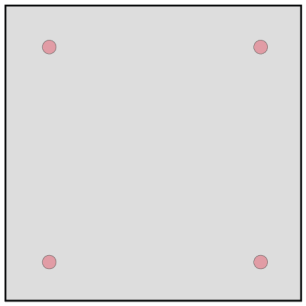
CROSS LAMINATED TIMBER
219 $kgCO_2e/m^3$
Ranges from 160 to 1,370 $kgCO_2e/m^3$



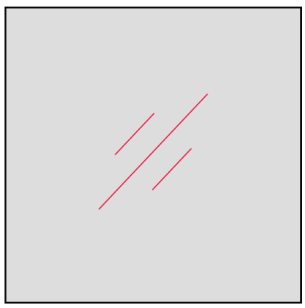
STONE GENERALLY
237 $kgCO_2e/m^3$
Ranges from 60 to 2,100 $kgCO_2e/m^3$



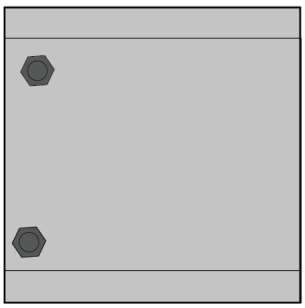
CLAY BRICK WALL*
345 $kgCO_2e/m^3$
Ranges from 260 to 1,100 $kgCO_2e/m^3$



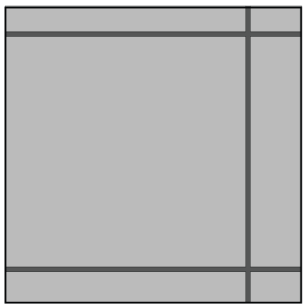
REINFORCED CONCRETE**
635 $kgCO_2e/m^3$
Ranges from 120 to 1,370 $kgCO_2e/m^3$



GLASS GENERALLY
3,600 $kgCO_2e/m^3$
Ranges from 2,300 to 5,100 $kgCO_2e/m^3$



STEEL SECTION
12,090 $kgCO_2e/m^3$
Ranges from 7,600 to 28,000 $kgCO_2e/m^3$



ALUMINIUM GENERALLY
18,009 $kgCO_2e/m^3$
Ranges from 2,400 to 58,000 $kgCO_2e/m^3$

Source: http://www.circularecology.com/embodied-energy-and-carbon-footprint-database.html
Using database summary values for product stage, does not include construction, use, end of life or benefits stages.
Ranges are presented to show how values can vary, and require interpretation based on source and analysis method.
*Based on values for brick walls, which use 1,500 bricks for m^3 of mortar
**Based on C32/40 concrete with 2% reinforcement, maxim based on 4% reinforcement

Figure 6 - The relative carbon emissions of different materials.
Source: Graphic based on illustration and research by Ciaran Malik

Through analysis and benchmarking of current practices, the construction industry has established that there are a number of steps that designers and developers can take to most effectively reduce embodied carbon emissions in new buildings and also in the process of renovating and refurbishing existing buildings .[47] These measures - all relating to material use - are summarised below.

1. Reuse existing buildings: Pursuing a strategy of retrofit, refurbishment, extension and reuse over demolition and new build. Reviewing VAT is crucial for supporting this measure[48]

2. Build using less material: Designing more efficient and lightweight structures and designing out waste

3. Build using low carbon materials: Use materials that have low or close to zero embodied carbon emissions

4. Build using certified recycled material: Moving towards a circular economy and reusing building materials and products derived from low-carbon recycling processes that can be repeated almost perpetually without quality loss

5. Build using long lasting and durable materials, designed for easy disassembly: Avoid products that require frequent maintenance or replacement but that can be dismantled for reuse

6. Build flexibly and for future adaptability to allow for the re-purposing of buildings

Yet for the above measures to be most effectively adopted, new regulations are required. In order to help inform where embodied carbon emissions reductions should be made, it is vital to first understand the specific impacts of materials and products used in new buildings and built assets on a case by case basis, starting at the early design stage. A construction industry standard has emerged for this kind of assessment, called a Whole Life-Cycle Carbon Assessment (See Glossary). The industry is not currently required to carry these out, the exception being for referable developments captured by the Greater London Authority's pioneering policy, and in a small number of local authorities, including Greater Manchester,[49] which are leading the way in requiring large developments to report on their carbon emissions and demonstrate efforts taken to reduce them.[50]

This means that proper assessments to help drive the reduction of embodied carbon are carried out only on a voluntary basis, and results are piecemeal. In its June 2020 "Progress Report to Parliament" the Committee on Climate Change addressed this and recommended that government support was given to the "assessment and benchmarking of whole life-cycle carbon emissions in buildings",[51] before the end of the year.

Rather than disputing the importance of this recommendation, The Government's response positions that such commitment would not be possible without a standardised method of calculation supported by a robust evidence base.[52] However, the industry is already equipped with these; in the form of BS EN 15978 as a framework, the RICS methodology, and significantly developed EPD databases such as EcoPlatform. If The Government perceives these as inadequate, inspiration can be found in other governments who have taken leadership to spearhead and support this challenge.

Within manufacturing, the transition to a zero carbon economy will require, in the simplest terms, "material substitution from high-embodied-carbon to low embodied carbon materials." [54]

Meanwhile, the RIBA[53] and LETI[54] have published voluntary targets and schemes for operational and embodied carbon figures which, whilst not yet fully aligned, show the industry's progressive action towards this challenge. Their work has quantified the damage if we continue to 'Build as Usual', and also outlined what 'Good' could be.

Within manufacturing, the transition to a zero carbon economy will require, in the simplest terms, 'material substitution from high embodied carbon to low embodied carbon materials.'[55] In December 2020, the Committee on Climate Change released its Sixth Carbon Budget, highlighting the emissions pathway UK industries will need to take between the years of 2033-37 in order to reach our 2050 goal. Their projections for the 2030s rely on immediate leadership and commitment this year towards a reduction in cement, mortar and brick production and an increase in timber production, as well as the substitution of high-carbon clinker within cement for waste products or 'innovative new types of lower-carbon cementitious materials'.

In this context the industry, whether at the design, construction or product stage, now requires the UK Government to set out what the next steps will be towards the introduction of regulations or policy to drive these reductions across all works for new and existing buildings. In order to increase professional knowledge and capability, a timeline should be set out for the adoption of whole building carbon calculations as a mandatory requirement. ACAN's proposal is outlined in the section 'Next Steps - Laying the Groundwork' further down in this report.

In addition to this, The Government should set out which, if any, materials will see carbon intensity limits placed upon them. These two approaches, targeting whole buildings or specific materials, for example in retrofitting, are looked at in further detail below.

"Whole new industries will be created and existing industries transformed as we move towards a low carbon, more resource-efficient economy."

UK Government Industrial Strategy white paper, 2017

Options for Regulating Embodied Carbon

When deciding how to introduce regulation or policy to tackle embodied carbon emissions in buildings there are two broad approaches that could be followed: the whole building scale and the product/material scale. An Aecom report produced for the CCC in 2019, **'Options for incorporating embodied carbon into the building standards framework'**, found that the most effective driver for reductions in embodied carbon is likely to be the introduction of mandatory targets, and that these could be applied at either scale. ACAN recommends these targets are aligned with Science Based Targets.[56] The two approaches do not preclude each other, and indeed could be complementary. Introducing policy or regulations at either scale would drive innovation within the sector.[57]

Suggested steps and best practice for both approaches are set out below, drawn from the Aecom report, with additional input from a 2018 review of carbon reduction systems globally, produced by Bionova:[58]

- Embodied carbon intensity reductions: Assessment should be targeted at the early phase of the project, through early planning processes, led by policies. Set requirements based on official standards and agreed methodologies. Agree a method for setting carbon limiting values and set out incentives for making carbon reductions. Set a clear timeline for how embodied carbon limits for common building types will be introduced, and begin to collect the data to inform these benchmarks. Set compliance requirements and ensure standards are upheld by developing the capacity of Building Control officers. Progressively tighten targets to drive lifecycle carbon savings.
- Elemental (products, materials or building elements) carbon intensity reductions: Identify elements, product types and material substitutions (for new build or refurbishment) with the highest life-cycle carbon values. Set carbon intensity limits for these elements, product types and materials, initially near levels met by incumbent options to support their adoption. Set a trajectory to reduce the limits for each element. Shift to regulation based on whole building carbon intensity targets once the groundwork has been established.

"The UK's two largest housebuilders confirmed they do not require a long lead in time to deliver higher standards..."

Business, Energy and Industrial Strategy Committee:
'Energy efficiency: building towards net zero' 12 July 2019

Our Proposal

There are myriad opportunities for policy makers to drive a reduction in embodied carbon emissions following either the elemental or whole building approach, and these can be deployed at both local and national levels. In the UK we have identified 6 key routes to introduce policies:

- Building Regulations
- National Planning Policy
- Local Planning Policy
- British Standards
- Public Procurement[59]
- Tax Rules[60]

We propose the most effective route to driving the necessary reductions in embodied carbon emissions, across the entire lifespan of a building, to be the phased introduction of whole life-cycle carbon limits for new buildings.

Assessment should be required at a number of stages and mandated within Building Regulations, National Planning Policy Framework & Local Planning Policy. This would bring embodied carbon emissions into the UK's building standards framework and in-line with considerations of operational energy use.

A mandatory requirement for assessment could be set a number of years ahead of the introduction of limit values, allowing the industry time to adapt and plan for the change. This would also allow for the collection of data to help inform targets, which could be set according to building type. Once introduced, the targets should be reduced incrementally every few years, towards zero. When the regulation is fully implemented, new buildings would need to be designed, constructed, and operated to not exceed established whole life carbon or embodied carbon limits.

In the following sections we set out Supporting Policies, International Examples, and Next Steps.

Main Proposed Policy

Embodied carbon limits for new buildings

Scope: National & Local

Policy Levers: Building Regulations, National Planning Policy Framework, Local Plans/Codes.

Planning Policy: Set out requirements for whole life-cycle carbon assessments to be completed at the early design stages, to be submitted as part of pre-application enquiries and full planning submissions for all developments.

Building Regulations: There are a number of options for how the Building Regulations could be revised to include whole life-cycle carbon limits;

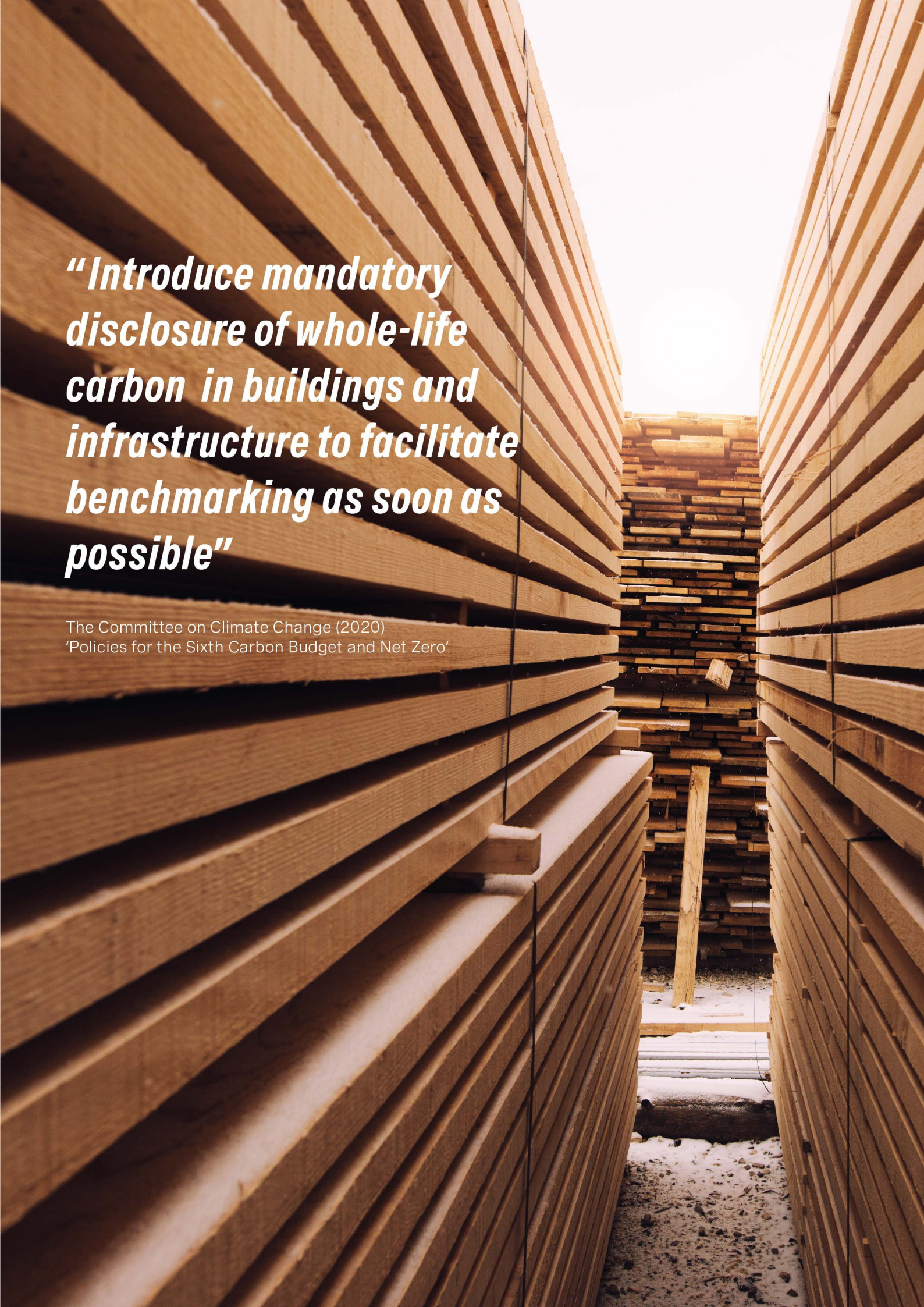
A new part to the Building Regulations, 'Part Z', could be introduced that covers embodied carbon emissions alone, for both works to new and existing buildings. Whole life-cycle carbon assessments would provide pathways towards complying with both Part L and the new 'Part Z', resulting in publicly available data similar to DEC ratings[61] as a feedback loop to the industry. A dedicated Building Regulation would ensure cross-profession engagement.

Alternatively, Part L of the Building Regulations, that covers aspects of operational energy use, could be expanded to bring embodied carbon emissions directly alongside operational energy use. However, it has historically omitted significant aspects of operational energy use, resulting in incomplete data and would more accurately represent operational energy use through requiring dynamic simulation modelling such as CIBSE's TM54.[62] During its review as part of the forthcoming Future Homes Standard, The Government confirmed that embodied carbon regulation would not be included within this Standard.[63]

Part 7, that covers materials & workmanship, could be amended to include limits of embodied carbon emissions, to sit alongside the limits already placed on operational energy use in Part L.

Agreed Methodology: British Standard BS EN15978:2011[64] and the RICS "Whole Life Carbon Assessment for the Built Environment" methodology statement.[65] Supported by a reporting template informed by the GLA's Whole Life-Cycle Carbon Assessment template.[66]

How will this reduce emissions?: Currently only a building's operational energy is regulated, but through introducing strict limit values on embodied carbon, all schemes will be required to consider and reduce these. Achieving net zero or low embodied carbon targets would require offsetting through verified schemes as a final step, which could provide significant financial investments into green technology and initiatives. Similar to offsetting for operational energy emissions, it should be of a similar quantum to disincentivise reliance on them.



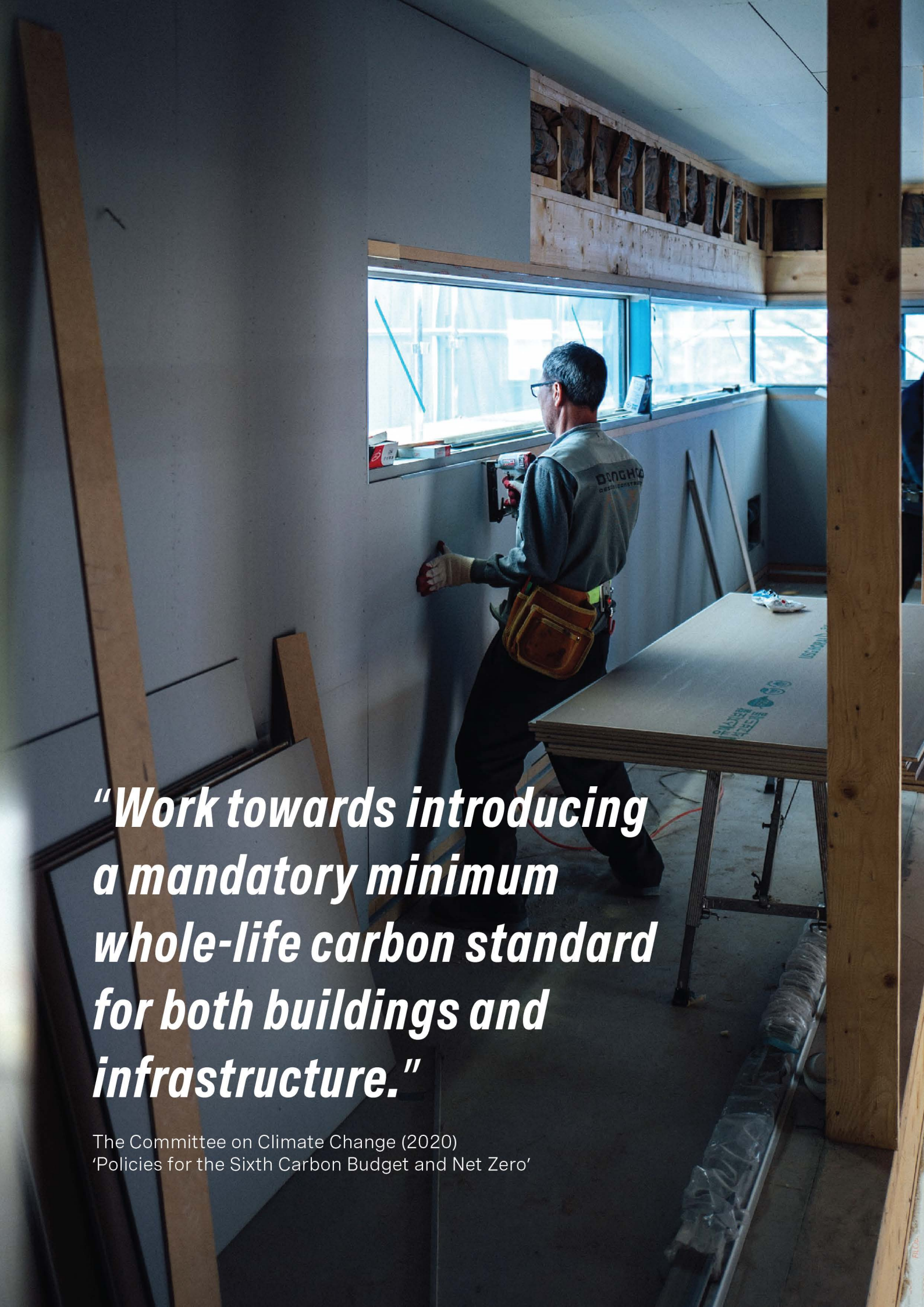
"Introduce mandatory disclosure of whole-life carbon in buildings and infrastructure to facilitate benchmarking as soon as possible"

The Committee on Climate Change (2020)
'Policies for the Sixth Carbon Budget and Net Zero'

Supporting Policies

This should be supported by policies that take varying approaches applied at a number of levels. Change has begun in limited areas of supply chains, however, regulations and policies can set new minimum standards. **The Carbon Neutral Cities Alliance has identified 52 policies from real-life global examples of how to drive reductions in embodied carbon**. We have selected those with the potential to be most impactful and applicable to the UK context and discussed these below.[67]

Life-cycle carbon calculation and reporting Introduction of a requirement for any new development or refurbishment of a minimum size to calculate and report life-cycle carbon emissions using a standardised measure. (Policy R9)	**Life-cycle carbon limits for new buildings** New buildings would need to be designed, constructed, and operated to not exceed established whole life carbon, or embodied carbon limits. (Policy R1)
Whole life carbon evaluation of retrofit versus redevelopment Comparative whole life carbon studies to be undertaken to inform the evaluation process between retrofitting or demolition and redevelopment. (Policy M6)	**Limiting the environmental damage from concrete** Require reporting of the volume and greenhouse gas emissions from concrete used for building and infrastructure projects, against set limits, to drive low carbon solutions (Policy R2)
Carbon limits for key materials Require Environmental Product Declarations to be submitted for specific material types for public projects and set global warming potential caps for each of these products. (Policy P1)	**Material-efficient structural design requirement** Improving the efficiency of a building's structural design in order to reduce material use and therefore lower embodied carbon. (Policy R3)
Bio-based materials for designated areas of development Introducing a requirement for the use of low carbon impact and ecologically beneficial materials in designated development areas based on building typologies (Policy Z2)	**Declaration of construction materials carbon efficiency** Introduction of a requirement for any new development and refurbishment of a minimum size to declare structural and building envelope material efficiency expressed in material mass per m^2. (Policy R6)
Embodied carbon targets for designated areas of development Introducing a requirement for assessment of development areas based on the potential embodied carbon impacts taking into consideration soil conditions and building typologies as well as transportation and energy use. (Policy Z1)	**Salvaged, reused or recycled material minimums** Requirement for all local authority construction projects to meet minimum levels for the use of salvaged, reused or recycled materials. (Policy M7)
Carbon-scoring of local authority land for sale or leasing Bids for the purchase / long-term lease of land owned by local authorities to be scored against a life-cycle carbon efficiency criteria. (Policy Z3)	**Increase demolition permission fees** An increase on demolition permission fees for existing buildings, based on their evaluated suitability for re-use. (Policy F6)



"Work towards introducing a mandatory minimum whole-life carbon standard for both buildings and infrastructure."

The Committee on Climate Change (2020)
'Policies for the Sixth Carbon Budget and Net Zero'

International Examples of Regulation

A number of countries have and continue to introduce policies and regulations to tackle the embodied carbon of new buildings and construction and ensure that industry can become part of the shift towards a low carbon economy whilst meeting their commitments under The Paris Agreement. A limited selection of different approaches taken internationally are described below. Between them, they cover a spectrum of measures that address the issues highlighted in this report. We identify some common themes and explore the benefits and shortcomings of each in order to help shape an approach suitable to the UK.

The Netherlands

In The Netherlands, The Building Act was updated in January 2013 to require all new residential and office buildings in excess of 100m^2 to account for their embodied carbon emissions and report this calculation in order to obtain a building permit. This is known as the building's 'MPG' value (shorthand for 'Mileau Prestatie Gebouwen' which translates as Environmental Performance of Buildings) and is calculated by performing a life cycle analysis (LCA) of all of the materials and products that are used in the building. This is made possible through a nationally agreed assessment method and an associated database of life cycle impacts: the Dutch National Environmental Database. It is important to note that both of these elements are managed at a national level to ensure consistency and certainty in data and reporting requirements that is vital for developers, housebuilders and contractors.

Since January 2018 a strict limit value has been in place on the 'MPG value'. All new offices and homes over 100m^2 need to meet this value. As of January 1st 2021, this limit value will reduce by 20% and further reductions are planned for the future ensuring a sequential reduction towards zero. For most construction materials in the Netherlands a LCA calculation is available in the Dutch National Environmental Database. The LCA calculation takes into account 11 environmental indicators: these range from Global Warming Potential to Ozone Depletion and Human Toxicity.

Key Features of the Dutch regulation

- Mandatory reporting of Environmental Performance (EP) of all new residential and office buildings >100m^2 since 2013
- 'Value' of EP for residential / office buildings >100m^2 capped since 2018
- Sequential reduction of EP Value over time to reach net zero
- National environmental database / Life Cycle Assessment calculation
- 11 environmental indicators considered including GWP and toxicity

Finland

Finland is developing a new building regulation to be introduced by 2025. Monitoring and reporting of embodied carbon emissions, as well as operational energy use, will be required through a whole life carbon assessment of all new buildings. The regulation will also introduce strict limit values or carbon budgets for all new buildings that will require reductions from the moment the regulation is introduced. The carbon budgets will be set by building type and accurate assessment will be made possible by The Government establishing a national database of Environmental Product Declarations, the documents that describe environmental data for materials and products. The budgets will be sequentially lowered in order to ultimately require all new developments to have net-zero carbon emissions associated with their construction and operation. The policy is being developed as part of Finland's world-leading aim to be carbon neutral by 2035 and carbon negative by the 2040s.

Key Features of the Finnish regulation

- Whole Life Carbon Assessment required
- The regulation will apply to all new buildings
- It will not apply to refurbishment or retrofit works
- Strict limit values, or 'carbon budgets', set by building type
- National Environmental Product Declaration /Life Cycle Assessment Database established
- Positive effects such as sequestration or offsets will be accounted

In France, 60% to 90% of the total carbon emitted by buildings come from the construction and demolition phases. [67]

France

The current French environmental regulation, called 'RT 2012' is building on consecutive improvements over time of the buildings' environmental performance but focuses solely on the operational energy use. However, an upcoming revision of the regulation for mid-2021, called 'RE 2020', responds to research showing 60% to 90% of the total carbon emitted by buildings come from the construction and demolition phases[68]. The regulation will aim at further improving building performance, ensure summer comfort, especially in extreme weather events such as heat waves and lower the carbon footprint of buildings by 30% to 40% in 2030 from current levels.

France has chosen to report embodied carbon over a 50-year building-life via dynamic whole life cycle analysis, a methodology that assigns a greater weight to the carbon emitted today than to the carbon emitted later. A Carbon Sequestration indicator will encourage the use of bio-based materials for reasons covered earlier in this report.

France has been trialling this new regulation since late 2016 on a voluntary basis, as part of the experiment called 'E+C-', shorthand for 'Energy Positive, Carbon Negative'. It allowed France to build a national database for EPDs, upskill professionals of the construction sector to carbon reporting and set benchmarks and future targets for the 'RE 2020' within realistic construction costs.

Key Features of the French regulation

- Dynamic Whole Life Carbon Assessment required
- National Environmental Product Declaration Database established
- The regulation will apply to all new buildings
- A progressive reduction of the embodied carbon targets every 3 years until 2030
- Positive effects such as sequestration will be accounted

United States

The US has no federal-level consensus on how to control and lower embodied carbon emissions in construction. Instead, there are various initiatives and policies that are being used across various states or city authorities, each at different levels of ambition. It is anticipated by industry professionals that this varied process will accelerate the learning process, and will enable the industry to more-quickly arrive at an agreed methodology for federal adoption. The limitation of this approach is that the less pioneering states - and those that have no concerns for the environment - continue operating under 'business as usual' practices until directed by federal law.

The first initiative to be signed into law was the Buy Clean California Act (BCCA),[69] which specifically focuses on addressing the Global Warming Potential (GWP) of materials through regulating procurement.[70] As of July 1st 2021, the procurement of certain construction materials in California will be controlled to only those that have a GWP below targets set by the State of California. In contrast to other policies, it is limited only to infrastructure projects, but this can include public buildings.

This is enforced through the requirement of planning applicants submitting evidence of various material specifications including volume and specifications such as cement content. As the projects proceed to construction, submission of Environmental Product Declarations are required and there cannot be any net increase in carbon emissions between planning and construction. The maximum allowable GWP targets per material will be reviewed every 3 years, making downward adjustments, but never upwards. Whilst only limited to a few materials (structural steel, reinforcement, flat glass, and mineral wool insulation board),[71] the methodology of limits could be applied to a wider scope, to make greater reductions in construction-related emissions.

Key Status of the US regulation

- No centralised consensus on approaches
- Various initiatives being pioneered State by State
- Carbon Intensity Limits on certain materials (BCCA). Enforced through Local Authorities with no net increase of emissions allowed between planning and construction

"Introduce a mandatory minimum whole-life carbon standard for both buildings and infrastructure which strengthens over time...

For homes, this standard should be included within the Future Homes Standard."

The Committee on Climate Change (2020)
'Policies for the Sixth Carbon Budget and Net Zero'

Next Steps - 'Laying the Groundwork'

Groundwork required for regulation

The Building Regulations

- **Expanding The Building Regulations** to include requirements to assess, report & reduce embodied carbon, within a new part: **"Part Z: Embodied Carbon Emissions"**
- Compliance to be achieved through a **"Whole Life-Cycle Carbon Assessment"** following the British Standard BS EN 15978
- **Limits placed on embodied carbon emissions** set by building type
- **Regulation 7** to be revised to introduce carbon limits on specific materials

Planning Policy

- **Clauses to be introduced to the National Planning Policy Framework** with requirements for Whole Life-Cycle Carbon Assessments to be submitted at three stages for all new buildings; as part of pre-application enquiries,full planning submissions, and at practical completion
- As an immediate measure **New London Plan Policy SI2** to be adopted by local authorities around the UK

Whole Life-Cycle Carbon Datasets

- **Create a freely accessible UK Environmental Product Declaration (EPD) database**, or adopt an existing freely accessible database, to ensure consistent and reliable assessments[72]
- **Require Environmental Product Declarations** to be submitted to the database from construction material suppliers above a certain size, with trade bodies assisting smaller organisations[73]
- **Establish a freely accessible database for anonymised Whole Life-Cycle Carbon Assessment data of new buildings**, to ensure lessons are widely learnt[74]

In order to meet its legal obligations to bring all greenhouse gas emissions to net zero by 2050, the UK must set out a route to regulate, limit and eventually significantly lower embodied carbon emissions with no further delay. A number of commonalities exist between the international examples that the UK can begin to put in place before the introduction of fully developed regulations.

Aspects of the background work required to regulate and reduce embodied carbon emissions have already been done. The Inventory of Carbon and Energy (ICE) Database was set up in 2005 and has been regularly updated since, giving users free access to critical UK-specific data on the carbon footprint of the products and materials they specify.[75] This tool started to give professionals the information they needed to design in a way that is conscious of the environmental footprint of buildings and infrastructure.

In 2011 the framework by which a building's environmental footprint, over its lifetime, should be calculated and communicated using an LCA - Life Cycle Assessment (see glossary) was set out by the British Standard BS EN 15978:2011.[76] This standard is applicable to all new and refurbishment building projects, and provides the standard methodology that can be used to cover the building's operational and embodied carbon emissions.

In 2012 the British Research Establishment (BRE) introduced IMPACT, 'the only standardised specification and dataset currently available in the UK' that ensures consistency in the application of LCA; 'accurate, repeatable and transparent' results and reliable benchmarks that include hundreds of buildings.[77]

In 2017 the RICS defined the scope and methodology for carrying out WLCA with the publication of "Whole Life Carbon Assessment for the Built Environment."[78] This document - widely used amongst professionals in the industry - explains that taking a whole life cycle approach, considering both operational and embodied emissions in parallel, is the most effective way to truly understand and lessen a building's carbon footprint. Importantly, in relation to operational carbon emissions, it identifies a short-falling of Part L, and the importance of dynamic simulations such as TM54[79] for better representing the true carbon emissions. Using the document professionals can understand, consistently measure and report the carbon impact of built projects, allowing results to be compared with one another.

In 2019 & 2020 the RIBA[80] and IStructE[81] published embodied and whole life carbon assessment guidance for architects and structural engineers respectively. These documents are aligned with, and build on BS EN 15978:2011 and the work done by the RICS, and contextualise embodied carbon for these two professions.

The UK construction industry is ready for embodied carbon regulation and we can learn from the steps taken in other countries to introduce legislation. We must act now to regulate embodied carbon in line with our commitments to tackle the climate crisis, requiring all projects to report whole life carbon emissions.

The following timeline will allow the UK to meet commitments to lower and eventually eliminate carbon emissions:

2021
The UK government should adopt the RICS "Whole Life Carbon Assessment for the Built Environment" professional statement as the nationally agreed methodology for measuring embodied carbon emissions, as set out by BS EN 15978[82]

Regulation 7 to be revised to introduce carbon limits on specific materials

New London Plan Policy SI2 to be adopted by local authorities around the UK, as encouraged within its guidance

2022
All developments should be required to assess and report embodied carbon emissions, in line with the methodology set out by BS EN 15978 and RICS statement. This information should be publicly-held in a free to access, anonymised database akin to DEC ratings, such as the GLA's London Building Stock Model.[83] Data collected from carbon reporting is an invaluable source for understanding and reducing carbon emissions. The database should be established in partnership with professional institutions such as RIBA, RICS and IStructE, in order to contribute towards knowledge sharing.

2025
In parallel to the new Future Homes Standard, introduce policy to tackle embodied carbon emissions, including strict limit values on embodied carbon emissions for all developments, which will be driven by the data gathered over the preceding 4 years.

2028
First reduction in limit values for all developments

2030 - 2040
Continually review and lower the embodied carbon limit values. By 2040 whole life carbon emissions for all new and refurbished buildings should achieve net-zero.

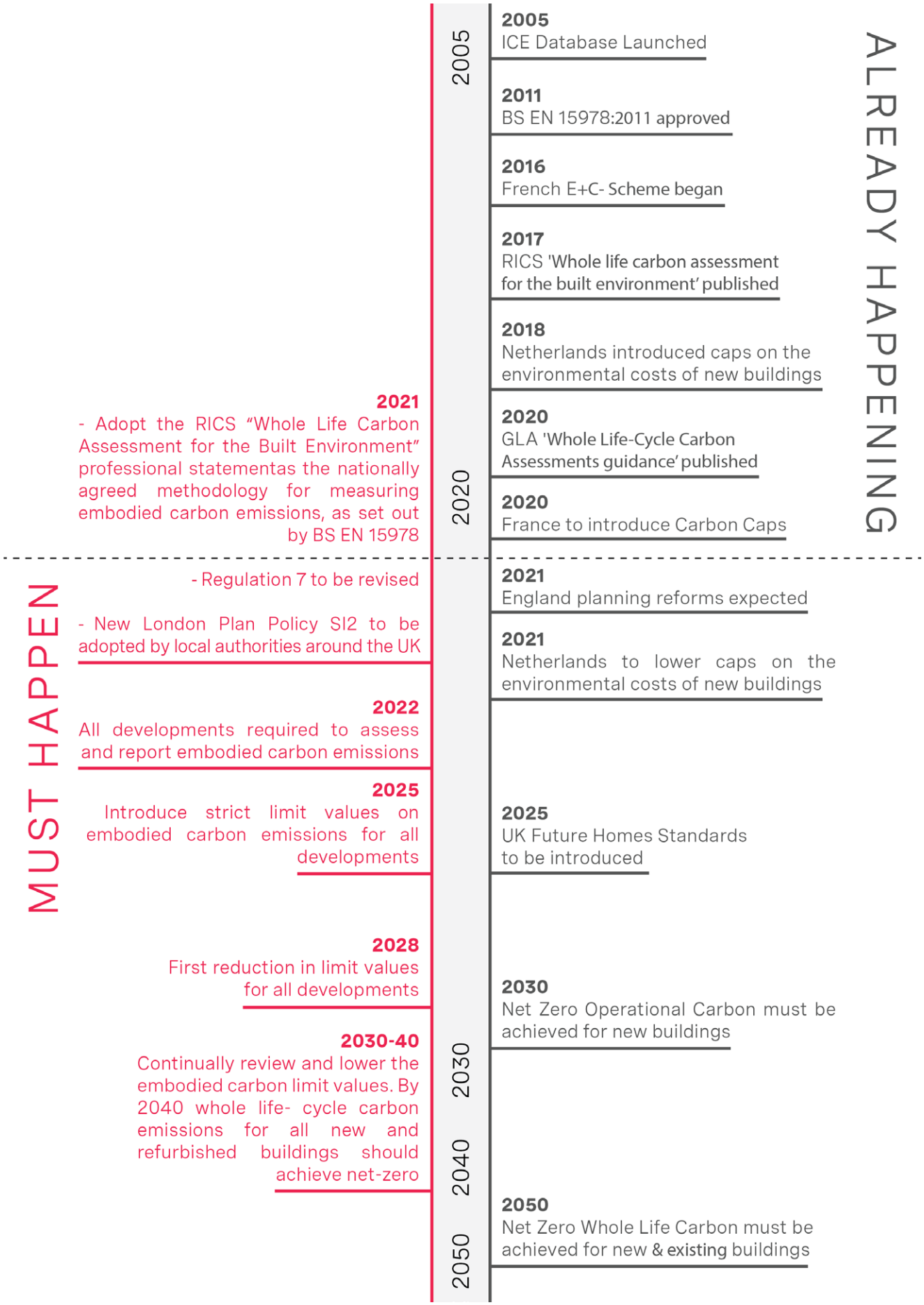
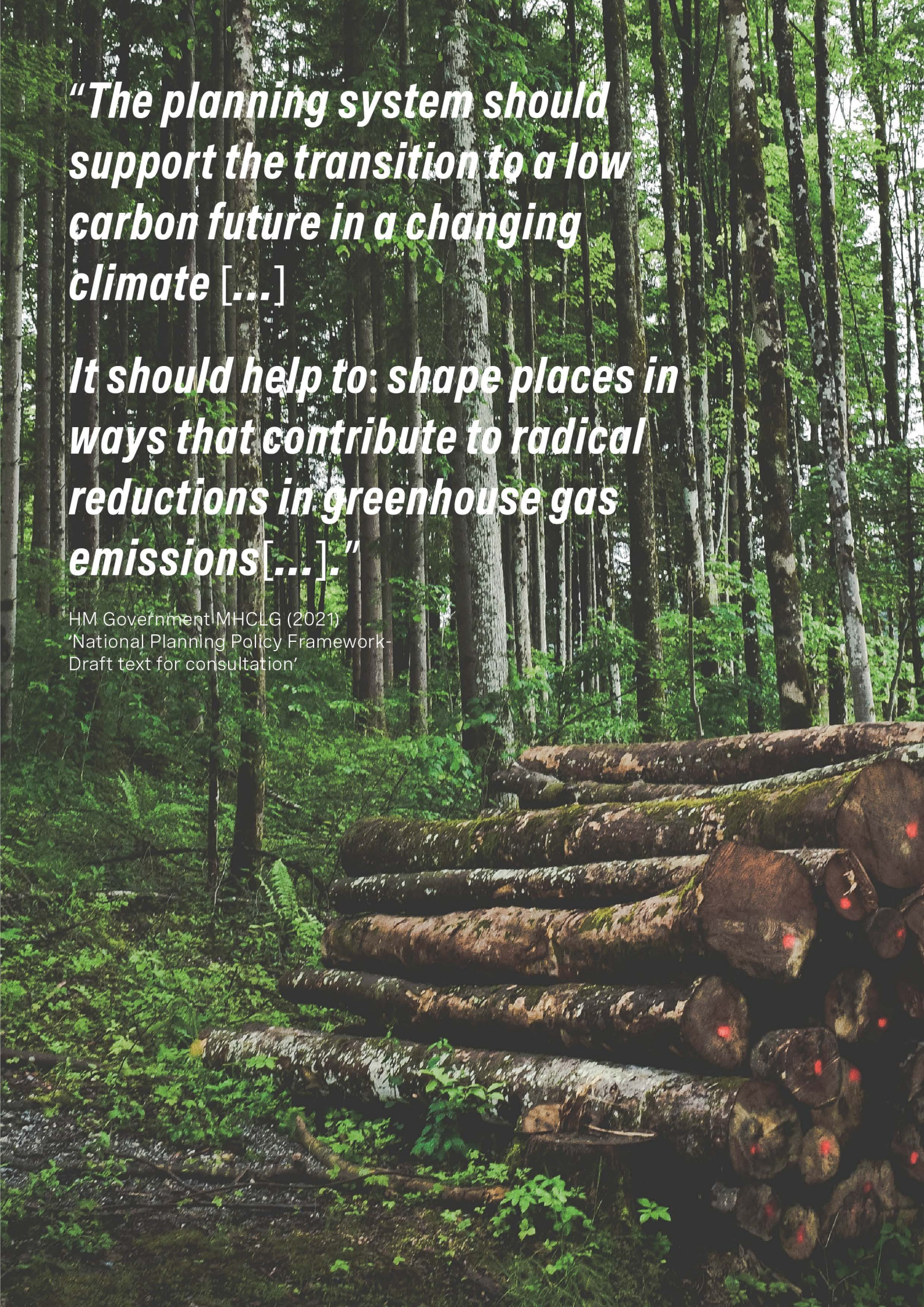


Figure 7 - Timeline



"The planning system should support the transition to a low carbon future in a changing climate [...]

It should help to: shape places in ways that contribute to radical reductions in greenhouse gas emissions [...]."

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Footnotes

1. Unless otherwise specified, 'carbon emissions' in this report refer to all greenhouse gases (GHGs) emitted in the atmosphere including but not limited to carbon dioxide. This is also referred to as 'CO2 equivalent' or in short 'CO2e'. For buildings this means CO2e emissions throughout the lifespan of a building, from product extraction to demolition and waste disposal.
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APPENDIX - Carbon Regulation Policies

These are a selection from the Carbon Neutral Cities Alliance & Bionova Ltd (2020) "City Policy Framework for Dramatically Reducing Embodied Carbon" document. They have been researched and rephrased for UK implementation.

Embodied Carbon Targets for Designated areas of development (Policy Z1)

Scope: Local

Applicable Regulation(s): Local Plan, SPG

What?
Along with the adoption of embodied carbon targets/benchmarks, introducing a requirement for assessment of development areas based on the potential embodied carbon impacts taking into consideration soil conditions and building typologies as well as transportation and energy use.

Why?
The adoption of this policy would significantly and irreversibly contribute to the reduction of upfront carbon emissions from materials, energy use and transport.

How?
Any new masterplan or new area of development shall, before starting date, be subject to an EN15978 / ISO 21930 compliant evaluation. Initial assessment should identify areas for development where soil conditions do not require carbon intensive foundations measures. Areas where soil conditions demand significant stabilisation should be identified for green spaces and public realm or very light and/or temporary structures only.

An assessment based on the adequate designation of specific building typologies for key soil types should also be conducted using the same EN15978/ ISO 21930 compliant legislation. This would allow for optimal designation of building typologies resulting in higher carbon impact (e.g. over 500 kgCO2e/m2 GEA) in order to ensure the local authority achieves targeted embodied carbon impacts which include sub- and superstructure, building envelope and any related parking structures.

A waiver could be applied for developments where the designation would compromise optimal carbon impacts achieved when transportation and energy use are taken into account.

When?
Local authorities could commission an assessment of all areas already designated for developments or require an assessment prior to individual planning application.

Examples of Policy in Practice
Examples of similar measures have been adopted in Norway, Finland and also the UK.

Bio-Based Materials for Designated areas of development (Policy Z2)

Scope: Local

Applicable Regulation(s): Local Plan, SPG

What?
Along with embodied carbon targets/benchmarks, introducing a requirement for the use of low carbon impact materials in designated development areas based on building typologies. Examples are shown below.

Why?
The adoption of this policy would help reduce carbon emissions and conversely increase carbon storage. It will also encourage the use of timber in construction, which is one of the healthiest materials to work with, and help stimulate the timber industry in the UK.

How?
Building frame and façade predominantly made of sustainably sourced (FSC or PEFS certified) wood (e.g. all buildings less than 18m-high) allowing for disassembly and reuse of the wooden elements in other buildings through the use of reversible connections and mechanical fixing other than adhesives.

or

Buildings to incorporate a minimum value (Kg CO_2e/m^2) of biogenic carbon storage in all permanent structures and materials.

When?
Planning application to demonstrate compliance.

Examples of Policy in Practice
City of Helsinki where all buildings in the district of Honasuo are required to have a wooden frame and façade, and all detached houses to be built with massive wood.

In the Austrian state of Vorarlberg grants are provided for new houses demonstrating low embodied and low operational carbon. In order to be eligible, projects should not include materials that are considered carbon intensive.

Carbon-scoring of local authority land for sales or to be leased (Policy Z3)

Scope: Local

Applicable Regulation(s): Competition and contract/tender rules

What?
Bids for the purchase or long-term lease of land owned by local authorities can be scored against a life-cycle carbon efficiency criterion which would carry a significant weight (e.g. 30%) whilst bidders are required to declare the carbon impact of their proposals. The winning bid could be allowed to revisit the development plans if the revised proposals demonstrate further reduction in carbon emissions. Verification by a third party is conditioned as part of the tender and on the development completion. The tender is rejected or a financial penalty is levied if the proposals / completed works fail to meet the original carbon efficiency declared.

Why?
Through ownership of land, local authorities have the powers to determine how that land is developed in a way that significantly minimises the carbon impact on their local environment. Through competitive rules developers are led to compete on the most carbon efficient concept developments without local authorities needing to set carbon limits.

How?
Bidding documents clearly state the evaluation and scoring process and attribute a percentage to the proposals' environmental impact (e.g. 30% of the total score). The latter is based on the declared life-cycle footprint of the submission including calculations of embodied carbon (upfront emissions), regulatory energy use and the solutions outlined to achieve carbon and energy efficiency. The bidders are required to use a recognised carbon calculator (e.g. www.oneclicklca.com).

When?
Proposals to demonstrate carbon efficiency at time of bidding and on completion.

Examples of Policy in Practice
The City of Porvoo, Finland concluded the sale of land designated for 20,000m^2 of residential development on the basis of 30% score attributed to the life-cycle carbon of the proposed joint venture development and 70% to the architecture. The city of Tampere, Finland, applied a life-cycle score of 10% for land competitively sold to make way for a new hotel. A plot sold for reconversion was also subject to a life-cycle carbon score weighting 10%. On completion the projects life-cycle carbon savings were 25% and 30% respectively.

Life-cycle carbon limits for new buildings (Policy R1)

Scope: Local & National

Applicable Regulation(s): Local Plans, Building Regulations & National Planning Policy

What?
New buildings would need to be designed, constructed, and operated to not exceed established whole life carbon, or embodied carbon limits.

Why?
Whole life carbon limits drive the project team to interrogate all life-cycle stages beyond simply the upfront embodied carbon emissions to achieve practical completion. This is important to drive awareness and consideration of maintenance impacts, and enabling demountability at end-of-life to support our transition to circular economies.

Clear targets within the planning process ensure that developers, investors, and design teams identify and agree to them from an early stage. Without this early consensus of targets, many of the low carbon solutions (e.g. structural timber) and carbon reducing opportunities (e.g. structural grid spacing) can be overlooked and challenging to reintroduce at a later stage without incurring additional cost or programme impacts.

How:
This involves calculating the material mass of the various building materials, and multiplying that by the relevant Global Warming Potential of that material. Nationally-recognised carbon accounting methodologies are available, based on European Standards to drive consistency within the calculation and reporting process.

It is important for Local Authorities to be able to review and audit the submitted data in order to levy appropriate penalties for projects failing to adhere to the limits. The conglomerated data can then be used to develop industry-benchmarking and encourage material innovation and efficiency.

When?
Planning applicants are required to submit calculated data through the planning process (e.g. Pre-application, Application, and Post Construction).

To support the adoption of this new process, cities such as Paris have introduced carbon reduction targets with soft-starts without penalties. This allows the creation of a robust preparedness of the industry that can then respond as the Local Authorities introduce penalties, and incremental changes to the limits to steer the industry towards lower emissions.

It is therefore vital for this process to start imminently, in order for limits to be introduced to reduce building-related emissions.

Examples of policy in practice:
In Vincent, Australia, new developments are required to achieve % reductions against code-compliant baselines. This is currently set at 50% reductions for residential units and 30% for commercial units.

In Douro-Dummer, Canada, in order to support the adoption of their Sustainable Development Guidelines, grants were available for the first 50 applicants whose projects achieved the carbon emissions target.

Limiting the Environmental Damage from Concrete (Policy R2)

Scope: National

Applicable Regulation(s): Building regulations

What?
Require reporting of the volume and greenhouse gas emissions from concrete used for building and infrastructure projects, against set limits.

Why?
Concrete is one of the most widely used and environmentally damaging materials in the construction industry. The use of concrete in the UK has far-reaching environmental and social impacts, affecting communities across the globe. Concrete has a high carbon footprint due to its cement content. Concrete production uses almost 10% of the world's industrial water use, and 75% of this consumption is in drought and water-stressed regions. The mining of the large volumes of sand used in concrete production has destroyed beaches and watercourses, is depleting global supplies, and supports organised violent crime. Air pollution is increased in areas where concrete is produced, and where associated mining occurs.

Its impacts can be reduced by eliminating the use of concrete where it can be replaced with other products with lesser environmental impacts and by encouraging the design of efficient, lightweight structures. The global warming potential of concrete can also be reduced, for example by specifying a lower carbon mix.

How?
First: Require the total volume of concrete proposed to be used and EPD data for this concrete to be submitted for all new and refurbishment projects.

Next: Introduce benchmarks for both the volume of concrete per m^2 NIA for typical building types and the environmental performance, as defined in the EPDs, for different concrete strength classes.

Then: Introduce limits on the volume and environmental performance of concrete, embedded in the building regulations.
This legislation will reduce the amount of concrete used in the construction industry, and then limit the embodied carbon emissions of the concrete that must be used.

When?
Information to be submitted for building control approval.

Examples of policy in practice:
Marin County, California: Low Carbon Concrete Code.
Singapore Building and Construction Authority: BCA Greenmark
Norwegian Concrete Association: Low Carbon Concrete Standard
Portland, Oregon

Material-efficient Structural Design Requirement (Policy R3)

Scope: National

Applicable Regulation(s): Building Regulations (Part A), Public Procurement Rules

What?
Improving the efficiency of a building's structural design in order to reduce material use and therefore lower embodied carbon.

Why?
The structure of a building constitutes a significant proportion of the total embodied carbon. This is due typically to the large quantities or high carbon nature of the materials used; the most common being steel and concrete. It is standard practice in the UK (as in many other countries) to over-engineer structural elements causing excessive material use. As an example, an analysis of office buildings built in London in the last 7 years or so - at the time of this report - shows that structural capacity is often up to 80% more than regulations and guidance demands due to historical regulations dated 1909.[84]

Digital design tools can offer an excellent opportunity for greater efficiency through analysis, testing and fabrication.

How?
Structural material efficiency can be implemented in a number of stages or different routes with design reviews and reports on efficiency to building inspectors to confirm design is not over-engineered.

The best approach could be a peer-review system among Structural Engineers. A similar system is used in highly seismic areas of the US where peer-review processes are mandated. Cities with such policies include San Francisco, Los Angeles and Seattle.

Reporting and data collection would be followed by setting targets and limits enforceable through building regulations.

Example Policy. First: All projects over a certain size (4 storeys or 1000m^2) to submit Structural Materials Quantities report and an Average Utilisation Ratio report for the whole project as part of the planning application. The collection of data is key to creating benchmarks which can be used as a basis for incentives or future regulation.

Next: Set targets for maximum allowable over-capacity with a focus on reduction of overall materials used. Maximum limits to reduce over time.

Examples of policy in practice:
BCA Green Mark Scheme - Singapore Building and Construction Authority
Scheme encourages best practice in environmental design and performance and rewards

Declaration of construction materials carbon efficiency (Policy R6)

Scope: Local

Applicable Regulation(s): SPG

What?
Introduction of a requirement for any new development and refurbishment of existing of a minimum size to declare structural and building envelope material efficiency expressed in material mass per m^2.

In parallel, introduction of a requirement for any new development and refurbishment of existing of a minimum size to provide materials passport and/or EPDs on all construction products. The requirement includes the provision of detailed information on how the products / components are to be installed to inform future use beyond the life of the building(s).

Why?
This policy would contribute to the expansion of benchmark data on building materials as well as data on material efficiencies that can be publicly shared for future projects. The policy would also support the development of a local circular economy by keeping a record of materials used across the local authority area and encourage their reuse when renovation or demolition permit is sought.

How?
All new or existing projects requiring planning permission for development or extension are required to provide construction materials efficiency declaration for key building components including quantity information re: ready mix concrete and pre-cast concrete elements in m^3, steel and reinforcement steel in tons, cement, bricks and glass in tonnes, insulation, gypsum and plasterboards in tons.

When?
Information to be submitted prior to and as part of the planning application process.

Examples of Policy in Practice
In the Netherlands the Platform CB'23 (Circular Construction 23) is being developed to stimulate the reuse of construction materials, products and elements and propose a new approach to the 'production, tendering for, design and implementation of construction projects' aligned with the principles of the Circular Economy.[85]

Life-cycle carbon calculation and reporting (Policy R9)

Scope: National

Applicable Regulation(s): Building Regulations, National or Local Plans

What?
Introduction of a requirement for any new development and refurbishment of existing buildings of a minimum size to calculate and report life-cycle carbon emissions using a standardised measure, separating embodied carbon and operational carbon.

(Or alternatively for embodied carbon only)

Whole life-cycle carbon assessment

Why?
This policy would help to develop greater understanding of carbon impact at all life cycle stages, improve familiarity with the assessment methodology and build a database for benchmarking and future targets or regulations. Significant reductions in operational carbon emissions of buildings have already been achieved through Building Regulations: Part L (Conservation of fuel and power). However, operational emissions only account for around 30% of a new building's total lifetime emissions: the other 70% coming from embodied carbon emissions. We need to calculate whole life-cycle carbon to understand the full picture and enable us to make the necessary changes.

How?
All new or existing projects requiring planning permission for development, extension or retrofit* would have to complete a whole life-cycle carbon assessment

When?
Information to be submitted as part of the planning application process, for building regulations approval and again at practical completion.

Examples of Policy in Practice
London Plan 2020, Policy SI 2 Minimising greenhouse gas emissions, part F.
London Borough of Camden, soft requirement in Local Plan 2017 (as under policy R1)
Royal Institution of Chartered Surveyors (RICS), all members must complete mandatory WLCA for new build infrastructure projects (May 2018)[86]

Carbon Limits for Key Materials (Policy P1)

Scope: National

Applicable Regulation(s): Public procurement rules

What?
Require EPDs to be submitted for specific material types for public projects and set Global Warming Potential caps for each of these products.

Why?
Some materials are ubiquitous within the construction industry. Glass, steel, concrete, insulation, gypsum board and refrigerant are all materials that might have different global warming potentials depending on how they are extracted, manufactured and transported. Specifiers can use Environmental Product Declarations (EPDs) to understand the environmental impact of these products. Currently, all products do not have EPDs, however, the number of EPDs available is growing. Public projects have the opportunity to lead by example and drive the market towards both increasing the number of EPDs available, and reducing the carbon footprint of common building materials.

This legislation will ensure that more EPDs are produced and drive down the GWP of common building products, using market forces, creating a wider positive benefit in the construction industry.

How?
First: Introduce the policy for all glass, steel, concrete, insulation, gypsum board and refrigerant specified.

Next: Introduce further materials to this list, such as stone and roofing membranes, as more data becomes available in the industry.

Then: As industry decarbonises, the caps on GWP for each of the products can be lowered.

When?
To form part of the tender documentation for public projects.

Examples of policy in practice:
Buy Clean California Act (BCCA)[87]

Whole Life Carbon evaluation of Retrofit versus Redevelopment (Policy M6)

Scope: Cities & Local Authorities

Applicable Regulation(s): Local Plans

What?
Comparative whole life carbon studies to be undertaken to inform the evaluation process between retrofitting or demolition and redevelopment.

Why?
The UK loses more than 50,000 buildings a year to demolition, and in many cases these lost assets could have instead been part of our low carbon future. Often the highest emission elements such as building structure can be retained and re-imagined to support new future-proofed buildings (e.g. UCL Student Centre).

Mandating WLC studies will drive project teams to fully interrogate existing buildings through an audit, their potential for re-use, and highlight the carbon emission savings possible through the re-use and re-imagining of existing buildings, and in doing so promote this sector of the industry.

How?
To submit planning, the applicant would be required to submit two life-cycle assessments; one of the re-use scenario and one of the demolition and new-build scenario. These involve calculating the material mass of the various building materials, and multiplying that by the relevant Global Warming Potential of that material. Nationally-recognised carbon accounting methodologies are available based on European Standards to drive consistency within the calculation and reporting process. To promote this as an instructive and informative process, these assessments should be demonstrated to have been done at the earliest opportunity.

To ensure rigour, it is important for Local Authorities to be able to review and audit the submitted data. The conglomerated data can then be used to develop industry-benchmarking and encourage retro-fit opportunities elsewhere.

An important mechanism for promoting building re-use is VAT. The current higher VAT rate of 20% applied to refurbishment, repair, and maintenance is a frequent reason cited for demolition and new build. In the UK, the Architects Journal, amongst others, have campaigned for a review of VAT and normalising it across construction would further enable lower carbon solutions.[88]

When?
There are no pre-requisites required for introducing this policy and in its initial form it does not mandate the applicant to adopt the lower-carbon solution.

Local Authorities would be able to determine scope of application, however the target should be making it mandatory for all buildings.

Examples of policy in practice:
The key with this policy is that it drives the lowest whole life carbon solution, irrespective of it being a retrofit or demolition and new build. For example, the City of Lahti in Finland applied this policy to two schools of circa. 8,000m^2 in total. The calculations were based on a 50-year life using proprietary software (One Click LCA) that is compliant with the relevant European Standard (EN 15978). The assessments showed that demolition and new-build resulted in a significantly lower whole life carbon impact.

Salvaged, Reused or Recycled Material Minimums (Policy M7)

Scope: Local

Applicable Regulation(s): Procurement rules

What?
Requirement for all Local Authority construction projects to meet minimum levels for the use of salvaged, reused or recycled materials. Local authorities could also introduce incentives for private sector projects within their boundaries if these meet the same criteria.

Why?
The reuse of existing structures (where safe) or materials (post-decomissioning or post-demolition of existing structures) for refurbished or new buildings will result in significant reduction in upfront carbon emissions which can amount to 70-80% of a building's carbon emissions over its lifetime. In addition, if adopted systematically across Local Authorities in the UK this requirement would lead to a drastic reduction in the amount of construction waste going to landfill. Currently this adds up to c. 25 millions tonnes each year.[89] Lastly this policy would stimulate the Circular Economy through the support of local and regional supply chains for salvaged, reused and recycled materials, creating in the process thousands of jobs in the green economy.

How?
Minimum requirements are introduced in procurement rules and/or guidelines either by material type or project from design to construction stage.
For instance:

In all construction projects delivered by the Local Authority or in part or all funded by the Local Authority preference will be given to salvaged, reused, recycled and recyclable materials as long as this selection will not adversely undermine the performance or safety of any components of the projects. Exemptions may be given for projects demonstrating one of the following:

- the necessity to use materials that are specific to the project function and are not available in a recycled form at the time of material procurement stage;
- a reduction of embodied carbon of a minimum proportion against an establish benchmark for comparable projects.

When?
The policy could be implemented through existing procurement rules.

Examples of Policy in Practice
The Construction Demolition Debris Recycling and Reuse Policy of Los Angeles County's Metropolitan Transport Authority (Metro) imposes that Metro gives preference to the use of recycled and recyclable products to the maximum indicated when selecting construction materials for Metro-funded or Metro captial projects.

Increasing demolition permission fees (Policy F6)

Scope: National, Cities & Local Authorities

Applicable Regulation(s): NPPF, Local Plans

What?
An increase on demolition permission fees for existing buildings, based on their evaluated suitability for re-use.

Why?
The UK loses more than 50,000 buildings a year to demolition, and in many cases these lost assets could have instead been part of our low carbon future. In 2020, permitted development rights in the UK were increased to include the demolition of vacant commercial buildings for redevelopment into new residential units. This will likely result in an unnecessary increase of demolished buildings, and an increase in new construction each with associated embodied carbon emissions. As a result, this PDR expansion has the potential to lead the nation in the contrary direction to the UK's decarbonisation targets.

Increasing the financial cost of demolition will incentivise property owners and developers to fully evaluate alternatives to demolition such as low-carbon and adaptive retrofit.

How?
The increased fee could be informed by a number of variables with higher rates for newer buildings, buildings demonstrating suitable re-use opportunities, or its suitability for deconstruction.

A co-benefit of this policy would be for the additional fees to contribute towards an improved deconstruction industry with improved material reclamation and salvaging procedures to support our transition to circular economies.

When?
Authorities would apply the permission fees through the planning application process.
It would be important that, where it can be demonstrated that the demolition and new-build scenario would result in fewer whole life carbon emissions, the demolition is not subject to increased fees.